REPORT

ON THE

RURAL ENERGY CENTRE (REC) PATTIYAPOLA

NATIONAL SCIENCE COUNCIL OF SRI LANKA

REPORT ON THE
RURAL ENERGY CENTRE (REC) PATTIYAPOLA

Prepared by

The Solar Energy Group of the
National Science Council

NATIONAL SCIENCE COUNCIL -
SRI LANKA

C O N T E N T S

PREFACE

This document consists of the impressions of a Group of local scientists directly involved or interested in "Solar Energy" R and D (the term used to cover alternative sources of energy), who have given some serious thought to the conceptual and operational aspects of the Rural Energy Centre (REC) Pattiyapola and have put down their observations, criticisms and recommendations for the future.

The report has evolved from "intellectual shramadhana" since some of the busiest local scientists and engineers holding positions of responsibility have given of their own free time on saturdays and public holidays to help in compiling this report and discussing the problems pertaining to alternative sources of energy.

The National Science Council has provided the infra-structure to enable the group to meet and also given its formal recognition which could assist in translating the decisions of the group into practical terms. This is just a single example of the useful and varied activities the NSC is engaged in.

It is significant that all those actively engaged in "Solar Energy" research felt that more could be achieved via this type of semi-formal gathering with voluntary representatives from different organisations, where independent work is carried out with self imposed co-ordination, rather than control by a central authority. It felt that too much effort and money would be dissipated in the creation of a formal authority. Especially at the present stage.

The misconception which is prevalent among administrators and laymen that duplication of research effort is undesirable and a luxury that cannot be afforded by a poor country, has been rejected in no uncertain terms by the members of the "Solar Energy Group". Those engaged in scientific research are only too conscious that the quality of their research can only be judged by their peers -

ie. co-workers,competitors etc.Laymen could usefully contribute an opinion on areas like relevance, priorities etc., but the details of execution has to be left to the professionals

The report is essentially in two parts. The report proper and the Appendices. Since the Appendices form a very large fraction of the total report some explanation is called for.

It was one of the objectives of this report to collect into one document as much information as can be obtained which pertains to the project in its raw form. This will provide ready reference to all those who may wish to study different aspects of the project (which has international collaboration) in more depth. Also the Appendix (I) introduces to the scientific community and decision makers the composition of the Solar Energy Group and its thinking via minutes of the meetings that have been held so far.

It should be finally stressed that this report outlines a line of action for the future which can become a reality only with cooperation in terms of funding and physical effort.

* * * * *

ACKNOWLEDGEMENTS

The Solar Energy Group wishes to make the following acknowledgements to :

(i) Professor P.C.B. Fernando
Professor C. Patuwathavithana
Mr. D.B.J. Ranatunga
for preparing the DRAFT REPORT

(ii) Mr. S.H. Subasinghe, Mr. B.P. Sepalage and Mr. D.S.R.Seneviratne of the Ceylon Electricity Board for demonstrating the Pattiyapola Project, having several discussions with the drafting committee and providing useful maps, diagrams and documents.

(iii) Mr. G.B.A. Fernando of the Ministry of Finance and Planning for making available several useful documents in connection with the History of the Project.

(iv) Mr. M.A.T. de Silva of the National Science Council for assistance given in arranging the trip to Pattiyapola covering the meetings of the Group and helping with the task of putting together this report.

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REPORT ON THE RURAL ENERGY CENTRE (REC) PATTIYAPOLA

1.0 Introduction

1.1 The National Science Council (NSC) which has been directed by the Minister of Industries and Scientific Affairs to accquaint itself with the REC by visiting this station at Pattiyapola, requested the "Solar Energy Group" to visit the Pattiyapola station and submit a report.

"The Solar Energy Group" is a group of scientists and engineers involved or directly interested in alternate sources of Energy - "Solar Energy - R & D, who will advise the NSC in matters relevant to "Solar Energy".

The nature and wider objectives of SEG is indicated more fully in Appendix (1) which consists of -

(a) The letter of invitation from the "Physical Science and Engineering Panel" of the National Science Council to a representative group of workers directly involved or interested in non conventional alternative energy (solar, wind, biogas etc.)

(b) Minutes of the inaugural and the subsequent meetings of the SEG (three)

1.2 A team of thirty scientists and engineers (Appendix 2) from SEG and NSC visited Pattiyapola on 14th July 1979. The officials of the Ceylon Electricity Board (CEB) in charge of the station Messrs. H.S. Subasinghe, B.P. Sepalage and D.S.R. Seneviratne were present and gave a demonstration of the generators installed and operating, and also explained the work that has yet to be done. We wish to record our thanks to these officials for their efforts in making the visit a useful one. The trip was arranged by the NSC who also met the expenses involved.

2.0 **Objectives of the Report**

2.1 To compile in a single document relevant information available in respect of the REC Pattiyapela, starting from its planning stage.

2.2 To consider the present status of the project from a technical view point and make a critical study.

2.3 To comment on its strengths and shortcomings and make recommendations as how to optimise the impact of the centre in realising in practical terms the ultimate goal of introducing "Solar Energy" to supplement the conventional sources of energy presently used in Sri Lanka.

3.0 **History of the Project**

The preliminary planning that went into the project formulation is available in the Appendices listed below and attached to this report.

Appendix (3) (a) Report on the visit of Dr. I.H. Usmani, Senior Energy Adviser UNEP to Sri Lanka on 19 October 1975 and the Proposal of the United Nations Environment Programme to establish a Rural Energy Centre in Sri Lanka - G.B.A. Fernando 10 November 1975.

(b) Relevant correspondence on the subject in chronological order (submitted by Mr. G.B.A. Fernando, Assistant Director, Ministry of Finance and Planning.)

(c) Final Feasibility Report - "An Energy Centre in Sri Lanka" - by H.J. Allison etal of Oklahoma State University

(d) Executive Summary of the Feasibility Report on the REC for the Pattiyapela Village in Sri Lanka I.H. Usmani 5 August 1976. (copy submitted by Mr. G.B.A. Fernando)

(e) Copy of Agreement between Sri Lanka and UNEP on the Establishment of the REC at Pattiyapela.

Appendix (4) (a) An appraisal of the proposed UNEP Rural Energy Centre at Pattiyapela - Sri Lanka - T.L. Shankar April 1978. (copy submitted by Dr. K.G Dharmawardene)

(b) Documents made available by the Ceylon Electricity Board (CEB)

(i) Report of the Socio - Economic Survey Pattiyapela Village Hambantota District 1977 - compiled by the Government Agent Hambantota District.

(ii) Statement by Messrs. H.S. Subasinghe, B.P. Sepalage and D.S.R. Seneviratne of the CEB who man the REC.

It is felt that although the History of the project is useful for the record and as a guide for the methodology in future planning and implementation of similar projects (taking into consideration its successes and shortcomings) from the view point of this report it would be more worthwile to look towards the future of the project. The detailed Appendices will be useful to those who have a special interest in planning projects of this nature.

4.0 <u>The present status of Project</u>

4.1 The location of the REC (is indicated in the map of Fig. 1). It is at Pattiyapela which is about 2 miles from the turn off to the left at the 126th Mile Post as you proceed from Colombo on the Colombo Kataragama Road. The approach road to the Centre is motorable with a few spots requiring repair.

4.2 The criteria for selecting Pattiyapela as the location for the Rural Energy Centre were evidently as follows -

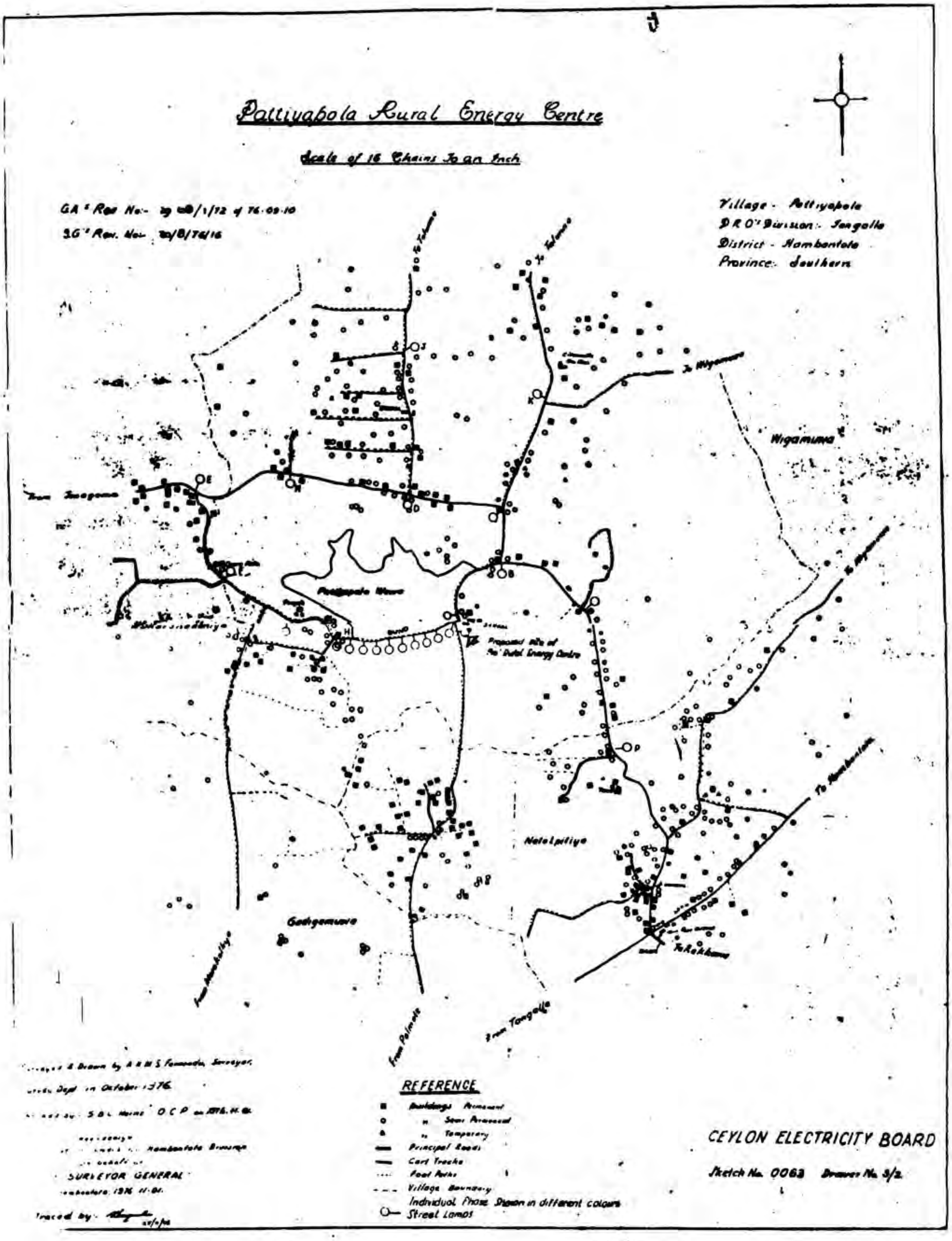

Fig. 1 Location of the Rural Energy Centre in the map of Matara.

4.2.1 It has the necessary ingredients of a rural environment (such as not being connected to the CEB national grid, availability of animal (cowdung) and vegetable refuse etc.)

4.2.2 The village around the Centre is still in the initial process of growth and hence can develop within the rationale of a REC concept.

4.2.3 The available Meteorological data for the Hambantota district indicated suitable wind speeds at Pattiyapola. Further, since the average cloud cover for the district is comparatively low throughout the year, a high Solar radiation input is available.

5.0 Description of Centre

The Centre consists of different types of solar energy generators installed in the field, a small building consisting of records, control, stores battery and engine rooms. Fig. 2 gives the original plan of the location of the Centre and details of the experimental installations respectively.

6.0 Solar energy generators

It is planned that the centre would eventually have the full range of generators. Presently the generators installed consist of a Biogas generator, two wind generators and a demonstration solar cooker and steam generator. Photovoltaic solar panels are available but not yet installed.

6.1 Biogas Generator

6.1.1 The Biogas generator at Pattiyapola employs a floating chamber which maintains a constant pressure as the mass of gas (a mixture of Methane, Carbon Dioxide etc.) builds up. The generator is designed to Indian specifications and was fabricated at site under the supervision of an Indian engineer Mr. H.R. Srinivasa Mr. Subasinghe and Mr. Sepalage from the CEB were the local collaborators. The fabrication and welding of the metal gas - tight floating chamber and the civil works connected with the building of the digestor were executed employing local labour.

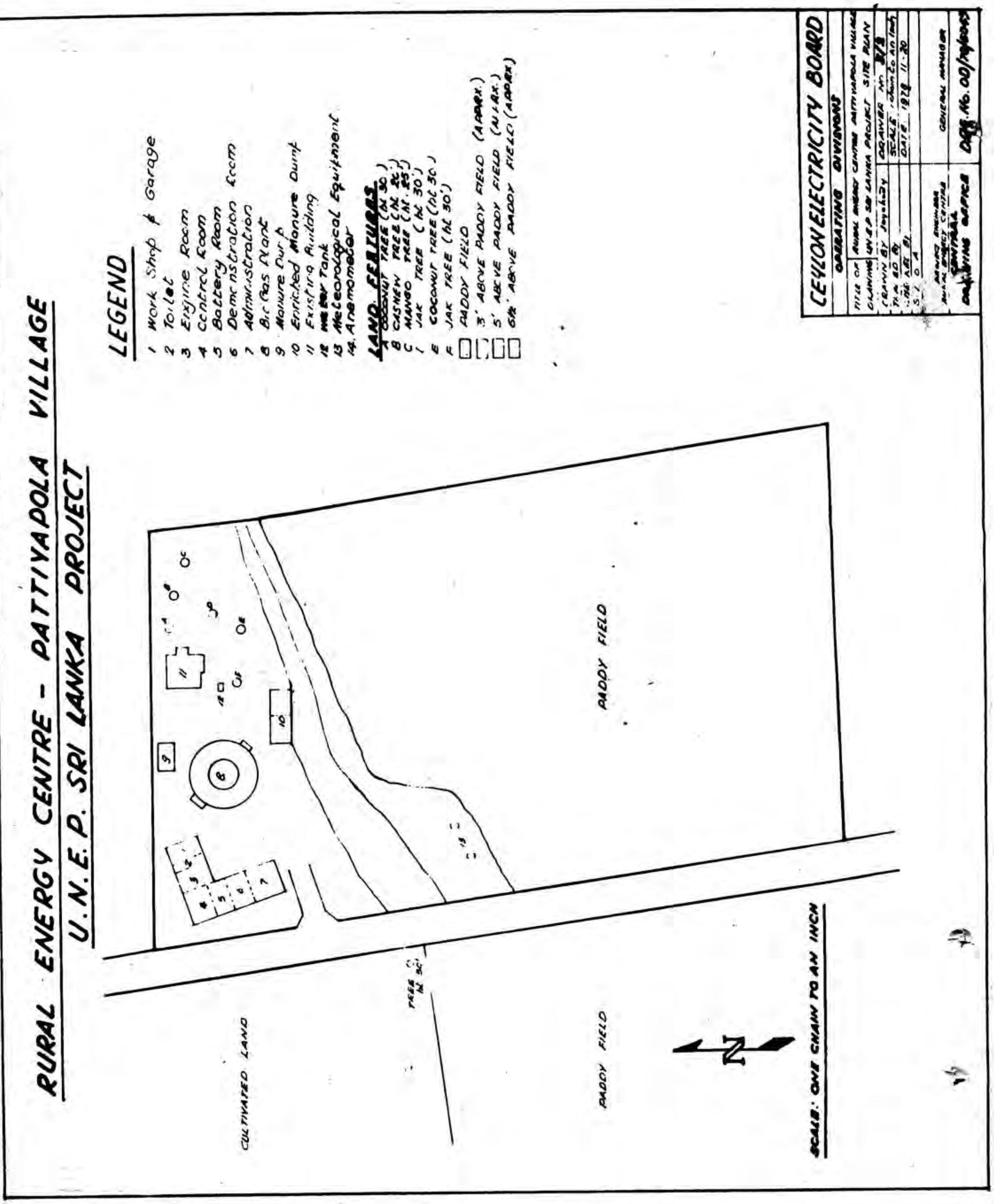

Fig. 2 Original lay out of the REC.

Fig. 3 is a sketch of the Biogas generator.

6.1.2 The performance of the Biogas Unit was demonstrated to us in qualitative terms by showing us

(a) A cooking stove utilizing the direct ignition of the biogas generated

(b) A diesel engine (18 H.P 3 Cylinder "Lister") coupled to an electricity generator (12.5 KVA 3 phase 50 Hz) where the engine employed a mixture of biogases (methane) and diesel in the proportion 80 : 20

(c) A spark ignition engine 50 H.P 6 cylinder "Onan" coupled to an electricity generator 37.5 KVA 3 phase 50 Hz. The engine operates on 100% biogas. The electrical fittings of the station like fluorscent tubes etc. were lit by the above generators.

6.1.3 Although there is no systematic continuous monitoring of the different parameters relevant to the generator the following account as given by an engineer manning the station - Mr. D.S.R. Seneviratne when the drafting committee interviewed him on 6th Saturday October 1979 - gave us a qualitative idea of the generators performance.
Mr. Seneviratne reported that since about June 1979 the regular street lighting load from 6.00 p.m. to 9.00 p.m. (about 25 x 60 watt. incandascent bulbs) of the village is met entirely by the Biogas Generator. He also reported that this is well under the average capacity of the generator. The plant which has a power output of 37 kw, is capable of supplying daily for about 3 hrs. 2 to 3 lamp points per house. Since supplying private lodgings with electricity requires policy decisions to be taken by the CEB after giving due consideration to cost factors, tarrifs A.RS. F.R. creation of precedents etc. the supply to private lodgings which request (2 or 3 points to about 10 points) has not yet been put into operation (although the plant is technically capable of doing so) It was roughly estimated that with the average cowdung obtainable from the village the generator which is capable of supplying a maximum load of 37 kw. is capable of a daily supply of about 90 kw. hrs. utilizing about 1400 kgms. of cowdung.

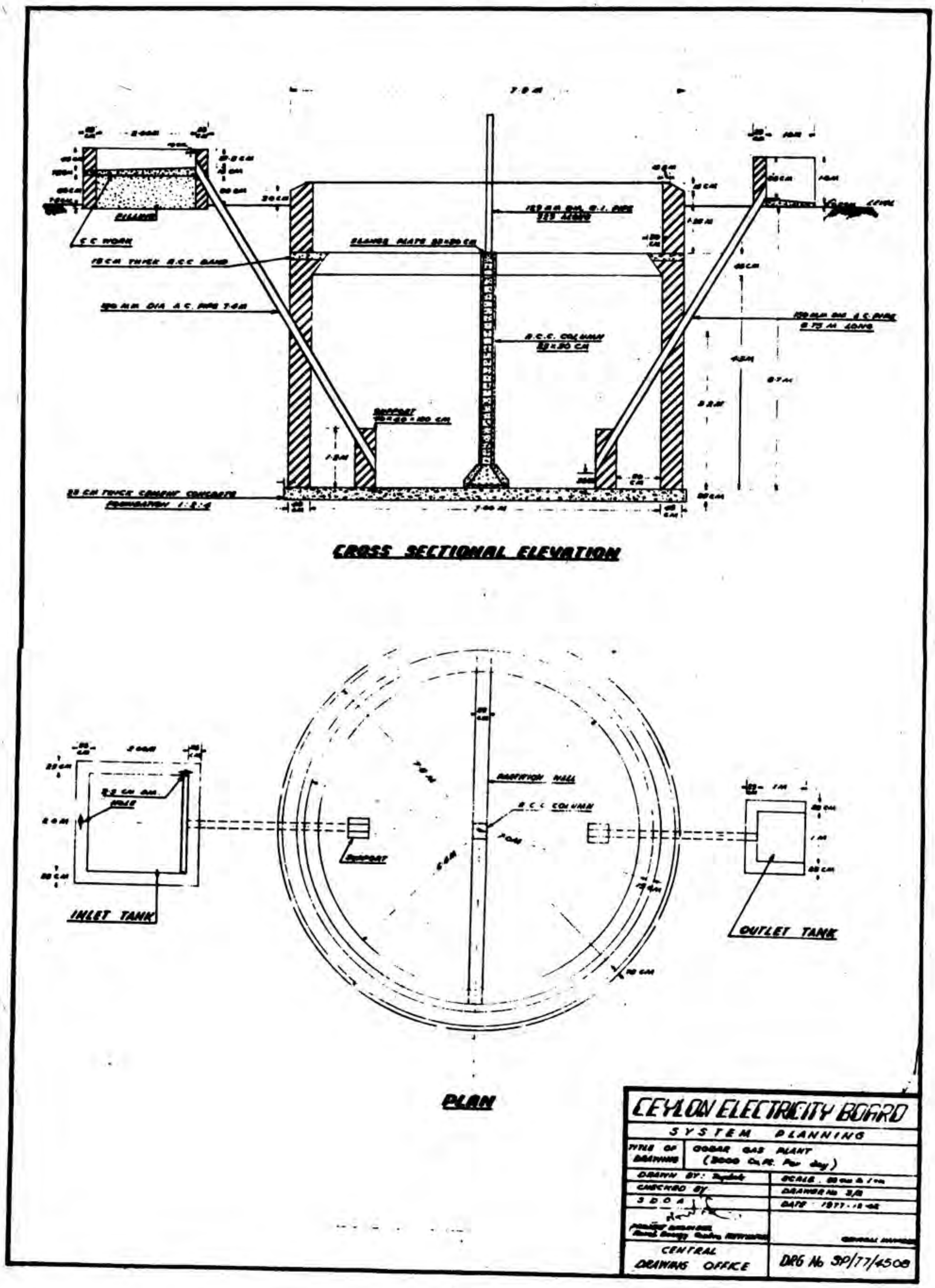

Fig. 3 Engineering drawing of Biogas Unit.

6.1.4 It is useful to note that the initial charge of cowdung to get the digester to begin operation was 40 lorry loads (80 tons) obtained from the Ridiyagama farm - 25 miles from the centre - Thereafter the day to day cowdung requirements have been met entirely from the cattle in village.

6.2 Wind Generators

6.2.1 Two windmills manufactured by Dunlite (Model 2000) having 12 ft. diameter blades and mounted on 60 ft. tall steel towers had been installed, Two more are to be installed in the near future. The electrical generators are coupled to the wind turbine after gearing up 10 times. This is mounted on the tower itself. The Wind generators have a rated capacity of producing 2 kw. each at a wind speed of 35 mph.

No quantitative measurements have been possible so far as the installation was still in progress. The electricity generated by these are stored by feeding battery banks when wind speeds are high enough.

6.3 Miscellaneous

6.3.1 For pure demonstration purposes a simple solar cooker where light is reflected by plane mirrors arranged to reflect radiation into a "green house effect" hot box had been set up. This is an imported cooker and the cooking volume is too small for the purpose of cooking meals in the local context.

6.3.2 We were also shown a demonstration solar steam generator - Rankine Cycle Engine type capacity 7.5 kw. Here the reflector is parabolic and has to employ a tracking device to look to the sun's movement.

The steam generated is fed to the Rankine cycle steam engine coupled to an electrical generator. Storage is via a battery bank.

6.3.3 Photovoltaic panels which were not installed were shown. The total cost of the system is approximately US $ 50,000 and has a total peak capacity of 2 kw.

7.0 Measurement

A sunshine recorder of the crystal ball type (campbell stoke) and a solar radiation recorder employing bi - metalic strips have been set up. Continuous measurements are being taken.

A cup anaemometer with counter has been set up at a height of 6 meters and systematic measurements on wind speeds are made.

8.0 Criticisms, Suggestions and specific Recommendations

8.1 Spirit in which criticisms are made.

Any criticisms of a detailed nature in this report must be viewed in the light of the general appreciation of the work that has already been done. That a beginning has been made in having an integrated project which will function as a demonstration Rural Energy Centre for South East Asia is laudable and efforts of all those who have contributed to the project at different levels and in different ways should be recognized and appreciated.

8.2 Criticism

In very broad terms the chief shortcoming of the project, as we observed it, was that there was no quantitative approach in respect of the performance of the generators, which is what will in the long term yield optimum and practically useful results. At present the stress seems to be on the demonstration aspect and that too is aimed at the layman. There seemed to be a lack of systematic data collection even at a semi-quantitative level. The relative isolated of the centre and the lack of staff permanently working on this project may be a possible reason.
The popularization of "Solar Energy" in Sri Lanka is very important.

However at Pattiyapola increasing emphasis than hither to should be given to "Solar Energy" R & D.

It may be argued that the centre will acquire an academic flavour if too much stress is given to quantitative systematic and continuous measurement and therefore defeat its main objective of becoming a model for spreading the message to the village. A closer scrutiny will show that a scientific approach to a problem does not necessarily obstruct its practical realisation. The converse is true. It is easier to duplicate or multiplicate successfully and trouble shoot malfunctions, if complete data in respect of performance in the local condition is available. Further if socio-economic planning projections are to be realistic the input figures must be as accurate as possible. They should be empirical rather than speculative.

The Biogas Generator

There was consensus that this was the most spectacular "exhibit" at the station. We would like to recommend that if possible measuring devices that do not require dismantling and modifying the present generator be incorporated.

Ideally one likes to see -

1. A Wattmeter and Voltmeter at the output of the generator preferably with continuous revording.
2. A Manometer and Thermometer which would continuously monitor the physical state of the Gas.
3. A flow meter (absolute and / or continuous) and regulator for the Gas flow.
4. Systematic and regular monitoring of the chemical composition CH_3 CO_2 .... etc. of the Biogas at regular and convenient intervals and their dependence on temperature, pressure etc. be analysed.
5. The weight, volume and frequency of the cowdung charge introduced to be monitored.
6. The cowdung added to the Biogas generator and the residue could be subjected to sampling analysis from a Biological view point on a regular and systematic basis.

7. Biogas generation of different species of cattle and on factors like feed patterns etc. could be tried out.

8. Different types of Animal Waste (Human, Cattle, Buffaloes, and Vegetables Waste etc.) could be studied as food.

It would have become apparent that some of these are "academic" and also multidisciplinary skills are needed. Further these aspects may have been studied in other countries.

It is also strongly recommended that at least one or two more biogas generators of different diameters to the present generators be built by local personnel and all on this site and measuring probes be introduced. This will obviously require a multidisciplinary effort with individuals drawn from different organisations and disciplines. The concept of a "time sharing"research facility could be usefully explored.

The possibility of using human faeces - a generator could be installed at the Ruhunu Campus when the new buildings are put up - be explored. Further the Ruhunu Campus due to its proximity to the Pattiyapola REC could work in close collaboration with it especially on the academic aspects.

A thorough socio-economic survey with the present system characteristics and a reapraisal of cost / benefit with the prevalent fuel prices be carried out by experts trained in this area.

Wind generator

The group took note of

(a) the observations of Prof. S. Sivasegaram, Engineering Faculty, University of Peradeniya / "the wind generators supplied appeared to be rated for higher wind speeds than locally available. This may lead to a rather adverse assessment of cost-benefit".

He also points out that -

(i) No study of variation of wind speeds has so far been done. Steps should be taken to carry out measurements of hourly, daily and seasonal variations in wind speeds and to measure gustiness. A full time officer has to undertake this task or a fully automatic measuring device should be used for this purpose.

(ii) A wind survey for the whole island is recommended. Initial steps should be taken now.

(b) The following statement of the CEB authorities :-

(i) The reasons for selecting the Dunlite model was that the foreign consultants wished to go in for a proven model. This decision was perhaps influenced by the experience of another brand of windmill which was first installed on site haveing collapsed under strion wind.

(ii) As for the measured wind speeds being low, they stated that the anaemometer is presently fixed at a height of only 6 meters and not 20 meters (where the blades of the windmill are).

(iii) Steps will be taken soon to fix the annemometer at 20 meters so that the correct wind speed (which could be expected to be higher than that presently measured) could be recorded.

9.0 Some general recommendations

9.1 REC as initially conceived is a demonstration centre for South East Asia. Steps such as those listed below should be taken to exploit REC as a demonstration facility for our local expertise and achievements in the field of alternative energy.

9.1.1 We recommend that the building area for instruments, stores etc. be expanded to include a display section. small library and living quarters (simple rooms and toilets)and kitchen.

The living quarters will provide housing for scientists and engineers who will use Pattiyapola as a research facility on a "Time sharing" basis.

The display section could be allotted to the different institutions like the Universities, CISIR, NERD IIP who can display with models and poster panels the Research or R & D efforts in these institutions. Since solar energy is not the focal point of interest in the above multi - disciplinary Institutions, the visitors to the individual Institutions will not in general have "Solar Energy" as their main interest.

Visitors to REC will on the other hand have "solar energy" as their focus of interest and the type of display recommended, if intelligently executed, will give an overview of the national effort and also indicate the different R or R & D efforts of each individual institutions.

9.1.2 REC should be developed also as a demonstration centre for "decision makers" both local and foreign and should attempt to give as reliable a picture of the potential of alternative sources of energy in the local context.

9.1.3 Since research workers on solar energy may find that in the Institutions they work this area may be considered of lower priority in relation to its other more pressing functions, REC could provide a focal point for research activity. Solar devices like solar cookers, driers, stalls, flat plate collectors etc. fabricated and tested at different institutions could be installed for investigation and comparison purposes. This will also serve the demonstration aspect.

9.1.4 It appears that if the biogas generator is to function at full capacity, supplying more adequately the needs of the village, a streamlined system for the purchase of the cowdung will have to be evolved. It appears that government regulations AR, FRs, etc. may have to be relaxed if such a system is to be operated and the Ridiyagama farm be used for exigencies.

9.1.5 Scope for systematic (sociological - veterinary) studies such as the variation of cowdung supply per day per cow during normal and grazing periods are indicated from some preliminary surveys conducted by those manning the station.

9.1.6 A committee to guide the implimentation of the recommendations of this report be appointed early.

10.0 Concluding Remarks

The purpose of this report is to acquaint scientists and engineers with the REC at Pattiyapola. It has not attempted an indepth study - since it is the out come of a brief visit - but hopefully gives an overall idea for the potential or target oriented research that can emanate from this project. The spectrum of disciplines from which scientists can get involved should be apparent from this document. We could roughly demarcate the areas to fall within the categories of Basic sciences (Physics, Chemistry and Biology), Engineering and the Social Sciences.

The report has examined the biogas generator in greater detail than the other generators which are either not installed or if installed are still to be operated on a regular basis.

The experience with the Biogas generator gives an idea as to what lines the REC Pattiyapola should develop. These are contained in the recommendations of sections 8.0 and 9.0.

We would like to conclude this report by stating that we are conscious that in technical projects it is easier to plan, monitor document and criticise a project than to actually work it.

Hence, this report would only serve a useful purpose if its recommendations are supported in practical terms via expertise, manpower, funds, removal of administrative constraints and the like.

We would like to see this project prosper and similar stations multiply in other parts of the country.

APPENDIX I

(a) The letter of invitation from the "Physical Science and Engineering Panel" of the NSC to a representative group of workers directly involved or interested in non conventional alternative energy (solar, wind, biogas, etc.)

(b) Minutes of the inaugural and the subsequent meetings of the SEG (three)

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47/5, மெற்லண்ட் பிளேஸ்,
கொழும்பு 7.

NATIONAL SCIENCE COUNCIL OF SRI LANKA
47/5, MAITLAND PLACE,
COLOMBO 7.
SRI LANKA

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APPENDIX 1(a)

10th May 1979

My Ref. EP/1.1

SOLAR ENERGY

The National Science Council (NSC) has recommended that immediate action be taken to implement the proposal of the Physical and Engineering Sciences Panel of the Research Grants Board (RGB) (a Statutory Committee of the Council) to have a meeting of scientists and engineers who have shown an active interest in "Solar Energy" R & D – the term is used in the wider sense to cover energy sources as biogas, wind, ocean etc. – R & D.

The meeting will be devoid of any ceremonies and be devoted to a serious consideration of topics as –

(i) the present state of the "art" – (a) in Sri Lanka
(b) internationally
- Since at the meeting there will be many who have attended international conferences it would be useful if as much technical information and data you possess is brought along to the meeting.

(ii) The successes and limitations in respect of the work done so far.

(iii) The formulation of a possible plan for the future in terms of an integrated programme yielding (a) short term (b) long term results.

... 2/

(iv) Any immediate steps that can be taken for implementation at Rural Development level.

NOTE: Obviously all these points cannot be comprehensively covered in a 3 hour meeting but we could make a definite beginning.

If you notice any significant ommissions I shall be very grateful to be informed by return post.

Subsequent to the meeting of the Panel, a letter was received by the Chairman, NSC from the Hon. Minister of Industries & Scientific Affairs which is most relevant to the proposed meeting.

Please note that the NSC has voted funds for a visit to Pattiyapola UNEP Solar Energy Demonstration Project. Some or all of the participants can arrange to go on this trip and then contribute to a technical report. The date of the trip could be decided at the meeting.

The meeting is fixed for the 2nd of June 1979 at 8.30 a.m. at the NSC Board Room, and your presence will be much appreciated.

Yours sincerely,

Prof. P.C.B. Fernando
Chairman, Physical & Engineering Sciences Panel of the RGB
- Convenor -

P.S. 1. A Chairman for the meeting will be elected by the participants.

2. We shall be grateful if you could inform us in advance whether you would be able to attend the meeting.

Encl. List of invitees

PCBF/ms.
5/680

LIST OF PRESENT MEMBERS OF SEG.

Prof. P.C.B. Fernando	- Chairman SEG
Dr. S.A. Abeysekera	- CISIR.
Mr. L.A.C. Alles	- Marga Institute.
Prof. M. Amaratunga	- Civil Engineering Department University of Peradeniya.
Mr. Nihal de Mel	- Appropriate Technology group of Sri Lanka
Dr. P.A. de Silva	- Mechanical Engineering Department University of Moratuwa.
Dr. K.G. Dharmawardena	- Atomic Energy Authority
Mr. G.B.A Fernando	- Ministry of Finance & Planning.
Dr. S. Gnanalingam	- CISIR
Prof. J.A. Gunawardena	- Electrical Engineering Department University of Peradeniya.
Dr. Tudor Gunawardena	- Department of Highways
Mr. Kolitha Herath	- Mechanical Engineering Department University of Moratuwa.
Dr. Leslie Herath	- Water Resources Board.
Mr. A.N.S. Kulasinghe	- Chairman NERD Centre
Dr. S. Mahalingasivam	- Ministry of Finance and Planning.
Dr. P. Nugawela	- CISIR
Dr. B. Nanayakkara	- NERD Centre
Dr. C. Patuwathawithana	- Faculty of Engineering, University of Moratuwa.
Prof. K.K.Y.W. Perera	- University of Moratuwa.
Mr. D.B.J. Ranatunga	- NERD Centre
Mr. D.T. Ruberoc	-
Mr. D.S.R. Seneviratne	- Ceylon Electricity Board.
Mr. B.D. Sepalage	- Ceylon Electricity Board.
Dr. P. Sivaprakasapillai	- University of Moratuwa.
Dr. S. Sivasegaram	- Mechanical Engineering Department, University of Peradeniya.
Mr. H.S. Subasinghe	- Ceylon Electricity Board.
Mr. D.L. Taldena	- NERD Centre.
Mr. K.S. Fernando	- Water Resources Board

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APPENDIX 1(b)

MINUTES OF THE MEETING ON "SOLAR ENERGY" CONVENED BY THE PHYSICAL & ENGINEERING SCIENCES PANEL OF THE RESEARCH GRANTS BOARD OF THE NATIONAL SCIENCE COUNCIL

DATE : 02-06-1979
TIME : 8.30 a.m.
VENUE : Board Room, National Science Council

Present: Dr. S.A. Abeysekera
Mr. L.A.C. Alles
Prof. M. Amaratunga
Mr. Nihal de Mel
Dr. K.G. Dharmawardena
Mr. G.B.A. Fernando
Mr. K.S. Fernando
Dr. M.A.R.V. Fernando
Prof. P.C.B. Fernando
Dr. S. Gnanalingam
Prof. J.A. Gunawardena
Mr. A.N.S. Kulasinghe
Dr. P. Nugawela
Dr. C. Patuwathawithana
Mr. D.B.J. Ranatunga
Prof. V.K. Samaranayake
Mr. D.S.R. Seneviratne
Dr. P. Sivaprakasapillai
Dr. S. Sivasegaram
Mr. H.S. Subasinghe
Mr. D.L. Taldena

1.0 Inauguration

Prof. P.C.B. Fernando as Convenor of the meeting said that the purpose of the meeting was to consider the question of alternative sources of energy. He thanked those present for accepting the Physical & Engineering Sciences Panel's invitation and attending the meeting in spite of the adverse weather and it being a Saturday.

Election of a Chairman for the meeting

Prof. P.C.B. Fernando was elected as Chairman of the meeting.

2.0 Discussions and Recommendations

2.10 It was acknowledged by the participants that R & D on alternate sources of energy was presently being carried out independently in several organisations. Also it was recognised that the basic knowledge in this area was already available and the problem was -

(a) As a short term measure to concentrate on R & D on the less sophisticated methods with a view of effecting wide scale practical use in the context of rural development schemes etc. relevant to Sri Lanka.

(b) As a long term measure, promote research, especially in the Universities to gain experience on the more sophisticated techniques which will become useful for "Solar Energy" technology of the future (eg. Solid State devices like solar panels).

2.20 There was consensus that centralisation and formal control by a central organisation of research and R & D on "Solar Energy" conducted in different organisations like the Universities, Research Institutes, Government organisations would be detrimental just now. Sharing of experience and data be best done at an informal level.

2.30 It was recommended that where coordination of effort becomes necessary, it be done by a study group to be called a "Solar Energy Group (S.E.G.)" which could be set up and affiliated to the National Science Council (NSC) via the Physical and Engineering Sciences Panel (P.E.S.P.) of the Research Grants Board (R.G.B.).

2.31 The functions of the S.E.G. would be to provide a forum for discussion and coordinate where necessary activities of "Solar" scientists.

2.32 The S.E.G should meet at intervals of 3 months.

3.0 Extracts from a letter to the NSC Chairman from the Minister of Industries and Scientific Affairs were read out.

1. acoquaint yourself with this programme by visiting the experimental station at Pattiyapola

2. report on the activities of a similar nature undertaken by your institution so far

3. report on proposal you have formulated if any for similar programmes and extension services you propose to undertake in the future

4.0 The United Nations Environment Programme (UNEP) sponsored project for the Region set up at Pattiyapola to demostrate the utilisation of alternative sources of energy, was discussed in some detail. It was reported that the Ceylon Electricity Board (CEB) was in charge of the project and the setting up of the station is not yet complete. The present work carried out was only on biogas, and the rest of the generators will be installed in the near future.

4.10 It was suggested that in the long term interest both from a scientific view point and for economic evaluation and projections related to energy planning, reliable and accurate quantitative measurements on relevant parameters be carried out.

4.20 It was pointed out that a major obstacle for making continous, reliable and comprehensive measurements was that the project site is a considerable distance from Colombo and it is difficult to get scientists, engineers and technicians (at different levels) to work at Pattiyapola for extended periods.

4.21 The meeting endorsed that the Ceylon Electricity Board (CEB) was the most appropriate organisation to handle the administration and day to day running of the Pattiyapola project.

4.22 All present agreed to extend their fullest cooperation towards making the project a success.

4.23 It was strongly recommended that -

(i) Non-sophisticated continously monitoring instruments be used for scientific measurements

(ii) A residential station be put up to house the instruments and the research scientists and technicians working on a visiting or permanent basis. It was felt that the CEB be requested to fund the building of this station.

4.24 The participants who wished to visit Pattiyapola were requested to give their names. It was agreed that those interested would be informed of the date and other details of the trip.

5.0 The meeting recommended that the Sri Lanka Scientific and Technical Information Centre (SLSTIC) of the NSC should serve as a repository for scientific and technical literature on "Solar Energy". Reports from conferences, technical reports etc. which are not open for wide circulation be made available for reference at the Centre. The security of these documents to be ensured by the Centre.

6.0 The meeting recommended that Prof. M. Amaratunga, Mr. A.N.S. Kulasinghe and Dr. S. Sivasegaram be consulted by the PESP on matters pertaining to Biogas.

7.0 The meeting was terminated at 12.00 noon.

Rappateur

-/ms. 5/7/6

MINUTES OF THE SECOND MEETING OF THE SOLAR ENERGY GROUP

Meeting : 79-2
Date : 18.08.1979
Venue : Board Room, NSC
Time : 9.00 to 11.30 a.m.

79-02-01 **Participants:**
Prof. P.C.B. Fernando, Chairman
Mr. G.B.A. Fernando
Mr. B.P. Sepalage
Mr. A.N.S. Kulasinghe
Dr. P. Sivaprakasapillai
Dr. C. Patuwathawithana
Dr. S. Sivasegaram
Mr. G.T. Ruberoe
Dr. R. Mahalingasivam
Mr. D.B.J. Ranatunga

Excuses:
Dr. S. Gnanalingam
Prof. J.A. Gunawardena
Dr. Patrick Nugawela
Mr. S.K. Subasinghe

79-02-02 **Minutes**

Minutes of the 79-1 meeting were confirmed subject to recording that the following documents were distributed among the members by Mr. G.B.A. Fernando.

(i) The Helios Strategy: An Heretical view of the potential Role of Solar Energy in the future of a small planet - by Jerome Martin Weingart

(ii) "The application of Solar Energy in Sri Lanka" - Country paper C.O.M.E.S. Solar Energy Conference in Bangkok -- by Abeysekera, S.A., Amaratunga, Milton, Ambalavanar, V., Fernando, G.B.A., Nugawela, P., Seneviratne, D.S.R.

79-02-03 **Matters Arising out of Minutes**

The Chairman stated that it is encouraging to note that all specific action that was recommended at the last meeting had been executed.

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They are: (i) The visit to the Pattiyapola Station which was very educative and a big success

(ii) The SLSTIC having written to members soliciting information relevant to Solar Energy and in particular requesting recommendations for books to be purchased by them

Mr. Kulasinghe at this juncture expressed fears about central control of Research and Development in Sri Lanka by the NSC via compiling Bio-data on Scientists and making decisions in respect of participation at foreign seminars etc. He felt that these should be decided by relevant individual organizations like the Universities, NERD, CISIR, etc.

The Chairman stated that he himself shared Mr. Kulasinghe's fears on the potentialities of the NSC developing on lines where it effects central control. However, he stated that as a member of the NSC he could mention, that the present policy of the NSC is coordination rather than central control and explicit expression of this attitude was reflected by the Council endorsing the catalytic nature of the SEG which is an appendage of the NSC. Further it has acknowledged the necessity of decisions being made by experts in referring several matters pertaining to solar energy to the SEG.

The Chairman then referred to the question of nominations for Seminars and Training courses where nominations have to be sent within a few days, and broad consultation is not possible. If normal procedures of writing to different Institutions is followed by the NSC Sri Lanka would effectively lose these offers, since time has to be left for formalities such as obtaining Prime Minister's permission. The Chairman stated that the information solicited at the bottom of page 3 and top of page 4 of his letter of 9th August 1979 was motivated by a desire to evolve a procedure so that seminar nominations can be made quickly, spread out over more individuals, and at the same time as appropriate as possible. He further added that these nominations will apply to Solar Energy conference invitations that come to the NSC and not to individual Institutions like the CISIR, NERD, Universities etc.

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79-02-04 Seminar/Training Programme-Committee

After some discussion on the above matter (79-02-03) it was proposed by Dr. C. Patuwathawithana that a committee be formed of five members plus two reserves from the SEG membership, representative of the different organisations presently active in "Solar Energy" - term used to cover alternative sources like bio-gas etc. who could be summoned to meet at short notice, for making recommendations. The members agreed and a committee will be appointed at the next meeting.

79-02-05 Membership of SEG (Selection criteria)

The meeting agreed to adopt the procedure of any two members of the SEG proposing and seconding the name of a new member, and the membership voting on the nomination. Notice must be given sufficiently in advance to permit the nomination to be listed on the Agenda contained in the notice calling an ordinary meeting of the SEG.

79-02-06 Technical report on the Visit to Pattiyapola

Dr. C. Patuwathawithana (Convenor) and Mr. D.B.J. Ranatunga, were requested to produce a draft of the technical report. It was also agreed to confine the report to the Pattiyapola Project only. The individual reports received so far from Mr. A.N.S. Kulasinghe, Mr. D.B.J. Ranatunga and Dr. S. Sivasegaram together with any others which may come later will be handed over to them. Mr. G.B.A. Fernando tabled the following two documents which would be very useful in drafting the report.

(i) Visit of Dr. I.H. Usmani, Senior Energy Advisor, United Nations Environment Programme, 19 October 1975.

(ii) Executive Seminar of the feasibility report on the Rural Energy Centre for Pattiyapola village in Sri Lanka.

79-02-07 Election of a Secretary

The meeting decided not to elect a Secretary but to continue the present practice of an official of the NSC functioning as rappáteur.

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79-02-08 Workshop on Solar Energy to be organised by the NSC in collaboration with the US National Science Foundation in 1980

No decisions were taken on this matter.

79-02-09 Membership of the International Solar Energy Society

Mr. B.P. Sepalage stated that he is a member of this society and would furnish relevant details for the next meeting.

79-02-10 Any other business

(i) Mr. Kulasinghe gave a brief account of the work presently carried out at NERD on Solar Energy R & D and the future plans to expand its activities.

(ii) The Chairman pointed out that the ultimate objective of the SEG should be to assist in translating into practical terms the utilization of Solar Energy in Sri Lanka. He stated that if all were to recognise the fact that there is a full spectrum of activity requiring the combined action of people with different skills and levels of scientific training (eg. Basic and Applied Scientists, Engineers, Technicians, Socio-Economists, Voluntary organizations (like Sarvodaya), government schemes (like Gramodaya) etc, it would go a long way in achieving this goal. Further these activities can be done concurrently. Mr. Kulasinghe stated that he has already contacted Mr. Ariyaratne of Sarvodaya and shall be having discussions with the Prime Minister.

(iii) There was consensus that the Ruhunu University College could be a suitable institute to get directly involved in the scientific component of work connected with the Pattiyapola project. It would be of mutual benefit to the University and solar energy R & D in Sri Lanka.

Rappateur
(M.A.T. de Silva)

MATdeS/ms.
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MINUTES OF THE THIRD MEETING OF THE SOLAR ENERGY GROUP

Meeting : 80-1

Date : 19-01-1980

Venue : Board Room, NSC

Time : 9.00 a.m. to 1.30 p.m.

80-01-01 **Participants**

Prof. P.C.B. Fernando (Chairman)
Dr. S.A. Abeysekera
Mr. J.N. de Mel
Dr. K.G. Dharmawardena
Mr. G.B.A. Fernando
Dr. S. Gnanalingam
Dr. T. Gunawardena
Mr. K. Herath
Dr. S. Mahalingasivam
Dr. P. Nugawela
Prof. C. Patuwathavithana
Prof. K.K.Y.W. Perera
Mr. D.B.J. Ranatunga
Mr. B.P. Sepalage
Dr. P. Sivaprakasapillai
Prof. S. Sivasegaram
Mr. H.S. Subasinghe

Excuses

Prof. M. Amaratunga

80-01-02 **Minutes**

The minutes circulated earlier were approved without amendments.

80-01-03 **Matters arising out of minutes**

Commenting on item 79-02-05 of the previous meeting Mr. G.B.A. Fernando said that all members should initially present their credentials in relation to their association with studies on Energy. However, it was pointed out that such a requirement was not necessary for the present membership, since they have all been invited to be members by virtue of their known association with Energy studies. The Chairman further explained that the National Science Council has fully endorsed the manner in which work was initiated in the SEG and the turn out at meetings held on Saturday mornings was further indication of the genuine interest of the members.

It was agreed after some discussion that there was no need to call for credentials from the existing membership. However, in future when new memberships are being considered the stipulations of item 79-02-05 of the second meeting will apply, with the member proposing a new name supporting the application with relevant information.

Dr. Gnanalingam said that since the SEG is an advisory body to the NSC all new nominations for membership in this group should be endorsed by the Council.

Prof. C. Patuwathavithana proposed that a formal register of membership be compiled up to date.

80-01-04 Enrollment of new members - Mr. G.K. Upawansa

The nomination of Mr. G.K. Upawansa, Officer In Charge, In-service Training Institute, Gannoruwa, was proposed by Prof. C. Patuwathavithana, seconded by Dr. K.G. Dharmawardena and unanimously approved by the SEG.

80-01-05 A proposal that a member who absents himself on three consecutive meetings without an excuse to be removed for membership

The Chairman explained that the purpose of this resolution was to have in membership only those who would continue to be genuinely interested in the subject of Solar Energy (defined in the widest sense). This proposal was unanimously approved by the members.

At this stage a letter sent by Mr. G.T. Ruberoe informing of his resignation from NERD Centre was read. In his letter he had also stated that he would wish to continue his association with the SEG. Since membership in the SEG was not given on the basis of the institution he belonged to but on his individual interest, it was unanimously agreed that Mr. Ruberoe could continue to hold the membership. It was decided that this principle could be applied in future cases too.

80-01-06 Ratification of the Draft Report on the 'Rural Energy Centre REC, Pattiapola' - prepared by Prof. P.C.B.Fernando, Prof. C.Patuwathavithana and Mr. D.B.J. Ranatunga

The Chairman apologised for the delay in presenting this report to the group, which he said was mainly due to the difficulty of finding time and opportunity to meet, and the difficulty of obtaining the relevant data.

The report was considered clause by clause by these present and all relevant amendments, ommissions, corrections which were approved were incorporated.

It was decided that the appendix 3(b) would be the summary of Dr. H.J. Allisons (Oklohoma State University) Report on the Feasibility of a Rural Energy Centre in Sri Lanka (1976) if such exists in the report, together with an indication where the copies of the report are available. Mr. G.B.A. Fernando was also requested to provide a statement of events which took place between Appendices 3(a) and 3(b).

Prof. K.K.Y.W. Perera, Mr. H.S. Subasinghe and Mr. B.P. Sepalage of the CEB provided the basic data on the equipment and instruments used at the REC. They also supplied the document "Report of the Socio-Economic Survey - Pattiapola Village, Hambantota District 1977" compiled by the Government Agent Hambantota District, for the Appendix of the Report.

It was decided that the Final Report with the necessary additions and amendments incorporated, should be submitted to the NSC for approval before presenting to the Minister of Industries & Scientific Affairs..

80-01-07 <u>Letter addressed to the Chairman, SEG by Mr. G.B.A.Fernando, on a proposal from CEB regarding the establishment of a Solar Energy Institute for Sri Lanka within the CEB</u>

The Chairman introducing the subject said that this letter was addressed to him by Mr. G.B.A.Fernando in his official capacity as Assistant Director (Planning), Ministry of Finance and Planning. Since a reply had to be sent early, the position of the SEG on this matter as specifically reported in the minutes of the group were communicated to Mr. G.B.A. Fernando, through the Secretary General, NSC. The group endorsed the reply sent by the Chairman.

Prof. K.K.Y.W.Perera, Chairman of the CEB explaining the position of the CEB in this matter, said that the project proposal was initiated by the Secretary, Ministry of Power and Highways with the hope of getting financial assistance

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from a foreign agency. Although the project proposal names the CEB as the implementing and managing authority, this arrangement was mostly to get the project off the ground. He further said that the CEB had no objection to any other institution or authority handling the implementation of this project.

Mr. Ranatunga said that the NERD Centre was also engaged in studies on Solar Energy, and therefore it would not be satisfactory to establish such a centre under an existing organisation.

The Chairman pointed out that the time was almost 1.30 p.m. and this proposal is too important an issue to be taken up at the tailend of a meeting. He suggested and the members agreed that a meeting be summoned in two weeks time to examine the proposal in respect of the setting up of an Authority or Institution for "Solar Energy"

80-01-08 Royal Society Esso Awards

Prof. Fernando explained that the SLAAS had written to him in his capacity as the Chairman of the SEG to nominate a suitable candidate for the above award, which is offered annually to a person or group of persons, whose work have contributed to the conservation or more efficient utilization of energy. After a short discussion the meeting agreed to recommend Prof. J.C.V. Chinnappa for this award.

80-01-09 SEG REPORT IMPLIMENTATION COMMITTEE

The members who were from the CEB Prof. K.K.Y.W.Perera, Mr. H.S. Subasinghe and Mr. B.P. Sepalage requested that a committee be appointed to guide the implementation of the Pattiyapola Report recommendations. This item was also postponed for the next meeting.

80-01-10 The meeting terminated at 1.30 p.m.

M.A.T. de Silva
Rappateur

MATdeS/mc - 49

APPENDIX II

List of participants who visited Pattiapola on 14 July,1979

APPENDIX 2

List of participants who visited Pattiapola on 14th July, 1979

1.	Prof. P.C.B. Fernando	University of Sri Jayewardenepura
2.	Dr. C. Patuwathavithana	University of Moratuwa
3.	Prof. M. Amaratunga	University of Peradeniya
4.	Mr. G.B.A. Fernando	Ministry of Finance and Planning
5.	Dr. S. Sivasegaram	University of Peradeniya
6.	Mr. Kolitha Herath	University of Moratuwa
7.	Mr. H.S. Subasinghe	Ceylon Electricity Board
8.	Mr. D.S.R. Seneviratne	Ceylon Electricity Board
9.	Mr. B.P. Sepalage	Ceylon Electricity Board
10.	Dr. R. Mahalingasivam	Ministry of Finance and Planning
11.	Dr. P. Sivaprakasapillai	University of Moratuwa
12.	Mr. J.N. de Mel	Appropriate Technology Group
13.	Mr. D.L. Taldena	NERD Centre
14.	Dr. P.A. de Silva	Ceylon Steel Corporation
15.	Mr. M. Nallaiah	NERD Centre
16.	Mr. D.B.J. Ranatunga	NERD Centre
17.	Dr. B. Nanayakkara	NERD Centre
18.	Dr. S. Weerarathna	NERD Centre
19.	Mr. P.A.S. Fernando	NERD Centre
20.	Mr. I.S. Jawahir	NERD Centre
21.	Mr. N. Buhari	NERD Centre
22.	Mr. V. Jegan Mohan	NERD Centre
23.	Mr. L.L.C. Silva	NERD Centre
24.	Mr. B.J.M. Cooray	NERD Centre
25.	Mr. Ediriweera	NERD Centre
26.	Mr. M.A.T. de Silva	National Science Council
27.	Miss. P.E. Juriansz	National Science Council
28.	Mr. N. Anbalagan	National Science Council
29.	Mr. T. Wijesinghe	National Science Council

APPENDIX III

(a) Report on the visit of Dr. I.H. Usmani, Senior Energy Advisor UNEP to Sri Lanka on 19 October 1975 and the Proposal of the United Nations Environment Programme to establish a Rural Energy Centre in Sri Lanka (submitted by Mr. G.B.A. Fernando, Assistant Director, Ministry of Finance and Planning)

(b) Relevant correspondence on the subject in chronological order (submitted by Mr. G.B.A. Fernando, Assistant Director, Ministry of Finance and Planning)

(c) Final Feasibility Report - "An Energy Centre in Sri Lanka" - by H.J. Allison etal of Oklahoma State University

(d) Executive Summary of the Feasibility Report on the REC for the Pattiyapola Village in Sri Lanka - I.H. Usmani - 5 August 1976 (submitted by Mr. G.B.A. Fernando, Assistant Director, Ministry of Finance and Planning)

(e) Copy of Agreement between Sri Lanka and UNEP on the Establishment of the REC at Pattiyapola

NA-48-3

Visit of Dr. I.H. Usmani

Dr. I.H. Usmani, Senior Energy Adviser, United Nations Environment Programme arrived in Sri Lanka on 19 October, 1975.

20th October 1975.

He met the following officials at the Board Room, 5th Floor, Central Bank Building 2, Ministry of Planning & Economic Affairs:

1. Mr. N.Sanmugaraja, General Manager, Ceylon Electricity Board.
2. Mr. C.E. Karunatilleke, Deputy General Manager, Ceylon Electricity Board.
3. Mr. P.B.N. Fernando, Chief Engineer, (Generation) Ceylon Electricity Board.
4. Mr. T.Sivathasan, Engineer (Systems Planning), Ceylon Electricity Board.
5. Prof. U.S. Kuruppu, President, Katubedde Campus, University of Sri Lanka.
6. Dr. P.A.de Silva, Senior Lecturer in Mechanical Engineering Katubedde Campus, University of Sri Lanka.
7. Mr. K.Herath, Senior Lecturer in Mechanical Engineering, Katubedde Campus, University of Sri Lanka.
8. Dr. S.Sivasegeram, Senior Lecturer in Engineering, Peradeniya Campus, University of Sri Lanka.
9. Mr. S.Sivathasan, Assistant Director, Ministry of Irrigation Power & Highways.
10. Miss. S.R. Paranavitarana, Assistant Director, Ministry of Planning & Economic Affairs.
11. Mr. V.Ambalavanar, Deputy Director, Ministry of Plan Implementation.
12. Mr. M.M. Pillai, Director, Ministry of Plan Implementation.
13. Mr. K.H.S. Gunatilaka, Colombo Port Commission.
14. Mr. G.V. Gunawardena, Deputy Director (Planning), Irrigation Department.
15. Mr. P.U. Ratnatungem Member, Water Resources Board,
16. Mr. S. Arumugam, Member, Water Resources Board.
17. Mr. E. Carlo Fernando, Engineer, Water Resources Board.
18. Mr. S. Sivasubramanium, Divisional Irrigation Engineer, Department of Irrigation.
19. Mr. D.L.O. Mendis, Deputy Director, Regional Development Division, Ministry of Planning & Economic Affairs.
20. Mr. G.B.A. Fernando, Assistant Director, Ministry of Planning & Economic Affairs.

Dr. I.H.Usmani explained the purpose of his visit to Sri Lanka to the officials present. He said that about 800 million people living in the third world in Asia in Africa and in Latin America do not have the basic energy needs for living. Even the current plans for rural electrification may take a very long time to meet their needs.

The increase in oil prices have made it even more difficult to meet their basic energy needs. Their lot can be improved by providing cheap alternative energy sources for cooking and lighting.

The United Nations Environment Programme is therefore of opinion that Rural Energy Centres to demonstrate how to harness Solar Wind, and Biogas Energy should be established in Asia, in Africa and in Latin America.

Such a model will be established by the United Nations in each of the three Continents to prove that those sources of energy could be harnessed to meet the basic needs of the rural poor in the third world.

He has come to look into the feasibility of establishing such a demonstration plant in Sri Lanka. The Government of Sri Lanka has already expressed their willingness to have such a centre in Sri Lanka. It was observed that 8.7% of homes in Sri Lanka use electricity while 91% of homes use oil for lighting and about 30% of homes use oil for cooking food in the urban areas.

He was interested in seeing some village sites having the best wind regime, plenty of sunshine and availability of agricultural and animal wastes for the establishment of the Rural Energy Centre. The villages to be visited should be far removed from the national electric power grid and have a small population of about 50 - 200 families.

Mr. Arumugam of the Water Resources Board said that areas with plenty of sunshine were the Mannar and Hambantota districts. Under - ground water was available in the Mannar district but not in certain areas in the Hambantota district.

Mr. Sanmugaraja of the Electricity Board mentioned that the Mannar area is likely to be served by the growth of the electricity grid in the near future.

The data available on wind speeds indicated the largest annual average wind velocity prevalent in Hambantota.

Dr. Usmani was pleased with the wind regime and availability of sunshine in Hambantota as mentioned in the data provided.

Mr. Ranatunga of the Water Resources Board then described in detail the suitable areas in the Hambantota district having underground water resources and areas with agricultural and animal wastes. The existence of a wind mill at Bogabapelessa was also mentioned.

Dr. Usmani expressed his wish to see the sites at the Hambantota District to assess the availability of Solar, Wind and Biogas Energy in these areas. He wished to see places in order to be satisfied that there are areas where the basic energy needs of the people could be met by the harnessing of Solar, Wind and Biogas Energy resources. He felt that there are such areas in Sri Lanka. The next step would be to send Professor Allison from the University of Oklahoma for about a month from around the third week of November with his team of University Researchers who would look into the suitable sites in greater detail to establish the Rural Energy Centre. All foreign exchange costs would be met by the UNEP and the local costs of U.N. experts would be reimbursed by the UNEP. The Sri Lanka Government would be expected to meet the local costs of land and building and of Ceylonese participation.

For this purpose, an agreement would have to be reached between the UNEP and the Sri Lanka Government.

The Demonstration Plant would be the model for Asia and many visitors would come to see it.

Once the demonstration plant is shown to be a success, the local needs in areas where there are demands for any of the three components could be met by Ceylonese enterprise. Solar, Wind and Biogas plants may be manufactured after scaling down costs by using local material wherever possible. It should be clear that this would be the next stage.

The Rural Energy Centre in Africa would in all probability be located in the Sahelian desert and the one in Latin America would be in the Carribean Islands. He estimated that the energy needs of about 40 dwellings with around 200 people could be met by a plant of about 30 KW power. A feasibility report on the use of these non-conventional energy resources in a few selected villages would be welcome. If the report shows promise of economic development it is possible to obtain United Nations assistance. He expressed his interest in meeting officials from the Meteorology Department, Irrigation Department and the Agriculture Department in the next few days. The meeting terminated at about 12.30 p.m.

03.45 p.m.

Dr. Usmani had discussions with Mr. Leelananda de Silva, Senior Assistant Secretary, Ministry of Planning and Economic Affairs on his mission. He expressed his wish to pay his compliments to the Prime Minister and other Ministers of the Rural Energy Centre should be in the hands of an organisation which has already built an infrastructure in engineering facilities and mentioned that in his opinion the Ceylon Electricity Board should be asked to execute the project.

Tuesday, 21st October.

09.00 a.m.

Dr. Usmani Visited the Katubedde Campus where he had discussions with the President, Prof. U.S.Kuruppu, the Dean, Prof. Sam Karunaratne and senior lecturers Dr. P.A.de Silva and Mr. K. Herath. He visited the workshops where he saw the efforts made to develop a Battery powered vehicle, Solar energy collectors and a devise to pump water that can be connected to a wind mill.

He saw mary possibilities for technological improvement could be achieved quickest by allowing the best Ceylonese students to be placed in Institutes in advanced countries where they will first assimilate the work that is being done in the advanced countries. Once they come back, they should adopt themselves to local conditions by attempting to devise equipment with local materials.

He was interested in seeing the developing countries attaining technological improvement and would be glad to give whatever assistance is necessary. He felt that the Campus could be made into a centre of excellence with the nuclei being formed by students who have been trained in the best institutes in the developed world. For this purpose the U.N. could help in the placement of students and provide the financial assistance.

10.30 a.m.

Although Dr. Usmani arrived at the Department of Meterology he could not meet Mr. K.D.N. de Silva Deputy Director as Dr. Usmani had to keep to another appointment.

11.15 a.m.

Dr. Usmani met Mr. N. Sanmugaraja, the General Manager of the Ceylon Electricity Board in his office. He familiarised himself with the electrical power position in Sri Lanka and wished that the institution that should execute the Rural Energy Centre is the Electricity Board. Assuming that all homes in Sri Lanka would need electricity for lighting purposes, as a theoretical exercise, it becomes clear that the total hydro power potential in Sri Lanka even if completely harnessed would fall short of the requirements by a large factor. Power plants of about 500 MW from non hydro resources would be needed to supplement hydro power plants to meet even these basic needs.

Solar, wind and biogas plants in areas where there is no electricity would light up these homes using locally available material. Expansion of the grid net work and infrastructure necessary to bring the electricity to all the homes from a central grid could be more costly. He was thinking in terms of a plan that would take about 10 years to implement.

12.45 p.m.

Dr. Usmani, accompanied by Mr. Leelananda de Silva and Mr. G.B.A. Fernando met the Hon'ble Mr. Maitripala Senanayake, Minister of Irrigation, Power and Highways.

Dr. Usmani explained the purpose of his visit to Sri Lanka. He said that the United Nations wishes to establish a Rural Energy Centre in Sri Lanka to demonstrate that Solar, Wind and Biogas Energy could be utilised to meet the basic energy needs for lighting and cooking in the rural villages. This demonstration plant would be the Asian Centre and would attract people from many countries. The Government of Sri Lanka has already agreed to this project in principle.

He wished that the executive body handling this centre should be the Ceylon Electricity Board which comes under the Minister. The Minister said that it would not be difficult to arrange this.

Dr. Usmani said that he was very keen in starting on this project as early as possible and without any delays. Dr. Usmani added that he could have only one demonstration plant, and therefore it can be installed only in one place.

Dr. Usmani was told that there would be no difficulties in starting on the project without delay.

Dr. Usmani added that he had made a few calculations and found that if electricity were to be used for lighting purposes in all Ceylonese homes, the 1500 MW of hydro power potential of Sri Lanka would not be enough to meet these needs. These resources would have to be supplemented by other energy sources. Ocean thermal differences is not yet a proven technology. The utilisation of Solar, Wind and Biogas in areas that are not served by the electricity board could bring light into these homes at an earlier date, using locally available sources.

Dr. Usmani said that the United Nations Environment Programme would meet all foreign exchange costs and reimburse the costs spent on their experts. The Ceylon Government is expected to bear the cost of land, buildings, and of the Ceylonese counterparts. Ceylonese participation is expected. Dr. Usmani then thanked the Minister for Irrigation, Power and Highways for granting him an opportunity for paying his respects.

04.30 p.m.

Interview with Mr. Dayananda de Silva of the Sri Lanka Broadcasting Corporation for broadcast over the Radio.

05.30 p.m.

Dr. Usmani addresses the Sri Lanka Association for the Advancement of Science on the Role of the Scientist in Economic Development with special reference to energy at the Auditorium of the Irrigation Department. Mr. D.L.O. Mendis President of Section 'C' presided and then called upon Mr. G.B.A. Fernando to chair the meeting.

Dr. Usmani mentioned that Scientists who return to the country after their academic attainments should be prepared to apply themselves to the needs of their home countries in the local environment. Otherwise their academic attainments are of no value.

Economists evaluate the progress of a country in terms of her Gross National Product. They would be satisfied if, at the end of the year, the G.N.P. has grown by a few per cent. He has found another method of evaluating the economic development of a country. His measure is the number of trained scientists and technicians, the country possesses. Population was not a problem for development. Holland is only a third of Kenya in size and has three times Kenya's population but Holland enjoys a higher standard of living. If the population density in the U.K. is introduced into the U.S.A., the entire world can be accommodated in the U.S.A.

Dr. Usmani continued to speak at length to the attentive audience for over an hour after which he answered many questions. There were requests that he should give another Public Lecture before he leaves S Sri Lanka.

Mr. Tilak Wijesinghe of the S.L.A.A.S. proposed vote of thanks.

On an invitation by Mr. Justin Samarasekera, President elect of the Sri Lanka Association for the Advancement of Science, Dr. Usmani and a few others adjourned to the Sinhalese Sports Club for a few drinks.

Those who accompanied Dr. Usmani to the S.S.C. were Mr. Justin Samarasekara, President Elect, S.L.A.A.S., Mr. G.B.A. Fernando, Mr. N.Sanmugarajah, G.M., C.E.B. Mr. D.P.Chandrasinghe, Consulting Engineer, Mr. Tilak Wijesinghe and Mr. John Diandas, Accountant.

Wendnesday, 22nd October.

Dr. & Mrs. I.H.Usmani, accompanied by Mr. G.B.A. Fernando left for Kandy at about 9.30 a.m. Lunch at Kandy was at the Kandy Club on the invitation of Mr. Justin Samarasekera, President Elect of the S.L.A.A.S.

Thereafter Dr. Usmani met the Director of Agriculture Dr. Abeyratne who is also the President of the S.L.A.A.S. Dr. Abeyratne was busy with an official from the World Bank and expressed his wish to meet him at some othertime for a lengthy discussion. An appointment was made to meet Dr. Usmani in Colombo on Friday afternoon. Thereafter Dr. Usmani visited the Faculty of Engineering in the University and saw the work that was being done in Solar, Wind and Biogas. Dr. Usmani was impressed by the location of the Peradeniya Campus and paid tribute to the designer of the Campus.

Dr. Usmani then proceeded to Nuwara Eliya where he saw the tea growing areas and then, through Hatton, arrived at the Castle reigh circuit bungalow where he was a guest of the General Manager of the Ceylon Electricity Board Mr. N.Sanmugaraja.

Thursday, 23rd October.

Dr. Usmani met the Government Agent, Hambantota District, Mr. H.V.K.K. Weeragoda after lunch. Dr. Usmani explained his mission to the Government Agent and had discussions with him on possible sites.

The Government Agent mentioned that at the site of the Windmill at Bogahapelessa about 1000 inhabitants were living without facilities for drinking in bowsers to these areas daily. It costs the Government about Rs. 1,100,000 anually to provide the water services.

Dr. Usmani considered the possibility of disalating brakish Water for the inhabitants in these areas. He also mentioned the possibility of using solar and wind energy for fertiliser plants with an output of about 10 tons per year which could serve the needs of a locality.

Although desalination of water for drinking purposes was a possibility, the desalination of water for irrigation purposes could be very costly.

Dr. Usmani mentioned that the site he had seen near the 52nd mile post on the A18 near Nonagama had plenty of agricultural wastes like straw, paddy husks and cowdang and had no channel water and was away from the electricity grid. The few rice milling machines were run on oil. This village had the ingredients he was looking forward to although he was not certain of the wind regime. He was keen on a site with a good wind regime.

Having seen the sites he said that one should be clear about the problems of Sri Lanka and the mission he has come on.

He felt that the problems of providing water to the inhabitants at Bogahapelessa in essentially a problem of the Sri Lanka Government, If Sri Lanka were to make a request to the United Nations, the United Nations would certainly look into the problem and would be willing to help.

But one has to be clear on the mission that he has come and should not mix issues.

His mission is a request by the United Nations to establish a demonstr tion plant in Sri Lanka for Solar, wind and Biogas energy. This request has been favourably looked into by the Sri Lanka Government and he has come here to see the possibility of locating a site. He would only give the paramaters he is looking forward to at the site, but would leave the selection of the site to the Sri Lanka Government.

The demonstration plant would be the model for Asia and therefore will attract many visitors. It should also be in a place that could be visited by as many people as possible in Sri Lanka so that they could copy the model for their own uses after scaling down costs by using local materials. His wish is to have a successful demonstration plant for all Asia to copy, where So lar, wind and Biogas energy could be used by the rural poor in the third world to meet their basic energy needs.

He would be sending Professor Allison from the University of Oklahoma around the third week of November. Prof. Allison would spend about a month in Sri Lanka. He hoped that data on possible sites would be made available to Prof. Allison when he comes.

The windmill at Bogahapelessa was a comet type 12 ft. in diameter, 45ft. high and was expected to lift 10 gallons of water per minute. The water table at that spot was at 13ft.

The windmill had enough power to lift water by 4ft. and pump it at 15 gallons per minute at wind speeds of about 6 mpg. The party then adjourned to the Tissa Resthouse, where he was a guest of the Government.

Friday, 24th October

Dr. Usmani accompanied by the Government Agent visited the site near the 52nd mile post on the A - 18 as a possible site for the demonstration plant. Dr. & Mrs. Usmani accompanied by the G.B.A.Fernando then returned to Colombo taking the coastal route.

Dr. Usmani pointed out other sites on his way back to Colombo that had strong wind regimes. One such site was at Maddawatte at the 102 mile post between Dondra and Matara.

3.00 p.m.

Dr. Usmani had discussions with the Director of Agriculture, Dr. Abeyratne who is also President of the Sri Lanka Association for the Advancement of Science.

5.00 p.m.

Dr. Usmani met officials from the Meteorology Department, Water Resources Board, Ceylon Electricity Board, Irrigation Department and the Ministry of Planning & Economic Affairs at the Hotel Intercontinental Those present were Mr. K.D.N. de Silva, Mr. P.V.Ratnatunge, Mr.S.Arumugam Mr. N. Sanmugaraja, Mr. S.Sivasubramanium, Mr. J.Dinadasa, Mr. Justin Samarasekera and Mr. G.B.A. Fernando.

Dr. Usmani mentioned that he came to Sri Lanka with the view to establish a Rural Energy Centre in Sri Lanka to demonstrate that Solar, Wind and Biogas energy could meet the energy needs of a rural village in the third world. Having seen some sites, he is satisfied that the Centre could be established in Sri Lanka. He has already mentioned the parameters he is looking forward to at the sites. He would leave the selection of the site to the Sri Lanka Government. The United Nations would meet all Foreign Exchange Costs and would reimburse the monies spent on experts who arrive in Sri Lanka for the project. The Sri Lanka Government is expected to provide the site and meet the cost of building and local expenditure. Ceylonese Scientists are expected to participate in the project. For this purpose and agreement would have to be reached between the United Nations and the Sri Lanka Government. Professor Allison and his team from the University of Oklahoma along with Ceylonese Scientists would establish the centre. This centre would become the demonstration model for Asia and would have several visitors. The latest available techniques would be used.

Once this is shown to be a success, areas in Sri Lanka that could benefit from any one of these components, Solar, Wind and Biogas could copy and multiply such plants after scaling down costs to meet local requirements.

In selecting a site, he would very much wish the Meteorology Department to conduct investigations on wind velocity and Solar energy input at the possible sites. The latest instruments could be provided for this purpose by the United Nations.

He spoke of the possibilities of producing fertiliser from these sources of energy. The Nitrogen would come from the atmosphere, the hydrogen from water and the carbon from paddy husks and straw. A plant could produce about 10 tons of fertiliser a year which could meet the needs of about 300 acres of cultivated land. Then one such plants may be installed.

In Egypt, he said that a series of windmills have been planned to be installed on Electric Transmission posts. The energy collected by these windmills could add electricity at the same frequency and voltage as that passing on the lines using a small device. This may be treated as a bonus.

He had seen a suitable site at Hambantota near the 52nd mile post on the A - 18 near Nonagama and another at Maddawatta near the 102 mile post between Dondra and Matara. He was looking forward to a place with a strong wind regime.

He was sorry that Mr. Leelananda de Silva of the Ministry of Planning & Economic Affairs was not present as he wished to put forward his views to the Government. As the only official from the Ministry of Planning & Economic Affairs present was Mr. G.B.A. Fernando, he hoped that the proposals he had made would be communicated to the Government by Mr. Fernando.

The Proposal of the United Nations
Environment Programme to Establish
A Rural Energy Centre in Sri Lanka

The increase in price of oil in 1973 has made many countries and international organizations reassess their energy requirements and reduce their dependence on a sources of fuel that is gradually depleting in the world.

It has been observed that the availability of cheap oil has lead many countries to industrialize, provide cheap transport, and facilitate domestic services in lighting, cooking, and in the heating and cooling of buildings.

Whilst major economic progress has taken place in the developed countries in the past few decades, the economy of the developing countries has remained stagnant over this period for no fault of their own.

About 800 million people living in Asia, in Africa and in Latin America do not have the basic energy needs for living. Even the current plans for rural electrification may take a very long time to meet these needs.

Scientific and technological progress is taking place to day to utilise alternative sources of energy. Rapid progress is taking place in harnessing Solar Energy whilst renewed interest is shown in Wind Energy and Biogas. The United Nations would have access to the latest techniques in these fields.

The geographical location of the developing countries in Asia, in Africa and in Latin America is such that these are the areas that would benefit most by the development of Solar Energy resources.

The United Nations Environment Programme is therefore of opinion that Rural Energy Centres to demonstrate how to harness Solar, Wind and Biogas Energy should be established in Asia, in Africa and in Latin America.

Such a model will be established by the United Nations in each of the three continents to prove that these sources of energy could be harnessed to meet the basic energy needs of the rural poor in the third world.

The United Nations Environment Programme is of opinion that the Asian Centre should be established in Sri Lanka The Government of Sri Lanka has accepted the proposal in principle.

The Senior Energy adviser of the UNEP, Dr. I.H. Usmani has been in Sri Lanka to look into the feasibility of such a project.

Background of Dr. I.H. Usmani

Dr. I.H. Usmani from Pakistan graduated at the age of 18 years, obtained an M.Sc. at the age of 19 years and a Ph.D in Atomic Physics from the Imperial College of Science and Technology in London at the age of 22 years in 1939. He then entered the Indian Civil Service where he served in several posts.

He was Chairman, Pakistan Atomic Energy Commission during 1960 - 1972. He was responsible for introducing Nuclear Power in Pakistan and for building a number of research institutes and laboratories. He has been Secretary to the Ministry of Science and Technology, Government of Pakistan. He has been Chairman of the Board of Governors of the International Atomic Energy Agency in Vienna from 1962 to 1963. He has been a President of the Pakistan Association for the Advancement of Science. He is presently Senior Energy Adviser, UNEP. In his address as outgoing Chairman of Pakistan Atomic Energy Commission he stated :-

"There has been some loud and harsh criticism against the so called lavishness of the expenditure on the buildings of our centres and projects, particularly PINSTECH and KANUPP. I do plead guilty to this charge that we have not followed the PWD standard because we are too poor to afford that luxury. I also plead guilty to the charge that I have been personally responsible for sprinkling in our centres a bit of art, a bit of landscaping and a bit of beauty so that they have become in the real sense 'Centres of Excellence' - centres in the making and working of which the artistes, the masons, the craftsmen, the scientists and the engineers of Pakistan have given their best. Why should only the Mausoleums, Mazars, Mosques and the Secretariat be prestigeous and not the Science Laboratries?"

Observations of Dr. Usmani

1. The ingredients necessary for the establishment of the Rural Energy Centre are available in Sri Lanka.

2. Sri Lanka has plenty of untapped hydro-power resources. She should establish an active Research and Development Centre for Hydro logical studies in order to maximise the utilisation of Hydropower resources. This would help Ceylonese to design Hydropower Schemes and reduce the foreign exchange component in hydro projects.

3. Only 8.7% of Sri Lank homes use electricity for lighting while 91% of Sri Lanka homes burn kerosene oil for lighting.

. Inquiries from typical rural homes revealed that a home consumes about 1 bottle of kerosene oil per day for lighting purposes. ½ a million tons of kerosene oil is consumed in Sri Lanka in one year.

4. If electric lighting were to be provided to all Sri Lanka homes even the complete utilisation of the hydropower potential would not be sufficient to meet these needs. Power plants of about 500 MW would be needed to supplement hydropower to meet these basic needs.

5. Fluorescent lamps should be introduced instead of the normal bulbs. They produce more light and consumes less electricity (only a third). He has in mind some circular types of fluorescent lamps that would be suitable.

6. Wind mills can be installed on the top of electrical transmission lines. By a suitable devise, the energy can be transformed into electricity at the same frequency and voltage as that passing through the electric lines. This could supplement the electric power.

7. Cottage industries could be introduced to homes with electric power. It would provide employment to people who would otherwise idle in their homes. Many industries could grow using manpower presently idling at homes.

8. In areas where the electricity grid is unlikely to generate, Solar, Wind and Biogas energy could be utilised to meet the basic energy needs of the rural poor.

9. Urea $\left(\begin{array}{l} CO\ NH_2 \\ 1 \\ CO\ NH_2 \end{array} \right)$ could be processed using nitrogen (N_2) from the air, Hydrogen (H_2) from water, Carbon (C) from paddy husks and straw and energy from the sun.

About 10 tons of urea may be processed annually. This fertiliser would serve any locality of about 300 acres or more of land under cultivation. If one plant is a success, many such plants may be installed. If this scheme is a success, the production of fertilizer from an oil based raw material like naptha may be eliminated.

10. Oil consuming omnibuses, in urban as well as sub-urban areas, are very popular. It is now possible to operate battery powered buses having a range of 60 miles. A normal urban bus route does not exceed 60 miles. It is therefore possible to have battery service stations at the bus termini and replace the oil operating system by a battery powered system. Such a system would then be serviced by hydro-electricity.

11. The Railways could be electrically operated and made more attractive to travel.

12. There are possibilities of improving the level of technology at the University Campuses. It is necessary to place the leading research workers in touch with the best institutes in the developed world. On their return they should use their experience to devise machin that could be made with locally available material.

13. Paddy husks, straw, tea refuse and possibly coconut husks along with cow-dung may be used to produce methane gas. The residue left would be richer in nitrogen content. The raw material may be used for fertiliser manufacturing and the production of oil.

14. If a feasibility report on the use of non-conventional energy resources to improve the economic conditions of a rural village is submitted; assistance for the project by the United Nations could be considered.

15. The Rural Energy Centre should be executed by a body which has already an infrastructure in engineering facilities. The Ceylon Electricity Board should in his opinion be asked to execute the project.

16. Ocean thermal differences is not yet a proven technology.

17. Population is not a problem for development. He compares Holland with Kenya.

18. The provision of drinking water to the inhabitants of Bogahapelessa is a problem for the Sri Lanka Government. Desaliration of water for drinking purposes may be possible but for irrigation purposes it could be expensive. Deep drilling for water below the bed rock at about 150 ft. could be a possibility. If Sri Lanka were to make a request to the United Nations for assistance in this project, it could meet with a favourable reply. Presently the Government spends Rs.1,00,000 per annum to provide the water services to the 1000 odd inhabitants at Bogahapelessa.

19. A site near the 52nd mile post on the A 18 near Nonagama had plenty of agricultural wastes like straw, paddy husks and cowdung and had no channel water. It is away from the electricity grid. It has sunshine but he was not certain of the wind regime. The rice milling machines presently run on oil, could be electrically driven.

Another site at Meddewatta near the 102nd mile post between Matara and Dondra had a strong wind regime and is also suitable.

20. As the Rural Energy Centre is a demonstration plant, it should be sited at a place accessible to the general public in Sri Lanka so that as many people could visit the site. It should therefore be not far removed from the populace.

21. It is expected that by the time Prof. Allison of the University of Oklahoma arrives in Sri Lanka around the third week of November, a series of sites would be considered in order that one may be chosen.

22. Dr. Usmani would be at Pakistan in December on home leave. He could then visit Sri Lanka during the SLAAS Annual Sessions if an invitation is extended by the SLAAS.

23. Once the demonstration plant is shown to be a success, areas that would use any one of the 3 components, Solar, Wind and Biogas could copy the model after scaling down costs using locally available material, by Ceylonese enterprise.

24. It is possible to use the plant when Wind Energy and Solar Energy are alternatively available. During monsoons, wind energy could be used. At other times Solar Energy could be tapped.

25. A series of refridgeration plants run on Solar Energy could be installed around the coast to preserve fish, fruit and vegetables.

26. A Scientific Service should be established in Sri Lanka.

Proposals of Dr. I.H. Usmani

Dr. I.H. Usmani wishes to place the following proposals before the Government of Sri Lanka :-

1. The United Nations Environment Programme wishes to establish a Rural Energy Centre in Sri Lanka for Solar, Wind and Biogas energy.

2. The Rural Energy Centre would be the demonstration model for Asia where it would demonstrate that Solar, Wind and Biogas energy could utilised to meet the basic energy needs of the rural poor in the third world.

3. The selection of the site would be left to the Sri Lanka Government.

However, the site should have a lot of sunshine, a good wind regime and plenty of agricultural and animal wastes. It should also be away from the electricity grid. All details he is looking forward to have been explained to Mr. G.B.A. Fernando. As it is a demonstration plant, it should be accessible to the general populace of the country.

4. The UNEP would meet all foreign exchange costs. The local costs of the U.N. Experts would be reimbursed by the UNEP.

Sri Lanka should provide the land and meet the local costs of buildings. Participation by Ceylonese Scientists is expected. For this purpose an agreement should be reached between Sri Lanka and the UNEP.

5. In order reduce administrative formalities, and thereby implement the project speedily, Dr. Usmani prefers to communicate with Sri Lanka's Permanent Representative to the United Nations at New York who could communicate direct with the officer dealing with the Rural Energy Centre at the Ministry of Planning and Economic Affairs or at the site.

6. Prof. Allison and his team from the University of Oklahoma would be in Sri Lanka around the third week of November to make all arrangements in connection with the Rural Energy Centre.

7. The UNEP wishes to establish the centre as early as possible and get it working even by January, 1976.

8. The Ceylon Electricity Board should be asked to execute the project as they have an infrastructure for engineering facilities.

Sgd. (G.B.A. Fernando).
Assistant Director.

November 10, 1975.

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APPENDIX 3(b)

UNITED NATIONS ENVIRONMENT PROGRAMME
PROGRAMME DES NATIONS UNIES POUR L'ENVIRONNEMENT

ADDRESS TELEGRAPHIQUE
... NEWYORK

15 September 1975

POSTAL ADDRESS
ADRESSE POSTALE
P O BOX 20
GRAND CENTRAL STATION
NEW YORK N Y 10017

...CE:

Dear Mr. Secretary,

Subj.: Rural Energy Centre in Sri Lanka

1. It was very heartening to know from your letter ECNA/7/30 addressed to Dr. Tolba that the Government of Sri Lanka is interested in the utilization of the renewable resources of energy (solar, wind and biogas) and has very kindly agreed to discuss the details with me sometime after mid-October. This is to request you to let me know whether 23 October through 28 October would be convenient to the authorities concerned. If so, I will make the travel arrangements accordingly.

2. During my stay I would like to pay my respects to the Prime Minister as well as to the Ministers concerned, at their convenience. I would also like to see some possible village sites so that the one having the best wind regime, plenty of sunshine and availability of agricultural and animal wastes could be selected for the establishment of the REC. The villages to be visited should be far removed from the national electric power grid and have a small population of about 50 - 200 families. In this connection, I may add that we consider it extremely important to contact the leading scientists and technologists working in the field of energy to work in full collaboration with UNEP experts and, as such, could you please arrange my meetings with them also. In short, I expect to get a detailed programme of meetings, interviews and visits from you as soon as possible. As I will be leaving New York on 8 October, I would appreciate if you could send the programme to reach me before then.

3. I am enclosing a questionnaire which may perhaps be answered by the Government departments concerned so that the data may help our experts to design the energy harnessing contrivances for the selected village, and prepare the feasibility report without losing much time.

I look forward to the pleasure of your reply.

Yours Sincerely,

I. H. Usmani
Senior Energy Adviser

The Secretary
Ministry of Planning and Economic Affairs
Colombo, Sri Lanka

Enc.

ECN.A/7/E/38

December 10, 1975.

Dr.I.H.Usmani,
Senior Energy Adviser,
United Nations Environment Programme,
P.O.Box 20,
Grand Central Station,
New York N.Y. 10017.

Dear Dr. Usmani,

Rural Energy Centre in Sri Lanka

I hope your received my letter to you of 14 November. I have not heard from you since your left Sri Lanka.

I understand from the President of the Sri Lanka Association for the Advancement of Science that you have been invited to attend the annual sessions in December 1975. They too have had no news from you.

Among the sites we have seen there is a village around a lake with about 200 families living with no access to electricity. It is situated about 3 miles from the coast and has strong winds during the North-East as well as the South-West monsoons. There is plenty of sunshine and agricultural and animal wastes. Unlike other sites that have developed around the roadways, this village has grown around the lake. There is a tremendous potential for development with Energy supplies. It is situated about 10 miles from Tangalle in the Hambantota District, and is called Pattiyapola Wewa.

A group of University Scientists from the Netherlands led by Dr.Paul T.Smulders is interested in a co-operative programme between Sri Lanka and the Netherlands, to install a series of Windmills in Sri Lanka. A copy of their report is enclosed for your information along with a note on the Ground Water of Sri Lanka by A.D.N.Fernando.

Although this group is independent of the UNEP Rural Energy Centre project, there could be areas where collaboration could be of benefit.

I would be glad to have your comments on the notes I had forwarded to you in my earlier letter and be informed about your decision to send Prof. Allison of the University of Oklahoma for investigations.

Yours sincerely,

Oklahoma State University

SCHOOL OF ELECTRICAL ENGINEERING

STILLWATER, OKLAHOMA 74074
202 ENGINEERING SOUTH
(405) 372-6211, EXT. 6476

8 January, 1976

Dr. I. H. Usmani
Senior Energy Advisor to UNEP
485 Lexington Avenue
New York, New York 10017

Dear Dr. Usmani:

I returned home from my trip to Bombay and Sri Lanka on Friday, January 6. Routing through New York City was difficult, so I entered the United States through Chicago.

I was most impressed with the biogas work in Bombay. I spent several days with Mr. Srinavasan of the Gobargas Institute of the Khadi and Village Industries Commission, and took with me detailed drawings of the 3000 cubic foot per day facility which they have developed. Mr. Srinavasan was most interested in participating in the UNEP program, and I arranged to send him funds sufficient to cover a trip to the site in Sri Lanka within the next few weeks. He is prepared on sort notice to make a preliminary visit to the site, and to start construction as soon as he gets the "go ahead signal" from UNEP. If funding were available, there is no doubt that the biogas component of the Rural Energy Centre could be installed before the rainy season in Sri Lanka.

I had a sort meeting with Mr. Priestley, the UN resident Representative for Sri Lanka, shortly after my arrival on the Island. Mr. G. B. A. Fernando of the Ministry of Planning and Economic Affairs joined me for that visit, and he arranged a complete program for me during my eleven day stay in Sri Lanka. I re-touched many of the diplomatic bases you touched during your visit, and was received with courtesy, interest, and enthusiasm wherever I went. I was interviewed by the local radio and newspapers, and gave several lectures on unconventional energy resources to receptive audiences in Colombo and Kandy.

Mr. "Raja" insisted on providing Mr. Fernando and I with a car and driver for our tour of the island. It was a generous gesture, and I could find no polite way to refuse it. We visited various potential sites for windmills and micro-hydro exploitation in the future, as well as the site you suggested near Matara. The high point of the tour of the island occurred when we visited the Pattiapola Village, which is the location suggested by the government of Sri Lanka for the Rural Energy Center.

Pattiapola Village is located a few miles inland near the southern tip of the island. The village is easily approached from the road between Hambantota and Matra. It is somewhat isolated from other villages in the area, and is distributed around an artificial reservoir, approximately 1½ by 1 mile in dimension. The reservoir, incidentally, dates back to approximately 200 AD, and the history of the village can be traced back to its formation. Officials of the Ministry of Planning and Economic Affairs, with the advice and counsel of the Electricity Board, chose this site for the following reasons:

1. Proximity to Colombo. Driving time is approximately three hours, through an extremely senic part of the island.

2. Contact of the desired continuity from a high government level to the gramma sevaka, or village elder already exists.

3. Proximity to Hambantota, where extensive meteorological information is available indicating that the solar and wind resources at the village should be suitable for the program.

4. Scenic beauty and history. The site is an extremely beautiful and interesting one to visit. It was believed that this constraint was significant in the selection of a site, since important people would visit it.

5. Statements of interest from the villagers. The gramma sevaka was most interested in the program, and pledged his co-operation in every way possible.

6. Initial contact with the village provided the information that it contained approximately 200 families, the upper limit given to Sri Lanka for the village size.

All of the above were valid, except for the last item listed. I requested a census of the village, and learned (a day after visiting the site) that it consisted of 376 families, as of the 1970 census. Total population of the gramma sevaka division of the village is 1850, of which 931 are over 18 years of age. This means that the village is somewhat larger than we had planned. However, I strongly feel that we should go along with the choice of site given to us, and implement the site in Pattiapola Village.

The layout of the village is such that 70% of the villagers are isolated by the reservoir from the remaining 30%. I have received assurances that no problems would result if one side of the village was chosen for implentation, if the other side was given reason to believe that it might have the same service at some time in the future. This represents one approach which might be used to cut the village down to the proper size. Another point which should be considered is the fact that the rural electrification program of Sri Lanka provides only that wiring which is required for illumination. Electricity for cooking is not provided from the primary distribution system. Problems would be encountered if we should attempt to provide electricity for cooking in the village due to this fact. Further, the village would be completely self sufficient if it has electricity from the centre for illumination, since it imports only kerosene oil for illumination at present. It has no diesel utilization at all.

I am confident we can design a system for the village which will provide sufficient electricity to illuminate the whole area. I am also confident that other energy needs which I have documented, including water purification and pumping, as well as solar cooking and refrigeration, can be put in the village within the funding levels previously discussed in past meetings of the RERED board. I am most anxious to complete the preliminaries for Phase I and get the construction phase of the program started.

Please consider the following points which indicate a sense of urgency for the implentation phase of the program. First, there is the fact that the non-aligned conference is scheduled in Colombo for mid-August. It seems that this conference would provide a valuable opportunity to present the basic concepts of UNEP with respect to renewable energy resources, if most of the system could be put into operation by that time. I believe we could do it by then, if the administrative details in Nairobi could be handled. Second, there is the problem with Mr. Fernando, who is the man in Sri Lanka most knowledgeable about the program. He is scheduled to come to the United States on a nuclear short course in September of this year, for a period of approximately three months. His availability in Sri Lanka is, as you know, of fundamental importance to the program. Finally, there is the fact that Eric Farber and I, along with the team of researchers we have set up, will have more time from June to August to devote to the UNEP program than at any other time during the year. For these reasons, as well as the fact that I came back with beautiful information about the site, it would appear that a rapid implementation of Phase 2 is desirable.

I wanted to send you this summary of events which took place on my trip as quickly as possible. More details, as well as copies of the slides I took during the trip, will follow. I'll call you later this week to get your reactions to this letter.

Sincerely,

H. Jack Allison

Oklahoma State University

SCHOOL OF ELECTRICAL ENGINEERING

STILLWATER, OKLAHOMA 74074
202 ENGINEERING SOUTH
(405) 372-6211, EXT. 6476

February 16, 1976

Mr. G. B. A. Fernando
Assistant Director
Ministry of Planning and Economic Affairs
Government of Sri Lanka
Sir Baron Jayatilleke Mawatha
Colombo 1, Sri Lanka

Dear Mr. Fernando:

Thank you very much for the many courtesies you extended to me during my recent visit to your beautiful country. My wife liked the things I brought her, and she is more interested than ever in the possibility that she might visit Sri Lanka some time in the future.

The trip home was rather tiring, but I had sufficient energy left to meet with my people to get them started on the final phases of our proposal to UNEP to get the implementation part of the program started. I'm afraid I wasn't much help to them after the initial meeting. I picked up some sort of "bug" on the trip home which incapacitated me for about a week. I am well on the road to recovery as of this date, however, and am working hard to get the red tape cleared away for the Energy Center in Sri Lanka.

Mr. Srinavasan, the gobar expert from India, has been sent the funds necessary for his visit to the site in Sri Lanka. I have suggested to him that he plan his visit for the middle of March. It would be desirable to have him visit the site to make a determination as to the extent that biogas energy can be used there, primarily for the generation of electricity. I'm enclosing a copy of the letter I sent to him, for your information.

Dr. Usmani agreed that we should propose to electrify the entire Pattiapola Village, with sufficient kilowattage to satisfy their illumination requirements. I told him about the meteorological data which was provided, indicating that the solar data was probably representative of the conditions which prevail at the site, and expressing reservations about the wind energy data, due to the distance between the site and the Hambantota meteorological station. At present, I intend to pursue the objective of finding a good method of providing electricity from solar resources, to complement the biogas and wind energy components of the system. I'm also enclosing a copy of the letter I sent to Dr. Usmani shortly after I returned. I have had several telephone conversations with him since the letter was written, and I believe he is both pleased and satisfied with the promise and challenge related to the site which has been selected.

The REPED team will meet during the first week of March to clarify the type of systems we will propose for the three Rural Energy Centers. Incidentally, Mexico has been chosen as the location of the Spanish speaking site. I intend to submit my proposal for Phase II, the implementation phase of the program, by March 15, as per Dr. Usmani's recent request. This means that information from Sri Lanka, regarding components of the system which could be obtained locally, data which could result from the site survey, and any information from the anemometer station which will be established at the site will not be available for that report. I am, however, still planning on setting up that fund we discussed, and will cable you as soon as the paperwork corresponding to the fund has been processed.

Dr. Usmani does not feel the implementation phase can go into full effect before October. He reminded me that both UNEP and the Government of Sri Lanka will have to approve the proposal, and that such details will consume quite a lot of time. His earliest expectation for the start of Phase II is sometime in May, 1976. If he is right, then October will probably be the time we will be able to get everything going. You will note in the letter I sent to him that I attempted to apply pressure to accelerate things, for the reasons we discussed on my visit. Time will tell the degree of success of that effort.

As soon as possible, I'll send you a stack of papers and information, as promised. Please convey my regards and appreciation to everyone in Sri Lanka, and assure them that I'm doing everything possible from this end to expedite the program.

Wish me luck.

Sincerely,

H. Jack Allison

H. Jack Allison

HJA

Enclosures

ECNA/ 7/ E / 38

30
26th March, 1976.

Professor, Jack Allison,
School of Electrical Engineering,
Oklahoma State University,
Stillwater,
Oklahoma 74074.

Dear Dr. Allison,

Thank you for your letter of 16th February, 1976 and copies of your letters to Mr. Srinivasan and Dr. Usmani.

Mr. H.R. Srinivasan of the Khadi and village Industries Commission was in Sri Lanka from 13th to 18th March 1976 in connection with the Biogas generator for the Rural Energy Centre as well as the gift of 10 Biogas generators from the Indian Government to the Sri Lanka Government.

We are as keen as you to provide the most suitable site for the Rural Energy Centre as the programme should be a success.

Mr. Srinivasan is of opinion that at the present site proposed, the population of the village is scattered and transmission of biogas by pipeline to houses far apart could escalate costs. Besides, the cattle are presently scattered at different pastures for the night and there could be problems in bringing all the cattle to one place for the night. Mr. Srinivasan felt that in places of this nature it is more useful to have individual small biogas units to meet the needs of each household.

We then took Mr. Srinivasan to a Government Experimental Farm at Bata Ata at the 132nd mile post on the Matara-Hambantota Road. There is a stable which presently houses 58 head of cattle. If more cattle is needed, it is possible to transfer some cattle from the Ridiyagama Government Farm which is not far away.

Contd...

There are many advantages the Bata Ata village has over the Pattiapela village.

1. It is on the main trunk road from Colombo to Hambantota. This area is not served with electricity and therefore the electrification of this area by SWB energy could provide a contrast to other areas to the many long distance travellers on this road.

2. It is closer to Ambalantota which, according to local observers, has a stronger wind regime than Hambantota where meteorology recordings are already available. The Solar Energy input is similar.

3. The Government Farm offers security to the valuable equipment that would be brought in by the UNEP.

4. If the energy produced is in excess of the requirements of the few houses at Bata-Ata, it could be transmitted electrically to the village of Hungama which has more houses and is about a mile and a half away on the main road.

5. The Agricultural Officers at the Farm are more knowledgeable scientifically that the average villager and therefore could be of great assistance to the programme.

6. Any benefits that accrue to the Experimental Farm by the provision of renewable energy resources would be immediately multiplied to other agricultural farms. Sri Lanka, being an agricultural country is bound to benefit enormously by any improvements that may occur in agriculture by the provisions of renewable energy resources.

Later we met the Director of Agriculture, Dr. Abeyratna who had also met Dr. Usmai briefly during the latter's visit to this Island.

Dr. Abeyratna was willing to place the Bata Ata Farm for the UNEP Rural Energy Centre, if required and pledged his whole hearted assistance to this project. Therefore we can expect the co-operation of the Department of Agriculture for this project.

I took Mr. Srinivasan to the Ridyagama Government Farm which has 1500 head of cattle. The milk is used for making curd. About 2 tons of firewood is burnt per day to heat the milk. Mr. Srinivasan is of opinion that a large biogas generator could provide sufficient gas to heat the milk and all that timber could be saved. Besides, the electric generator, presently run on diesel, could be run instead on the biogas.

In summary, the Bata Ata Village has the following facilities -

1. There is plenty of sunshine throughout the year. The Meteorology Data on sunshine recordings for Hambantota should be valid at Bata Ata.
2. The wind regime is about the best in the Island.
3. Plenty of cattle is available. At the Experimental Farm agricultural wastes of different types could be tried out.
4. The site is on one of the main highways of Sri-Lanka and is readily accessible.

I have asked the Government Agent, Hambantota to provide me with the other details of Bata Ata and they would be transmitted to you as soon as I receive them. You should be able to trace the location on the 1" to a mile topo sheet of Ambalantota that I have given you.

Mr. Srinivasan intends setting the Biogas generator in a month if the UNEP has approved the implementation of the programme.

I am expecting the literature you had promised as many of those who were interested have asked me if I have received the literature. The funds may be sent to the UNDP who would transfer it to this Ministry.

I am writing to Dr. Usmani by the same mail. Sorry for the delay in replying. Enclosed herewith is the article that appeared in the Press on the interview you had granted.

Yours sincerely,

(G.B.A. Fernando)
Assistant Director.

SCH.4/7/3/33.

Dr.I.H.Usmani,
Senior Energy Advisor,
United Nations Environment Programme,
P.O.Box 20,
Grand Central Station,
New York, N.Y.10017.

Dear Dr.Usmani,

I understand that Mr.Srinivasan had visited Sri Lanka and has now decided to change the venue for the Rural Energy Centre from what was contemplated earlier.

I have learnt from Mr.G.B.A.Fernando that the present location suggested is a large Government Agricultural Farm at a place called Bata Ata in the Hambantota District.

Your project is to be a model project to serve the future needs of Asian villages. But what I could say of the Bata Ata farm is that it does not constitute a village and to this extent it would be meaningless to locate the type of project you contemplate within this farm area as it will not serve the desired purpose. I would therefore suggest that this matter be reconsidered and that a typical Sri Lanka village be selected although the conditions there may not be ideal.

It is my view that the village should be a typical one rather than an ideal one if the project is to have a multiplier effect in the Asian Region. The reason behind Mr.Srinivasan's decision is that a large quantity of cow dung is available at the Government Farm at Bata Ata. If one selects a cattle farm, there would no doubt be a large quantity of cow dung. However, there will not be very many places in Sri Lanka where there will be that amount of cow dung available, and if this is a pre-condition, the uses of this project could be extremely limited.

I would therefore like to reiterate that this project be located in a typical village near the coast in Sri Lanka where the basic conditions are met rather than go in for an ideal location where the conditions are not quite typical.

It has also been brought to my notice that Prof.Jack Allison of the Oklahoma State University who was also here some time ago had agreed on the Pattiyapola village as a suitable location. This was the village selected by the Government Agent on the basis of the specifications laid down by you. I am most interested to hear your views on this subject.

Kind regards.

Yours sincerely,

(G.P.H.Leelananda de Silva),
Senior Assistant Secretary,
for Secretary,
Ministry of Planning
& Economic Affairs.

<u>P.S.</u>

I have just received a copy of the Report to the Governing Council of UNEP prepared by Prof.Allison and his entire discussion is based on the project being located in Pattiyapola village. If Mr.Srinivasan's view is to to be accepted, then this report cannot be accepted.

CTO
COLOMBO

NAIROBI 212 23 2135 P1/50
LTF
UNDEVPRO
COLOMBO

MISC 2109 REFERENCE ESTABLISHMENT RURAL ENERGY CENTRE PATTIYAPOLA VILLAGE SELECTED BY SRI LANKA GOVERNMENT OKLAHOME STATE UNIVERSITY HAS SUBMITTED PRELIMINARY FEASIBILITY REPORT WHICH HAS BEEN EXAMINED WE CONSIDER THAT FINAL VERSION OF FEASIBILITY REPORT MUST BE PREPARED WITH ACTIVE ASSOCIATION OF METEOROLOGISTS SOCIAL SCIENTISTS ENGINEERS AND ECONOMISTS WORKING IN SRI LANKA INSTITUTIONS AND GOVERNEMNT DEPARTMENTS CONCERNED REQUEST YOU ASK GOVERNMENT TO DESIGNATE LOCAL EXPERTS OR INSTITUTIONS TO ASSIST OKLAHOME STATE UNIVERSITY IN PREPARATION FINAL VERSION FEASIBILITY REPORTS AND ASSESSMENT FOLLOWING ASPECT

1 ASSESSING TECHNICAL DATA REQUIRED FOR STUDY

2 CAPITOSTIN FOREIGN EXCHANGE AND LOCAL CURRENCY OF REC ENERGY PROVIDING CONTRIVANCES FULLY INSTALLED

3 ANNUAL RECURRING COST OF MAINTENANCE OF REC ENERGY PROVIDING CONTRIVANCES

4 RECURRING COST FOR FAMILY OF USING ENERGY IN FORM OF ELECTRICITY FOR LIGHTING AND POSSIBLY COOKING AND FOR SHARING COST OF PROTECTED WATER SUPPLIES

5 FINANCIAL CAPABILITY OF RURAL FAMILIES FOR PAYING RECURRING COST AND COST OF ELECTRICAL FIXTURES AND COOKING STOVES ETC

6 POSSIBILITY OF GOVERNMENT SUBSIDISING INSTALLATION OF ENERGY USING EQUIPMENT AND FIXTURES IN ALL FAMILY HOMES

7 POSSIBILITY OF REPLICATING AND LARGE SCALE MANUFACTURING OF REC CONTRIVANCES FOR USE IN OTHER VILLAGES

8 ENVIRONMENTAL IMPACT ON LIFE OF VILLAGE AS RESULT OF INPUT OF ENERGY SUPPLIES PROPOSED

MOLLENHAUER UNITERRA NAIROBI

Recd. on 25.4.76
ag.

UNITED NATIONS ENVIRONMENT PROGRAMME
PROGRAMME DES NATIONS UNIES POUR L'ENVIRONNEMENT

CABLE ADDRESS
ADRESSE TELEGRAPHIQUE
UNATIONS NEWYORK

POSTAL ADDRESS
ADRESSE POSTALE
P.O. BOX 20
GRAND CENTRAL STATION
NEW YORK, N.Y. 10017

REFERENCE

10 May 1976

Subj/: Rural Energy Centre at Pattiyapola Village

Dear Mr. Leelananda de Silva,

1. Kindly refer to your letter number ECN.A/7/E/38 dated 1 April 1976, which I saw only on my return from Nairobi towards the end of April. A copy was shown to me by your High Commissioner in Nairobi. I had a fairly long discussion with him and assured him that Srinavasan's report is not going to change the site selected by the Government of Sri Lanka for the establishment of the Rural Energy Centre at Sri Lanka. His fear is that it may be difficult to ensure a regular supply of animal wastes for the biogas plants because the 1,000 cattle or so roam around grazing all over and are not penned by the villagers even at night. I believe this aspect was discussed by Professor Allison of Oklahoma State University during his visit to Sri Lanka and he was assured by your Government spokesmen that villagers could be persuaded to collect the cattle in an enclosure over some Government land and to supply the dung for the biogas plants. Whether this can be translated into actual practice or not, only you can say. But, when the Government of Sri Lanka and UNEP are prepared to invest so much in the Rural Energy Centre, I don't see why the villagers, through their own local committee of elders, cannot discipline themselves to cooperate in the successful implementation of the Rural Energy project. So, if you think that collection of animal wastes, for two biogas plants for generation of electricity and not for piping of the gas to homes (as Srinavasan envisages), could be arranged, there is no question of shifting the site of the Rural Energy Centre.

2. We are most anxious to finalize the feasibility report so that implementation may start soon after the monsoon season is over. For this we feel that the Government of Sri Lanka should designate a group of experts to work under an executive department or agency who could serve as a focal point for the supply of all local information and data required for the feasibility report. In fact, all the conclusions drawn in the final version of the report, like: (a) the form of energy

Mr. G. P. H. Leelananda de Silva
Senior Assistant Secretary for Secretary
Ministry of Planning and Economic Affairs
Government of Sri Lanka
P. O. Box 1689
Colombo 1, Sri Lanka

supplies from the Rural Energy Centre like electricity for lighting, cooking and pumping water, (b) the social acceptability of the supplies, (c) the capital cost to be incurred in local currency, (d) the recurring cost of operation and maintenance of the Rural Energy Centre to be borne by the villagers (with or without subsidy) and (e) the possibility of replication and manufacture of the devices installed in Sri Lanka will have to be made with the full concurrence and cooperation of the Government of Sri Lanka. All the meteorological data to be used and figures adopted must have the endorsement of your meteorological department. All of this is necessary because we would like to make it perfectly clear that the responsibility for the actual construction of the Rural Energy Centre and the installation, and commissioning, etc., of the devices and equipment will be that of the Government of Sri Lanka. UNEP will only support the Government with the services of the experts, first with the preparation of the feasibility report and then during the completion of the Rural Energy Centre, if needed. It is, of course, understood that the entire foreign exchange cost of the services of the OSU experts and the hardware and equipment required will be borne by UNEP while all local currency expenditure will be incurred by the Government of Sri Lanka, subject to the joint approval of the cost estimates.

3. It is likely that the OSU experts may visit Sri Lanka again in June by when I hope you will have streamlined and designated the agency and the group of your experts who will work with OSU on the feasibility report.

4. Kindly let me have a cable reply to this letter.

With best wishes,

Yours sincerely,

I. H. Usmani
Senior Energy Adviser

21st June, 1976.

ECN.A/7/E/38

Dr.I.H.Usmani,
Senior Energy Advisor,
United Nations Environment Programme,
P.O.Box 20,
Grand Central Station,
New York N.Y.10017.

Dear Dr.Usmani,

UNEP Rural Energy Centre

I have taken the liberty to reply to your letter of 10 May 1976 addressed to Mr.Leelananda de Silva.

Mr.Leelananda de Silva was at that time away in Nairobi for UNCTAD IV. He took that opportunity to visit UNEP Headquarters where he had discussions with Mr.Rameses S. Mibhaul and Mr.Denis Schmidt on the REC Project in Sri Lanka. Dr.Mollenhamer was not available at that time. He informed them of the Government's decision to go ahead with the REC Project on your recommendation as well as that of Dr.Allison.

The points raised by you in this letter were discussed at the UNEP Headquarters in Nairobi.

A Standing Committee has been appointed consisting of four University Lecturers from the Campuses at Peradeniya and Katubedde, The Director of Meteorology, the General Manager, Sri Lanka Electricity Board, a Deputy Director in the Irrigation Department, the Government Agent of Hambantota, an Engineer in the National Water Supply and Drainage Board, a Senior Economist from this Ministry, a Sociologist and myself.

The Focal Point will be the Ministry of Planning and Economic Affairs and I will be the Project Co-ordinator. The Sri Lanka Electricity Board will be the executing body.

I understand that the OSU Team intends visiting Sri Lanka again in June in order to complete the feasibility report with the active participation with Ceylonese Officials, and that you may accompany them.

It would be good if this visit could be made early as it will be difficult to make arrangements towards the end of July when the Non-Aligned Conference is about to begin.

A visa would ~~not~~ be needed to enter Sri Lanka owing to the Non-Aligned Conference. This could be obtained from our Embassy in Washington.

Yours faithfully,

(G.B.A.Fernando),
Assistant Director.

UNITED NATIONS ENVIRONMENT PROGRAMME
PROGRAMME DES NATIONS UNIES POUR L'ENVIRONNEMENT

POSTAL ADDRESS
ADRESSE POSTALE

P.O. BOX 20
GRAND CENTRAL STATION
NEW YORK. N.Y. 10017

12 July 1976

Dear Fernando,

Subject: Rural Energy Centre

1. Kindly refer to your letter No. ECN.A/7/E/38 dated 21 June 1976 on the subject mentioned above. I am very happy to know that a Standing Committee of all the officials concerned has been formed and that within the Ministry of Planning and Economic Affairs, which will serve as a focal point, you have been designated as the Project Co-ordinator with the Sri Lanka Electricity Board as an Executing Agency in the field.

2. I understand from Prof. Allison that a copy of the final version of the feasibility report has been sent to you and Mr. DeSilva so that by now you must have digested its conclusions and recommendations. There are, however, some questions on which I feel that the comments of the Government of Sri Lanka are of vital importance. These are summarized below:

(i) Do the Government of Sri Lanka agree with the energy needs of the Pattiyapola village on the basis of the scale suggested on page 61 of the OSU report?

(ii) Is the adoption of the solar radiation and wind data of Hambantota for the Pattiyapola village, based on the analysis and projections done by OSU, acceptable to the Met. Department and the Government of Sri Lanka?

(iii) Will the Government of Sri Lanka ensure the collection of animal wastes by the villagers, to feed the biogas plant of 3,000 C. ft. capacity suggested by OSU? It may require some local incentives and the co-operation of the villagers.

(iv) OSU have suggested the provision of energy supplies only to a segment of the Pattiyapola village, so that the REC concept may be demonstrated within a compact block of houses. Is this acceptable to the Government of Sri Lanka? If so, can the segment of the village be selected by the

Mr. G. B. A. Fernando
Assistant Director
Economic Affairs Division
Ministry of Planning and Economic Affairs
Sir Baron Jayatilleke Mawatha
Colombo 1, P. O. Box 1689

Government of Sri Lanka in collaboration with the villagers and a layout of that segment (showing the number of houses and the sizes of families living in each house, within a diameter of 1 km) be prepared and sent to OSU with copies to me?

(v) A D.C. system of power supplies from the battery bank will be much cheaper, more efficient and convenient to operate and use by the villagers. D.C. supplies are characteristic of the REC system of rural electrification as distinct from the conventional A.C. supplies from the national grids. The only constraint is that the houses to be electrified must be near each other, say, within a distance of about 1/2 to 1 km of the REC to minimize distribution losses. Mr. Raja of the Sri Lanka Electricity Board may please be persuaded to accept the REC D.C. system of supplies so that a transmission layout may be worked out by OSU.

(vi) Is flourescent electric tube light acceptable in place of an incandescent bulb? The latter is more energy consuming and has limited life even though it is cheaper. Both can be mass produced.

(vii) We are very keen that the Pattiyapola village should get protected supplies of water for drinking purposes and that the energy lost in boiling the water before drinking by each family is conserved. Accordingly, do the Government of Sri Lanka accept the recommendation made by OSU on page 277 of their report (Appendix D)? There will be enough energy in the REC system to pump the heated water to an overhead storage tank to enable supplies to be made from that tank too to a reservoir on the ground with community taps to enable villagers to bring their pitchers for filling from these taps.

(viii) Do the Government of Sri Lanka agree with the cost economics of the REC project as worked out by OSU on the understanding that all the foreign exchange cost of the devices, equipment and services may be borne by UNEP and the local costs (land, buildings, locally available materials, duties and taxes, local cost of transport of personnel) may be borne by the Government of Sri Lanka?

(ix) Nairobi is very keen that whatever is envisaged by the REC energy system (production and use) should be socially acceptable to the villagers. I think a write-up on this aspect can only be attempted by the sociologists of Sri Lanka. Will the Government kindly take steps to get a statement of social impact prepared as a supplement to the OSU report? If there is any information required by the Government on the REC system and energy supplies, which OSU can supply, please don't hesitate to write to me.

(x) As to the economic capacity of the villagers to pay for the energy supplies produced from the REC system, much would depend upon the policy of the Government of Sri Lanka. In the United States and many other countries, when rural electrification was done by extending the national power grid to the rural areas, the whole effort was heavily subsidized. In many developing countries also this has been the practice. Where power lines don't go, the prices of kerosene and diesel oil are subsidized. A statement on the policy and practices in Sri Lanka in regard to supplies of energy to rural areas may also be prepared by the Ministry as supplement to the OSU report.

(xi) Would the Government of Sri Lanka take the responsibility of installing the solar, wind and biogas devices at the REC or require the services of OSU engineers and engineers of suppliers of equipment on the site for such installation, testing and commissioning? If so, for how long and at what stage of the implementation of the project?

(xii) Can construction activity be sustained throughout the year at Pattiyapola which is located in a comparatively "dry" area?

(xiii) Are there local science and engineering graduates available in and around the Pattiyapola village who could be selected for on-the-job training abroad for ultimate employment as operating and maintenance personnel at the village site?

3. On receipt of answers to the questions raised above, I intend to plan a trip to Sri Lanka preferably with Professor Allison. In the interest of early implementation of the project, perhaps the Ministry of Planning and Economic Affairs may wish to collect the answers to the questions, submit a summary to the Cabinet and obtain orders. Kindly acknowledge receipt of this letter and act as quickly as you can.

With best wishes to you and Mr. De Silva.

Yours sincerely,

I. H. Usmani

I. H. Usmani
Senior Energy Adviser

cc: Mr. H. Mollenhauer (Nairobi)
Mr. M. Priestley (UNEP Res.Rep. in Sri Lanka)
Prof. H. J. Allison (OSU)

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INWARD TELEGRAM

ලැබෙන්නේ/From : LANKAREP GENEVE

දිනය/Date : 9-9-76

ලැබීම/Receipt.

දිනය / Date: 10-9-76

වේලාව / Time: 0910 hrs

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(අ) කටයුතු සඳහා / (a) For Action: Mr.W.S.Nanayakkara (Min of P & EA)

(ආ) දැනගැනීම සඳහා / (b) For Information: D/EA

පාඨය/Text

No.226 . Following for Secminplan Attention W.S.Nanayakkara, Deputy Director. Rural Energy Centre Project accepted by Government on the basis that it will be UNEP Project. Government was to provide assistance. Understand Usmani has now gone back on that position. Sri Lanka should not accept responsibility as viability of Project is uncertain. Stu[dy] files and also UNEP Governing Council decisions. It should be a UNEP Project and not Sri Lanka Project. Also finalise invitations Rea Meeting.

Leelananda de Silva.

මාණ්ඩලික සහකාර.
Staff Assistant.

දිනය/Date : 10-9-76

/lw

The Economic Affairs Division
Ministry of Planning & Economic Affairs,
Central Bank Building 2.
Sir Baron Jayatilleke Mawatha
Colombo.

6th September 1976.

ECNA/7/E/38

Dr. I.H. Usmani,
Senior Energy Adviser,
United Nations Environment Programme,
P.O. Box 20,
Grand Central Station,
New York 10017.

Dear Dr. Usmani,

Rural Energy Centre

I refer to your letter of 12th July 1976 and subsequent cables.

I have received the two copies of the Feasibility Report from Dr. Allison. Thank you for sending me three further copies of the finel version of the Feasibility Report.

A few members of The Standing Committee of the Rural Energy Centre met on two occassions to discuss your letter.

We wish to place the following comments on your letter of 12th July.

(1) The quantum of energy needs of the Segment of the Pattiyapola Village on the scale suggested on page 61 of the OSU report is acceptable with a redistribution of energy for cooking, drinking and lighting as follows-

Basic Needs	Electrical Energy
1. For cooking of food. Firewood with greater efficiency eg. the smokeless strove as given in page 259 of the report is recommended. Please see Sec. 5 as well.	-
2. For pumping drinking water 10 gals/person/day	1250 KWh
3. For lighting 3 bulbs of 40 watts per home for use 4 hours per day.	8210 KWh
4. For misc. purposes such as street lighting lighting of village Community Centre, dispensary and operating an refrigerator for preserving drugs.	9125 KWh
5. Other. For some cooking of food for the running of cottage industries. This estimate is for 50 families. If there is an excess of electrical energy, more families may be incorporated into the scheme.	81,415 KWh

(ii) According to the Department of Meteorology the solar radiation and wind data of Hambantota can be considered as reasonably representative of the condition prevailing at the Pattiyapola Village.

(iii) The Government of Sri Lanka will ensure the collection of animal wastes by the villagers to feed the biogas plant of 3000 C.ft capacity suggested by OSU.

(iv) The Government of Sri Lanka accepts the provision of energy supplies to a segment of the Pattiyapola Village so that the REC concept may be demonstrated within a compact block of houses. The segment of the village to be selected by the Government of Sri Lanka in collaboration with the villagers is shown in the attached sketch.

(v) The Village electrification schemes in Sri Lanka are all A.C. Systems, and the villagers are used to AC appliances.

The Schematic of the proposed system on page 51 of the report is suitable with the distribution system for the village on A.C. In view of standising electrical appliances, the villages would prefer on A.C. system.

If this demonstration village is to have a multiplier effect, the A.C. system is prefered in Sri Lanka.

(vi) Fluorescent electric tube lighting is acceptable in place of an incandescent bulb. In order to reduce losses we propose 2 ft. 20w lighting lamps.

(vii) The energy required for drinking water has been calculated on 2 gals/person/day. The supply of drinking water alone may not be realistic. The main use of water by the villager is not for drinking alone, but for washing and cooking of food as well. Our observations in Sri Lanka indicate that an average of 10 gals/person/day is being utilised.

A village of 50 families would need about 2,500 gals/day today and about 6000 gals/day in 1986.

The OSU recommendation to adapt American Water Purification Units (APU) appears to be the best solution if water is extracted from wells in the area. The American Water Purification Unit is capable of producing 540 gals/hr. It could meet a requirement of 10,000 gals/day on a 20 hr supply It is unlikely that one well could yield more than 5000 gals/day and therefore a 2 well unit is required.

The Wewa in the village could be another source of supply of water to the village if it does not dry during the drought.

The quality of the wewa water would be much better than the well water. The wewa waters should be analysed. A pumping test on one of the wells in the village should be undertaken to determine the yield and observe salienation after extraction over a period.

Continued extraction from wells in this area may lead to increase the salinity of the water beyond

(viii) The Government of Sri Lanka agrees with the cost economics of the REC project as worked out by the OSU on the understanding that

(a) all foreign exchange costs of the devices equipment and services may be borne by the UNEP

(b) the Government of Sri Lanka will bear the local costs of land, building, locally available materials, duties and taxes, local cost of transport of personnel and labour to the amount stipulated in your subsequent letter, namely the equvalent of US $ 42,500 in local currency

(ix) No resistances to this scheme is anticipated. On the other hand, the extent to which it is accepted in usage depends upon a set of attributes of the scheme which will no doubt be made clear in due course. These attributes refer to such aspects as cost to individual house holders, particular tasks which have to be performed, costs of installation etc.

(x) The Ceylon Electricity Board expects a return of 20% per annum on the investment for deeming a project as a viable one.

In case of rural electrification the investments on High Tension Lines and substations is considered viable if it gives a return of 5% per annum, with the additional requirement that the investments on the low Tension distribution should give a return of 12% per annum.

It will be observed that expenditure on Rural Electrification Schemes are subsidised.

The taxation rates are lower for Kerosene and diesel than for petrol.

(xi) If there are adequate instructions, installation could be done by Ceylonese staff.

A Technical project co-ordinator, who has an intimate knowledge of the equipment may be sent at the time of installation.

(xii) Construction activity can be sustained thoughout the year at Pattiyapola which is located in a comparative dry area.

(xiii) Yes

Yours very sincerely,

G.B.A. Fernando
Project Co-ordinator.

Copies to: Mr.H.Mollenhaner (Nairobi)
Mr. M. Priestley (UNEP Res. rep.in Sri Lanka)
Prof. H.J. Allison (OSU)

15 February 1977

Dear Mr. Sanamngaraja,

<u>Rural Energy Centre at Pattiyapola Village</u>

As I told you, Prof. Allison and I had come to the HQ of UNEP here for Consultations and during our stay we reviewed the implementation phase of the Sri Lanka project at the highest level. Frankly speaking, we are a little disappointed at the slow rate of progress despite all the freedom of action which the Project Document (signed between UNEP and the Govt. of Sri Lanka) gives to you in the matter of appointment of consultants and placement of orders for equipment and hardware etc. For example:-

(a) Although the cheque for the first instalment of $30,000, envisaged under Section 3.5 of the Project Document, was despatched on 26 October 1976, it took more than a month for the foreign exchange account in the name of the Ceylon Electricity Board to be operational.

(b) Prof. Allison could not visit Sri Lanka in Nov. /Dec.'76 because he was forced to travel by Air Ceylon when that airline does not fly from USA nor does it have an agent.

(c) Though Prof. Allison and Mr. Srinavasan, ultimately reached Sri Lanka together and finalized discussions with you regarding their role as your consultants, in the second week of January 1977, they have not yet received anything in writing about the terms and conditions of their appointment. As far as UNEP is concerned, both of them are acceptable to us and, therefore, while appointing them you can presume our concurrence which will follow as soon as we receive the copies of the appointment letters.

(d) The documents specified as (1) and (2) in Section 4.1 of the Project Document have not yet been received even though they were expected to be ready in January 1977.

2. I want you to know that the first instalment of $30,000 was released by us to enable you to engage consultants and generally to help you to mobilize the effort required to initiate the project. As such, please do not delay in formally appointing Prof. Allison and Mr. Srinavasan as your consultants on the terms and conditions which were mutually agreed with them in January 1977. Kindly send copies of the letters of appointment to me at the New York address, to Mr. Yusuf J. Ahmad, Associate Director of the Fund, P.O. Box, 30552, Nairobi, and the Resident Representative of the UNDP in Colombo, for information.

3. It is terribly important for you to get the second instalment of the balance of UNEP's contribution mentioned in the Project Document as soon as possible to enable you to place orders for the equipment, instruments and hardware etc. required to be imported. But as this is conditional upon your sending us the blue prints of drawings mentioned in Section 4.1 of the Project Document, please comply with this condition without delay, so that on approval UNEP may release the balance of the money as required under the terms of the Project Document.

4. It is extremely urgent to proceed with the construction of the biogas plant in the current dry season. I understand that Mr. Srinavasan is agreeable to provide the services of a supervisor at site and to fabricate the steel items in Bombay and to ship them in time for installation before the S.W. monsoon season starts. Please keep chasing him on the phone, get the quotations and place funds at his disposal to pay for the fabrication of the special items in Bombay and recruitment/passage of the supervisor out of the amount of $30,000 already placed at your disposal.

5. Please note that the entire responsibility for the execution, operation and maintenance of the REC project is that of the Government of Sri Lanka who have designated you as the Project Manager and the focal point for liaison with UNEP. You are, therefore, free to place orders for the equipment conceived for the project without obtaining prior concurrence from me or anyone else in UNEP. We are there to help you and support you whenever called upon by you to do so on any specific issue or problem which you may face; but this is not to veto your decisions or interfere with the discharge of your responsibilities and obligations as the Chief Executive of the Project. I know you have executed many big projects in your career and are even now engaged in some of them costing millions of dollars. It is, therefore, presumptuous on my part to suggest how you should go about executing the small REC project placed under your charge. But as it is unique in concept, in that it aims to harness variable sources of energy to produce firm power, by devices which though commercially available, are not yet mass-produced, it requires some special handling and attention. My personal advice (and please take it only as advice) is that in respect of all imports of solar and wind energy devices, water purifacation plant and the batteries together with auxiliary equipment and instruments etc. whose list had been agreed upon during Prof. Allison's visit in January 1977, you should authorize him to:-

(a) Fix the specifications and invite price quotations on CIF basis from responsible manufacturers and negotiate the most advantageous prices with the selected manufacturers.

(b) Place orders on your behalf after arranging for such performance tests as may be necessary before packing and shipment.

(c) Obtain guarantees of performance of devices etc. after installation at the Pattiyapola REC site, from the manufacturers concerned.

.....3.......

(d) Include such extra components and spare parts (like solar collectors) which may be required in the near future, in the orders placed for the main items.

(e) Pay an advance up to 20% of the cost of the device/equipment on your behalf to the selected manufacturers at the time of placing the supply orders, 60% on proof of insured shipment and the balance of 20% after installation and commissioning at the site.

6. For discharging the above responsibility, you should make arrangements for quick payments in USA and for this purpose perhaps it may be a good idea to enter into arrangements with the Oklahoma State University (OSU) Development Foundation, which is a non-profit making organization, and which could enable you to remit money in bulk from time to time for disbursements against receipts and vouchers from manufacturers selected by Prof. Allison. Please write to him about this.

7. As the Campus of the Oklahoma State University is in a small suburb of Oklahoma City, called Stillwater, I suggest that you ask Prof. Allison and the OSU Development Foundation to register a telegraphic address in the main city of Oklahoma so that telex messages received from you and others may be immediately read out to Prof. Allison on the telephone and action is not delayed at their end. Some time the cables to Stillwater take more than 8 days to reach Prof. Allison!

8. Finally, I beg you to send a monthly progress report under three broad heads: (i) Activities at the Site, (ii) General Progress and (iii) other Matters, for information and record, to : (a) Mr. Yusuf J. Ahmad in Nairobi, (b) me in New York (c) Prof. Allison in Stillwater, (d) the UNDP Resident Representative in Colombo and (e) Your Ministry and Ministry of Planning and Economic Affairs.

9. As I told you on the phone, Mr. Leelananda D'Silva's cable to Mr. Yusuf Ahmad requesting for the amendment of the Project Document as envisaged in his letter dated 31 January 1977, has caused considerable concern here in Nairobi. We don't know what he means because the said letter has not yet been received but, at this stage, we have no intention of altering the basic features of the Project Document as signed. Perhaps we can review the progress when I visit Colombo next sometimes in mid- March.

10. I am sorry for writing such a long letter, but I thought it would clear the air for you to proceed with speed and complete a project which would be sympolic for all the developing countries, particularly those of Asia.

With warmest regards and best wishes,

Yours sincerely,

I. H. Usmani

(I.H. Usmani)
Senior Energy Adviser

Mr. N. Sanmugaraja
General Manager
Ceylon Electricity Board
Colombo, Sri Lanka

cc. Mr. R. B. Stedman
Deputy Executive Director

Mr. Yusuf J. Ahmad
Associate Director, Environment Fund

Mr. H. Mollenhauer
Director, Division I

Prof. J. Allison,
Dept. of Electrical Engineering,
Oklahoma State University,
Stillwater (Oklahoma)
USA

Mr. Leelananda D'Silva,
Senior Asst. Secretary,
Ministry of Planning and
Economic Affairs,
Govt. of Sri Lanka,
Colombo,
Sri Lanka.

Oklahoma State University
SCHOOL OF ELECTRICAL ENGINEERING

STILLWATER, OKLAHOMA 74074
202 ENGINEERING SOUTH

July 25, 1977

Mr. N. Sanmugaraja
General Manager
Ceylon Electricity Board
P.O. Box 540
Colombo, Sri Lanka

Dear Mr. Sanmugaraja:

Under separate cover, I am sending the information necessary for making a determination as to the specific nature of the equipment needed for the Rural Energy Center work in Sri Lanka. In addition, I am also enclosing a revised basic schematic for the REC and a brief description of the general character of the system. Two copies of this file of information will be sent by air mail today. The third copy will be brought with me when I come to Sri Lanka in August. In the event that this trip becomes impractical, I will immediately send that copy by air mail.

I have recently acquired information about the windmills I recommended in my Feasibility Report which requires a revision in the number and type of windmills to be recommended at this point in time. None of this information was available early in 1976 when my Feasibility Report was completed. Various mechanical and electrical problems have become apparent in the DAF vertical axis windmill which raise serious questions about its performance in an integrated REC in a remote area of the world. The Swiss Elektro windmill we had recommended has developed problems in its feathering mechanism in gusty winds which make it vulnerable to mechanical damage in such an environment. The AWT manufacturing company has recently modified the electrical components of its unit, and the testing program to demonstrate the success of that modification is incomplete. This leaves only the Australian-made Dunlite windmill on the list we discussed in January.

In an effort to find other windmills to replace those discussed in the preceding paragraph, I re-considered the use of the Windstream and Aerowatt units described in my Feasibility Report. Both were eliminated from consideration earlier, primarily because of their relatively high cost. Unfortunately, the Windstream unit is still not being manufactured on a reasonable scale, and a six months delay would be required before we could acquire one. The Aerowatt units are presently being subjected to extensive tests in a United States government facility in Rocky Flats, Colorado, USA, and initial tests by that impartial group have not been impressive, to say the least. (The first unit tested was destroyed recently by a 40 mile per hour gust - well below the rating of the unit!)

For the above reasons, I recommend the purchase of two Dunlite units immediately, according to the price structure and terms contained in their quotation. Further, I recommended that you wait for two or three months before considering the purchase of any other windmill for use at Pattiyapola village. This will give me more time to gain definitive information about some of the other units which might, in the near future, prove to be suitable for our purposes.

You will note that photovoltaic panels have been added to the basic schematic for the REC. In my Feasibility Report, I indicated that such devices offered the greatest promise for the future harnessing of solar energy, and that this type of solar contrivance could not be recommended because of its relatively high price. In recent months, a significant price "break" has come to pass, making it possible for me to recommend the use of such a system in Sri Lanka. That price break, incidentally, is entirely due to the concerted efforts of Dr. Usmani, whose persuasive powers are well known to you. I consider the purchase of the panels described by Spectrolab to be essential for the Sri Lanka REC. They are clearly superior to those quoted by the Dow Corning company, in that they provide their power without the use of concentrators. This offers the interesting possibility that concentrators can be developed for the Spectrolab unit which will at least triple the rating of their unit without substantially increasing their cost. Both quotations are included in the package I have sent to you. I'm recommending the Spectrolab system.

I do hope that Srinivasan has been able to proceed with the construction of the biogas unit we discussed. The quotation from Onan International for a spark ignition engine which has a rating of 24 kilowatts when operated from the biogas from his unit is included in the file I have sent to you. I have not included the quotations from three other manufacturers of such units. I am totally convinced that the Onan group is by far the best group to do the necessary modifications on such an engine, and I recommend that you proceed to order their unit without delay. Incidentally, I am gathering information about the type of treatments which can be used to remove carbon dioxide from biogas. If I can find one which is simple and inexpensive, I'll recommend its use in the Sri Lanka system. This will increase the biogas system rating from 24 to 37.5 kilowatts.

As I indicated in an earlier letter, I am prepared to undertake the testing and performance certifications necessary for the SI unit as an addition to my agreement with you. It now appears that an additional $1,500 will cover the cost of that procedure and make it possible for me to use the services of Dr. Richard Murray, whose credentials were described in that earlier letter.

The water purification unit I am recommending is essentially self explanatory. The increase in price for that unit resulted from a combination of inflation, water quality in the village reservoir, operating conditions, and the 50 HZ electrical requirement. Please note that a storage tank is included as an addition to the quotation. It can be provided by the manufacturer indicated if you wish. I'll leave that decision up to you.

As you know, the lifetime of the battery storage unit is more sensitive to abuse than the other system components. For this reason, I have modified the batteries recommended by changing the type of batteries to be used in the REC and by including special chargers for the batteries which will prevent them from being subjected to overcharge or excessive heat conditions. Two strings of C&D Type C145-21 cells are recommended. This means that the two parallel battery banks will be identical. When paralleled, the battery banks will provide more than 300 KWH of energy storage capability at 125 VDC. I have also increased the discharge time of the batteries from 3 to 6 hours, and this represents another reason for the change in batteries from those quoted in my Feasibility Report. I am recommending that the C&D quotation be accepted, and that their units be ordered as quickly as possible.

Please note that I have arranged for the batteries to be shipped in sets of 4 cells, each of which will weigh approximately 1000 pounds. This is the minimum feasible interconnection for shipment, and I asked for the packing to be done this way to reduce problems of unloading and transporting them when they arrive in Sri Lanka. Another point - I am aware that the cost of the items I am recommending has risen appreciably since my report was prepared in 1976. I have no doubt that UNEP was aware that such a circumstance was inevitable, due to the time lag between recommendation and shipment of equipment, and due to the world trend toward high inflation in every product manufactured anywhere. If these price increases develop into insuperable financial problems for the foreign exchange items to be used in the Sri Lanka REC, then only one string of C145-21 batteries should be ordered. This will cut the energy storage capability of the battery banks in half, but would still allow the system to perform satisfactorily, at a decreased rating.

A comparison of the up-dated quotations from the static inverter manufacturer and the motor-generator manufacturer is most interesting. The increase in cost of the static inverter is due to inflation and the necessity of providing a three phase unit (something not included in my original recommendation). The dramatic increase in the cost of the motor-generator set is due almost entirely to inflation. Obviously, the static inverter system represents the best buy, in terms of dollars per kilowatt. In addition, the static inverter recommended has the capability of easy synchronization with other 50 HZ power sources, through the interaction made possible by phase locked loop circuitry. This circuitry allows two or more AC signals to automatically track each other, and it does not require the sophistication associated with conventional methods of paralleling AC signals. I'm recommending that two of the Type 4 units be purchased.✓ Again, however, if price becomes the dominant factor in your decision to purchase the foreign exchange components of the system, one of the Type 4 units and its associated forward transfer switch will still allow the system to demonstrate its capability.

Incidentally, another advantage of using the static inverters in the Sri Lanka REC lies in the fact that no isolation-distribution transformers of the type we discussed in January will be required. The necessary degree of isolation and voltage adjustment required in the system can be provided by the static inverters without such transformers.

Some information related to the solar collector/Rankine Engine component of the system is also included in the package I have sent to you. That information is not yet in a form which can yield a definitive recommendation from me. As you know, Dr. Usmani is convinced that a test of the solar collectors with the Rankine Engine must be conducted to our satisfaction before either item can be ordered or recommended. The test is tentatively scheduled for mid-August, 1977. If the test is successful, then I will be most happy to recommend that you should purchase Mr. Minto's unit immediately. If the test is unsuccessful, or if the schedule for the test slips more than one or two months, then I am prepared to recommend an alternate solar collector to be used with the Minto Rankine Engine.

I have witnessed tests of the Minto Rankine Engine, and I am convinced that it will produce its rating of 10 KW when it is supplied with hot water at approximately 180°F and 50 gallons per minute, and stabilized at the cold side by 90°F water at the proper flow rate. Many solar collector manufacturers can provide collectors which can supply the proper temperature and rate of flow for the hot side of the engine. We could not arrange for a variety of collectors to be tested with the Minto Engine. The cost and logistics associated with such an approach proved to be untenable. I'm sure you can appreciate the risks which will be taken if we attempt a wedding of a collector and an engine for the first time in Pattiyapola village. We are presently trying to eliminate such risks by testing the two together before shipment.

The boiler shown in the basic system schematic will be capable of supplying hot watter at 180°F and 50 gallons per minute, for use in the Rankine Engine. The Huval Company in Sweden manufactures a boiler which appears to exhibit the desired characteristics. I will ask Mr. Srinavasan to supply the necessary biogas burner for this system component. The price for the complete system, even if I have to build it here, still falls within the range we discussed in our January meeting. I regret that I cannot supply more specifics relating to this item at this time. The probability of delays in ordering the Rankine Engine has caused me to give this component a relatively low priority.

I do hope the preceding discussion and the supplementary material I am simultaneously mailing to you is sufficient to allow you to begin placing orders for equipment. As of this writing, I have not received the funds necessary for my visit to Sri Lanka, or an up-dated list of equipment. These two factors, coupled with news we are receiving in this country about the post-election difficulties you are experiencing may make my visit impractical. I have tried to make this letter sufficiently detailed to allow you to proceed even it I am unable to give you an in-person presentation.

In this regard, let me make some procedural suggestions. As quickly and as expeditiously as possible, you should order the necessary components from Srinavasan to complete the biogas system, the Onan spark ignition engine-generator, the Speotrolabs photovoltaic panels, the water purification unit, half the batteries, all of the chargers, one 30 KVA static inverter and forward transfer switch, and two Dunlite windmills (complete with towers, etc.). These items will not completely exhaust your foreign exhange funds. After the funds for these items have been spent, then we can provide UNEP with an estimate of the increased budget which will be required for the complete system to be installed in Sri Lanka. My present belief is that significant delays might occur if we notify UNEP of the possibility that a budget increase before a significant amount of the funds already allocated have been committed.

If you follow the recommendation made above, a workable system which functions from solar, wind, and biogas resources will result, even if we are unable to acquire additional funds to complete the project. Again, I consider it unlikely that additional funds will be denied, but I respectfully suggest that you should minimize such a possibility by ordering some of the equipment as soon as possible.

Each of the manufacturers was made aware of the payment terms you suggested in your correspondence. (20% down, 60% on proof of insured shipment, 10% after installation, and the final 10% on completion of one year of successful operation.) None were willing to undertake their part of the program on such a basis, although some of the manufacturers indicated that they might participate in the program on those terms if they could revise their quotations upward to cover their risks. I am confident that each of the manufacturers is reputable, and I recommend that their terms as contained in their quotations be followed.

At a later date, I'll write a detailed letter relating to the training aspects of the REC program. Tentatively, I'd like to suggest that some of your people should visit Oklahoma for at least one week for an overview of the system, then visit the Minto facility in Florida to participate in testing the Rankine/solar unit, Spectrolab in California to observe the photovoltaic panel assembly, C&D Batteries in California to gain experience in handling large storage batteries, Rocky Flats in Colorado to view many of the windmills which may be suitable for insertion into RECs in the future, and Sandia Laboratories in New Mexico to obtain a perspective on solar and wind energy research as done in the United States. I can work out an itenerary for such a program, after I receive word from you as to the number of men involved in the activity, and the time available for them to particpate in a training effort. I'd like to be able to accompany them on the trip: however, I doubt that funds for that purpose will be available.

Finally, let me apologize to you for not following our agreement, which provided that I should send you telegraphic quotations for each item to be ordered when they became available to me. The various changes which have been described in this letter proved to me that I had to wait for all the information I have enclosed to come in before I could give you a clear picture of the system to be recommended.

I hope to see you soon.

Very truly yours,

H. Jack Allison

AL FISCAL REPORT

Project Director: H. J. Allison

t or Grant No. Sri Lanka REC Program

; May 1, 1977 through July 31, 1977

of Contract: Nine Months

ANALYSIS OF EXPENDITURES

Itemized Salaries

H. J. Allison - 3 months @ $550.00 per month	$1650.00
Secretary - 3 months @ 50.00 per month	150.00

	Current Charges	Cumulative Charges to Date
Salary Total	$1800.00	
Liability Insurance (included in salaries)	-0-	
Employee Benefits & FICA (included in salaries)	-0-	
Supplies & Services	60.00	
Equipment	-0-	
Travel	-0-	
Computer	-0-	
Publication & Reproduction	112.50	
Communications	85.00	
Freight	-0-	
Indirect Costs at 33% of -0- (not applicable)	-0-	
TOTAL EXPENDITURES		

Project Amount	$3000.00 (initial payment
Total Expenditures	2057.50
Balance Remaining on Project	$ 942.50

Oklahoma State University

SCHOOL OF ELECTRICAL ENGINEERING

STILLWATER, OKLAHOMA 74074
202 ENGINEERING SOUTH

July 26, 1977

THIS IS AN ADDENDUM TO MY LETTER TO YOU OF JULY 25, 1977.

A combination of factors has made it necessary for me to cancel my plans to visit you during the first week in August. It is my hope that this letter, and the accompanying information, will reach you during that period.

I'm sure you realize that Dr. Usmani is most concerned about the progress of the Sri Lanka REC. On numerous occasions, I have told him that the delays in getting the program going in Sri Lanka are primarily due to the slowness of UNEP to react to circumstances, especially when they relate to the transfer of funds. He insisted that I should come to Sri Lanka immediately, to determine the reasons for any delay in proceeding with the construction phase of the REC activities.

I believe the letter to which this addendum is attached contains essentially all of the information I could give to you concerning my part of the program, if I came to Sri Lanka. I believe, therefore, that I should give you an opportunity to respond to the contents of that letter before I undertake the trip. Frankly, I am unable to justify using $3000 of your UNEP funds to make the trip, when there is a high probability that the enclosed material may make that trip unnecessary.

The letter of credit needed by Srinivasan should be made available to him as soon as possible. Orders for at least part of the equipment described in the attached letter should also be handled as expeditiously as possible. This should calm Dr. Usmani, and convince him that real progress is being made in Sri Lanka. I am confident you will be able to accomplish these objectives.

A budget statement covering the last three months of my association with your program is attached. When the additional funds covering the cost of my visit to Sri Lanka arrive, I will deposit them in a special account in the First National Bank of Stillwater, Oklahoma USA, to be used for a future trip, or for continuing expenses related to my contract with you, or for return to you at some future date. Incidentally, it now appears that the funds you telexed to me went to the wrong bank, which accounts for the reason I have not yet received them. It would be helpful if future funds were sent to the bank named above.

H. J. Allison

Members of the Standing Committee

Mr. G.B.A. Fernando (Convenor)	Ministry of Finance & Planning
Dr. M. Amaratunga	University of Peradeniya
Dr. N.E. Wijesundera	University of Peradeniya
Dr. P.A. de Silva	University of Moratuwa
Mr. K. Herath	University of Moratuwa
Mr. K.D.N. de Silva	Director, Department of Meteorology
Mr. N. Sanmugarajah	General Manager, Ceylon Electricity Board
Mr. E. Carlo Fernando	Ceylon Electricity Board
Mr. S. Sivasubramaniam	Department of Irrigation
Mr. N.D. Peiris	National Water Supply & Drainage Board
Dr. S.P.F. Senaratne	Marga Institute
Mr. D.B.J. Ranatunga	National Engineering Research & Development Centre
Mr. Ivon Cooray	Industrial Development Board
Government Agent	Hambantota
Mr. Arthur C. Clerke	

Chairman

SEG

Prof. H. Jack Allison visited Sri Lanka in January 1976 followed by Mr. H.R. Srinivasan in March 1976. It was felt that although the Bata Ata Farm was a better site than the Pattiyapola village for biogas, a decision was taken on the Pattiyapola village site because the Farm was not a typical village and may not serve the desired purpose.

Following H. Jack Allison's preliminary report in March 1976, UNEP Nairobi requested a standing Committee of Meteorologists, Social Scientists, Engineers and Economists working in Sri Lanka institutes and Government Departments appointed to assist OSU in preparation of final feasibility report. The standing Committee was appointed but OSU prepared the final report independently and wanted the standing Committee to answer questions posed in a letter of July 12th 1976 by Dr. I.S. Usmani. Soon afterwards on the recommendations of the standing Committee, a Project agreement was signed between Sri Lanka and UNEP to establish the REC by November 1978 with the General Manager Electricity Board as the executing agent. The original project at a cost US $ 233,500 (UNEP US $ 191,000. Sri Lanka US $ 42,500 in local currency) was revised with additional funding of US $ 105,000 by UNEP to be completed by November 1979.

Dr. I.H. Usmani has requested that the standing Committee now meet and submit a report on the project. I intend doing so very soon.

Sgd.
G.B.A. Fernando

APPENDIX 3(c)

FINAL FEASIBILITY REPORT

AN ENERGY CENTER IN SRI LANKA

Report No. ER-77-R-1

PREPARED FOR THE GOVERNING COUNCIL OF THE
UNITED NATIONS ENVIRONMENT PROGRAMME

June 30, 1976

H.J. Allison, Project Director
J.D. Burson
J.C. Burba
C.E. Gordon
S.R. Southerland

THE ENGINEERING ENERGY LABORATORY

College of Engineering
OKLAHOMA STATE UNIVERSITY
Stillwater, Oklahoma 74074

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NA-48-4

FEASIBILITY REPORT

AN ENERGY CENTER IN SRI LANKA

Chapter I

INTRODUCTION

In May, 1975, the Governing Council of the United Nations Environment Program issued a decision which addressed the problem of improving the human environment in remote villages in the developing world. The decision observed that hundreds of millions of people living in rural areas of the developing countries of Asia, Africa, and Latin America are far removed from the mainstream of development activities, and that they live in conditions of poverty which cause degradation of the quality of their lives and of the social dimension of their environment. It also noted that an input of energy on a comparatively small scale could provide the basic energy needs for cooking of food, pumping and desalination of water for drinking and irrigation, and lighting of dwellings in such areas. Such energy inputs could, the decision noted, lead to an enhancement of the quality of life and therefore of the social environment in those parts of the world.

Conventional methods of supplying energy to remote villages in the developing world involve an extension of existing electrification grids or the installation of autogeneration, or diesel generators, in each village. Such methods generally require the continuous importation of hydrocarbon fuels for their operation. The rapid rise in the cost of such fuels, coupled with its finite availability, has discouraged the expansion of energy systems in much of the developing world.

The decision of the Governing Council recognized that most of the rural areas in the developing world have no fossil fuel resources, but possess, in varying degrees, renewable energy resources such as solar energy, wind energy, hydro power, biogas obtained from agricultural and animal wastes, and wood from quick-growing trees, which could be harnessed to meet the energy needs of the local communities. Finally, the decision expressed the belief that the existing state of the art of the appropriate technologies for harnessing renewable energy resources under the conditions prevailing in the rural areas of developing countries of Asia, Africa, and South America could justify, on socio-economic considerations, the use of such technologies.

As a result of the decision by the Governing Council, the Executive Director of UNEP gave a high priority to the establishment of a few demonstration centers which harness the renewable resources of energy locally available in some of the typical rural areas in the developing world. Senegal, Barbados, and Sri Lanka were chosen as prospective sites for the demonstration centers. Brace Research Institute of Canada, the University of Florida of the United States, and Oklahoma State University of the United States were asked to participate in the conceptual phases of the rural energy center development program.

Since 1961, an interdisciplinary team of researchers at Oklahoma State University have been developing a family of energy systems which operate from an input of solar and wind energy to provide electrical energy which can serve a wide variety of human needs. It was this background, coupled with a long history of associations with developing countries, which caused UNEP to choose OSU to assist in efforts to develop energy systems for use in developing nations around the world.

The idea that small packages of energy, derived from the widely distributed, non-depleting, and ecologically secure energy of the sun could be incorporated into rural villages in the developing world in a manner which could dramatically improve the quality of life in such villages, as advanced by the Governing Council of UNEP, has been basic to the OSU research effort since its inception.

In June, 1975, a small group of researchers at OSU began accumulating information related to contrivances which might be helpful in developing a rural energy center in Sri Lanka, in anticipation of future association with the UNEP program. Various scenarios were constructed, based on the assumption that a site could be located which had sufficient solar and wind energy resources to provide power which could satisfy several basic needs, such as illumination, water purification and pumping, and cooking in a small village far removed from an electrical power grid. This effort was accelerated when the UNEP funding was received, and it was sharpened in focus by information obtained during a visit to Sri Lanka by Dr. H. Jack Allison, Head of the OSU UNEP team.

In December, 1975, Oklahoma State University signed a contract with the United Nations Environment Program, to develop plans for a Rural Energy Center to be installed in Sri Lanka. Funding for this program reached OSU in January, 1976. This report represents a summary of activities undertaken and results obtained by OSU during the period covered by the contract with UNEP.

This report will document the characteristics of the village which was selected by the Government of Sri Lanka for the proposed energy center, analyze the meteorological data associated with the site, describe the system design recommended for the site, and compare the economics associated with the proposed system with more conventional solutions to the problem of supplying energy to remote villages in the developing world. An interim report, based on guidelines suggested by Dr. I. H. Usmani, Senior Energy Advisor to UNEP, was submitted to the Governing Council of UNEP in March, 1976, for use during the annual meeting of the Council in Nairobi, Kenya. As requested by UNEP, various aspects of the interim report are included in this final Feasibility Report, in an effort to provide a complete and comprehensive document which satisfies the letter and the spirit of the contract between OSU and UNEP.

Chapter II

SITE SELECTION

Sri Lanka (formerly Ceylon) is a teardrop shaped island near the southern tip of India. It is approximately 270 miles long and 140 miles wide, and it has a total land area of 25,332 square miles. Geographically, its location is between 6° and 10° North Latitude and between 79° and 82° East Longitude. Total population of the island is approximately 13.5 million people.

Approximately 80% of the population of Sri Lanka is located in rural areas of the country. Approximately 80% of the population of the island is involved, directly or indirectly, in agriculture. Export trade is primarily dependent on plantation crops such as tea, rubber, and coconut. In 1974, Sri Lanka had a balance of trade deficit of 170 million dollars. Approximately 30% of the foreign exchange earnings in Sri Lanka is spent in the importation of oil.

The climate of Sri Lanka is governed by the mountain barrier of its highlands, which are located slightly south and west of the center of the island. These mountains, some of which are over 8,000 feet in elevation, interact with the south-west and north-east monsoons which are characteristic of that part of the Asian sub-continent to produce heavy rainfalls in the mountain areas, and lesser amounts of rain in the costal lowlands. Average rainfall for the country is 76.3 inches.

The combination of heavy rainfall and the abrupt change in elevation from the mountainous area to the costal lowlands has given Sri Lanka excellent potential as a source of hydro power. Total hydro potential for the island is presently estimated to be in excess of 1,500 megawatts. Presently, approximately 250 megawatts of that potential has been exploited. A considerable investment in time and capital will be required before the hydro potential of the island can be fully developed.

In short, Sri Lanka is blessed with many advantages which could make it a model for the rest of the developing world in the future. The country is not overpopulated, has an excellent climate, good water resources, untapped energy resources, a fine university system, and a relatively stable political structure. The fact that Sri Lanka will be the host country for a major meeting of the non-aligned nations of the world in August, 1976, is further evidence of the leadership role Sri Lanka has in the developing nations of the world.

A series of maps which identify the bioclimatic, rainfall, water table, and ground water characteristics of Sri Lanka are shown in Figure One, Figure Two, Figure Three, and Figure Four. These maps were provided by Mr. A. Denis N. Fernando, the Senior Deputy Director of Planning in the Ministry of Irrigation, Power and Highways of Sri Lanka. The maps were used to identify prospective sites for the UNEP Rural Energy Center, and they will be referred to in subsequent sections of this narrative.

A basic premise of the proposed UNEP effort to install rural energy centers in developing nations throughout the world is that the basic resources of solar, wind, and biogas energy are available in most of the villages which could benefit from such energy centers. The relative mix of available energy inputs can be expected to be sensitive to the specific village selected. It is expected that significant differences might occur between systems installed in one area of the world as compared to others, due to the availability of energy and the specific human needs of the villagers. Although site selection for implementation of the rural energy center concept is not expected to be critical as the systems expand, it was considered important that the site selected for the first demonstration centers be carefully considered, and that they be chosen with respect to a specific set of constraints. Many of these constraints will not be necessary when the systems are multiplied throughout the developing world. Further, some of the constraints proved to be in conflict with other criteria used during the site selection process. The following discussion of the factors which influenced the site selection process is included in this report to document the reasons for selecting Pattiyapola village in Sri Lanka as the site for the proposed Rural Energy Center.

Accessibility to a major transportation artery was one constraint imposed on the selection of the site for the demonstration center in Sri Lanka. It was agreed the center should be made conveniently accessible to visitors from throughout the world. This would enhance the possibility that its basic attributes could be given the widest possible exposure to other interested nations. This consideration dictated that the site chosen should be within a few hours driving time from Colombo, the capital of Sri Lanka.

Isolation from a conventional electrical distribution grid was another consideration used in the site selection process. This constraint proved to be in conflict with the accessibility constraint listed above, since the establishment of a good road system is generally paralleled by the construction of electrical transmission grids in the general vicinity of the transportation artery. It was anticipated that a compromise between accessibility to a power grid and accessibility to a good road system would have to be struck in selecting a site for the demonstration center, and that the site selected might have to be only a few miles from a conventional electrical grid.

Availability of all three of the basic energy inputs at the energy demonstration center site was considered essential. If such a site could be found, then visitors from other parts of the world could select from the operating system those components which would operate from the resources available in their area. An external examination of the meteorology of Sri Lanka was conducted in an effort to locate an area which appeared to have good solar and wind energy regimes. The examination suggested the southern part of the island would be most promising as an area in which to search for a site. This area of Sri Lanka, as shown in Figure One and Figure Two, is in the dry zone and could, therefore, be expected to have a high degree of solar insolation. Further, the combination of inland mountains and nearby ocean at the southern part of the island could be expected to create the temperature gradients required for strong, reliable winds.

From a scientific viewpoint, it would be desirable to have total documentation related to the availability of solar, wind, and biogas resources at the proposed site. Such total documentation is, of course, not possible in a remote, isolated village in the developing world. It would require the installation of a relatively sophisticated, battery powered meteorological station at various candidate sites around the island, then accumulating several years of data before making a choice of location for the UNEP energy center. The time delay inherent in such an installation made it unacceptable for this UNEP program. The approach taken was, therefore, to search for a site close enough to an existing meteorological station to justify the use of data from that station, then estimate the energy available at the site on an extremely conservative basis.

Village size and infra-structure were other important criteria used in the site selection process. The direct relationship between village size and the amount of energy required to satisfy the basic needs of its people dictated that a relatively small, isolated village should be selected. Another factor limiting the size of the village selected was, of course, the cost of the system to be installed. Since many aspects of the system to be developed would require the co-operation of the village as a whole, it was considered desirable that a village with strong leadership and a solid infra-structure could be found in the southern part of Sri Lanka. Good rapport and an established working relationship between the leadership of the village and progressively higher levels in the government of Sri Lanka was also considered essential to the successful operation of the energy center during the constructing and testing phases of the program.

The site selection process began with a visit to Sri Lanka by Dr. I. H. Usmani, Senior Energy Advisor to UNEP, in October, 1975. Dr. Usmani made personal contacts with the government, industry, and university officials who had an interest in the Sri Lanka Energy Center Program. He described the nature of the project, emphasizing the environmental advantages which might result if the energy center concept could spread throughout the developing world. Accompanied by Mr. N. Sanmugaraja, General Manager of the Ceylon Electricity Board, and Mr. G. B. A. Fernando, Assistant Director of the Ministry of Planning and Economic Affairs of Sri Lanka, Dr. Usmani toured the southern part of Sri Lanka, pointing out various sites which might be chosen for the Asian

Energy Center. His efforts were received with enthusiasm, and he charged the Government of Sri Lanka with the responsibility of choosing an appropriate site for the energy center, based on the general constraints of basic need, availability of solar and wind energy resources, and accessibility to Colombo.

When Dr. H. Jack Allison, head of the OSU UNEP team visited Sri Lanka in January, 1976, he was received with courtesy, interest, and enthusiasm. This was a direct result of the earlier visit by Dr. Usmani. Dr. Allison spent eleven days on the island meeting various officials and consulting local experts in the meteorological and technical areas who had a background of interest in solar, wind, and biogas resources. Dr. Allison was impressed with the fact that the government of Sri Lanka has already decided to develop its renewable energy resources, primarily hydroelectric in nature, instead of committing its future development to dependence on hydrocarbon or nuclear options. Existing research efforts to determine the feasibility of using solar, wind, or biogas energy resources were also impressive. It was apparent that the installation of a Rural Energy Center would be a great stimulant to local research in the unconventional energy area.

The high point of the OSU UNEP representative's visit occurred when he arrived at Pattiyapola village, the site chosen by Sri Lanka for the Asian Rural Energy Center. Pattiyapola village is located a few miles inland near the southern tip of the island. The village is easily approached from the road between Hambantota and Matara. The specific location of the village is indicated on the map shown in Figure Five. Also indicated in Figure Five is the location of those meteorological stations in Sri Lanka which contain wind energy instrumentation. Figure

Six is an aerial photograph of the village, which shows its proximity to the southern coast of the island and indicates the nature of the terrain in and adjacent to the village. The bioclimatic map shown in Figure One describes the site as a hot, arid, lowland tropical area. The rainfall map shown in Figure Two indicates the fact that the village is in the dry zone of the island. The water table map of Figure Three indicates that potable, sub-surface water might be available to the village at a depth of slightly more than thirty feet. The ground water map shown in Figure Four indicates the high availability of ground water recharge at the site.

Pattiyapola village is somewhat isolated from other villages in the area. It is distributed around an artifical reservoir, approximately one mile wide and one and a half miles long. The reservoir dates back to approximately 200 AD, and the history of the village can be traced to its formation. Officials of the Ministry of Planning and Economic Affairs, with the advice and counsel of the Ceylon Electricity Board, chose the site for the following reasons:

1. Proximity to Colombo - driving time is approximately three hours, through an extremely scenic part of the island.
2. Contact of the desired continuity from a high government level to the Gramma Sevaka, or village elder, already exists.
3. Proximity to Hambantota - where extensive meteorological information is available which indicates the solar and wind resources at the village should be suitable for the program.
4. Scenic beauty and history - the site is an extremely beautiful and interesting one to visit. It was believed that this fact was significant in the selection of a site, since important people would visit it.

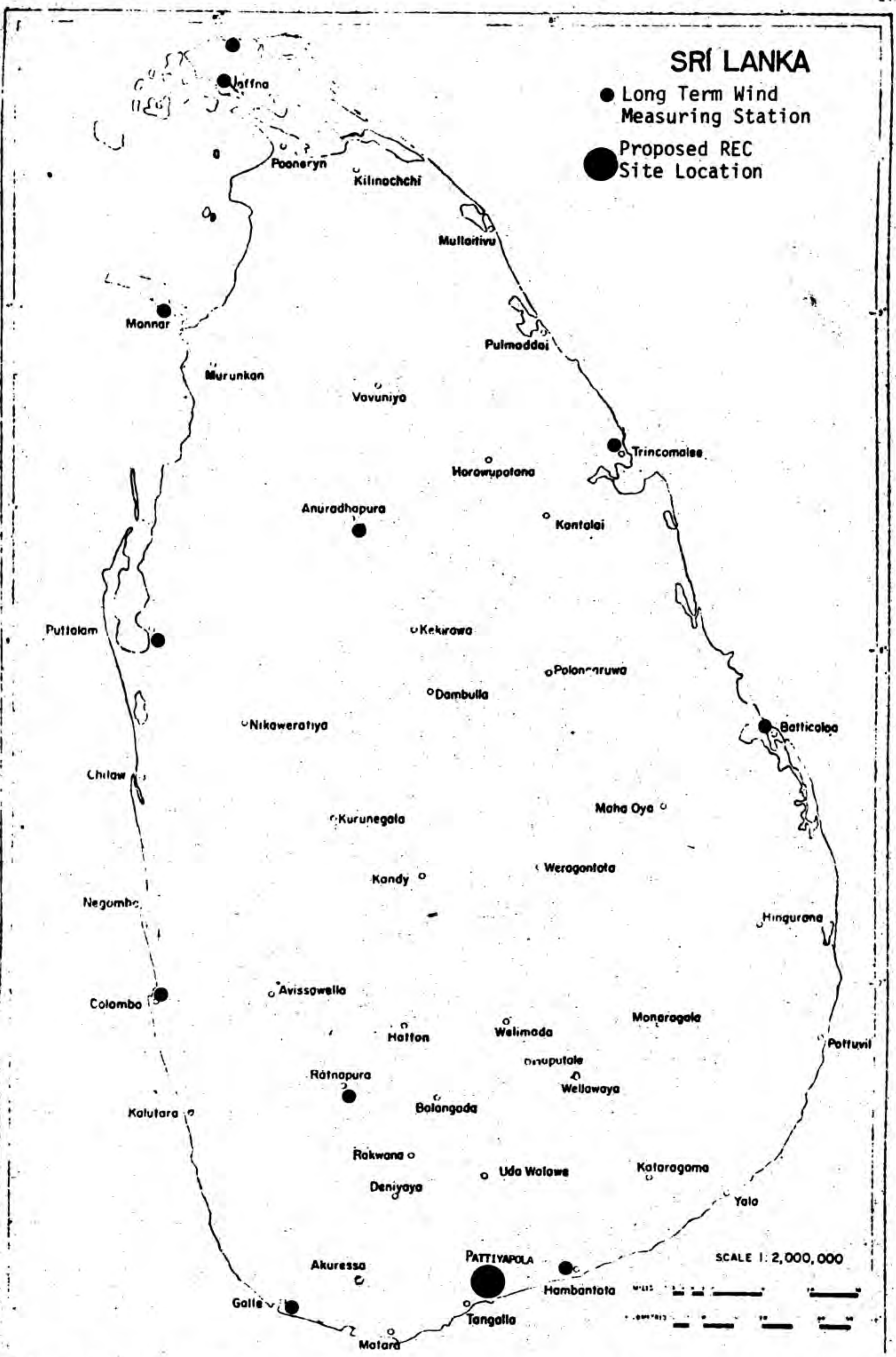

Figure Five. Map Showing Location of Proposed Site for UNEP Energy Center.

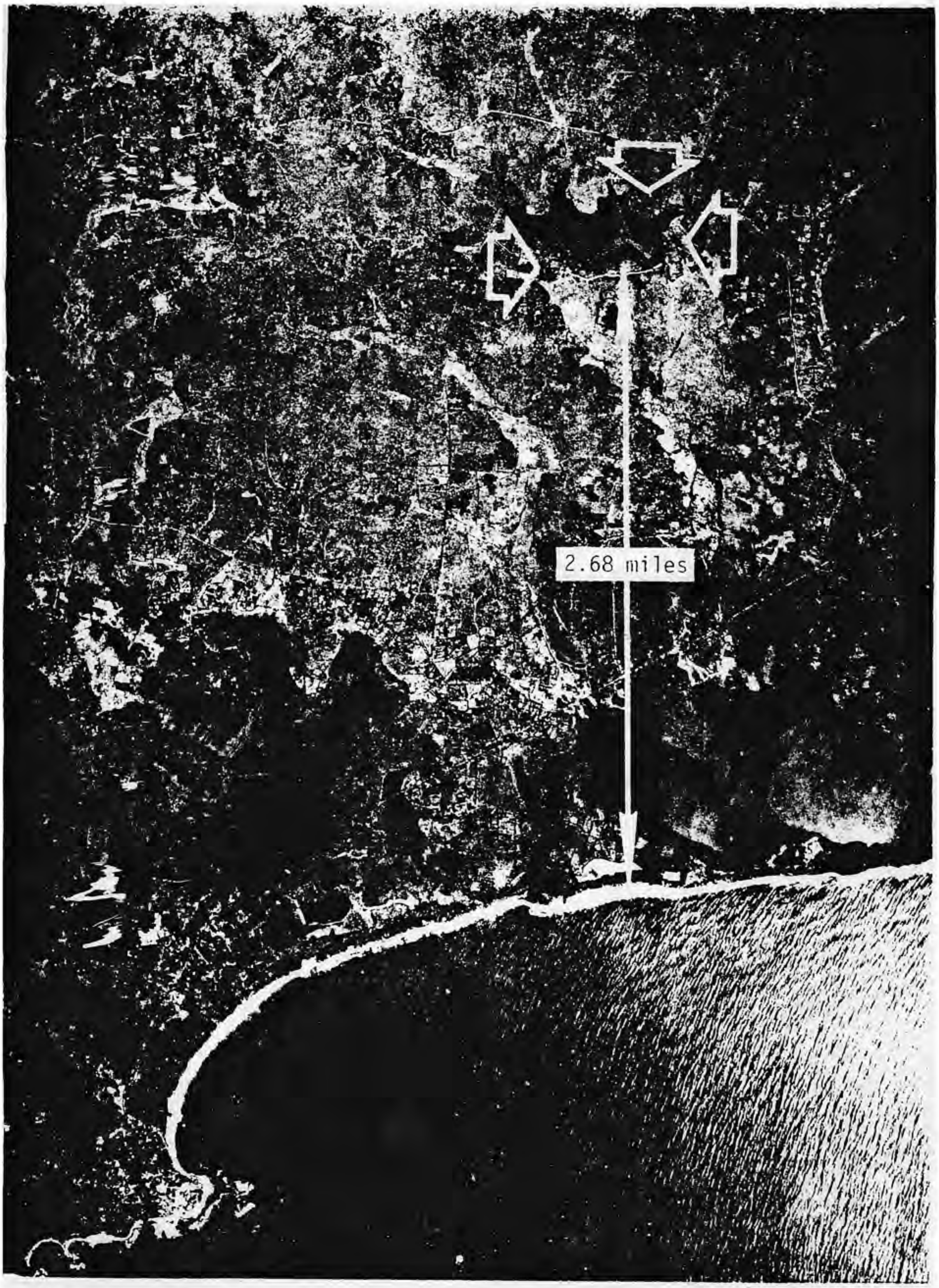

Figure Six. Aerial Photograph of Site, Indicating Topography of Site and Its Environs.

5. Statements of interest from the villagers - the Gramma Sevaka was most interested in the program and pledged his co-operation in every way possible.

6. Layout of the village - Most of the villages in the southern part of Sri Lanka have developed along the roads linking the larger cities in the area. They are, therefore, spread along several miles of roadway, and cannot be considered villages in a classical, compact sense of the phrase. Pattiyapola village lies along a reservoir boundary and is, therefore, more compact than most of the villages considered for the Rural Energy Center. This is a definite advantage in terms of logistics and economics if the Energy Center enters a construction phase at some time in the future.

Chapter III

METEOROLOGICAL INFORMATION

As previously noted, the southern part of Sri Lanka was considered promising as a site for the Rural Energy Center, based on an external examination of the topography and rainfall patterns on the island. This promise was confirmed by the Sri Lanka Meteorology Department. Extensive data was provided which documented the solar and wind characteristics at various meteorological stations around the island. Of particular interest was the data provided for the Hambantota station, which is located a few miles west of Pattiyapola village. As shown in Figure Five, only three meteorological stations in the area have records of wind velocity measurements over a suitable period of time. The relatively large distance from the site to Ratnapura and Galle, coupled with the differing bioclimatic, rainfall, or elevation characteristics of those stations, made it impossible for data from those stations to be used in analyzing the meteorological conditions associated with Pattiyapola village.

The data associated with the Hambantota, Sri Lanka meteorological station is summarized in the remainder of this chapter. The basic source for the information presented is the Report on the Colombo Observatory for 1967, by L. A. D. Ekanayake, former director of the Department of Meteorology for Sri Lanka. This source was confirmed and complimented by data provided by Mr. K. D. N. de Silva, present director of the Sri Lanka Meteorology Department. Except for the absence of information related to cloud cover, or cloudy days, the information provided made possible a rough estimate of the solar and wind energy resources associated with the proposed center.

Figure Seven is a plot of average monthly wind speed at Hambantota versus wind speed for the period of 1911 through 1960. The data shows an average wind speed of 12.3 miles per hour for the 49 year period. Figure Eight and Figure Nine represent similar plots for 1967 and 1975, respectively. The average wind speed for those years is shown to be 13 miles per hour, respectively. These plots demonstrate an extremely reliable and strong wind regime for the Hambantota station over the past sixty-four years. The distribution of wind speeds at Hambantota on an average day for each month of the year for 1975 is indicated by the table shown in Figure Ten. The table shows that, except for the months of April and November, a wind speed in excess of ten miles per hour can be expected to occur for more than half a day for an average day at Hambantota.

Solar energy data for the Hambantota station is processed in Figure Eleven, Figure Twelve, and Figure Thirteen. Figure Eleven is a plot of average solar intensity per ten hour day, in watts per square foot, versus months for a typical year, 1965. The data shows a minimum solar intensity of approximately 44 watts/ft^2 average for July, with a maximum solar intensity of approximately 78 watts/ft^2 average for April. Inspection of Figure Eleven indicates that at least 500 watt hours per square foot of land surface can be anticipated in regions of Sri Lanka which are in close proximity to Hambantota. This rather conservative figure is significantly higher than solar insolation figures characteristic of sunny areas within the continental United States. Figure Twelve is a plot of average solar intensity in watts/ft^2 versus hours for an average day in 1965 at Hambantota. Again, an average insolation energy in excess of 500 watt hours per square foot is noted. Figure Thirteen is a plot indicating the rain pattern associated with the Hambantota station. Although that plot cannot be used to determine the

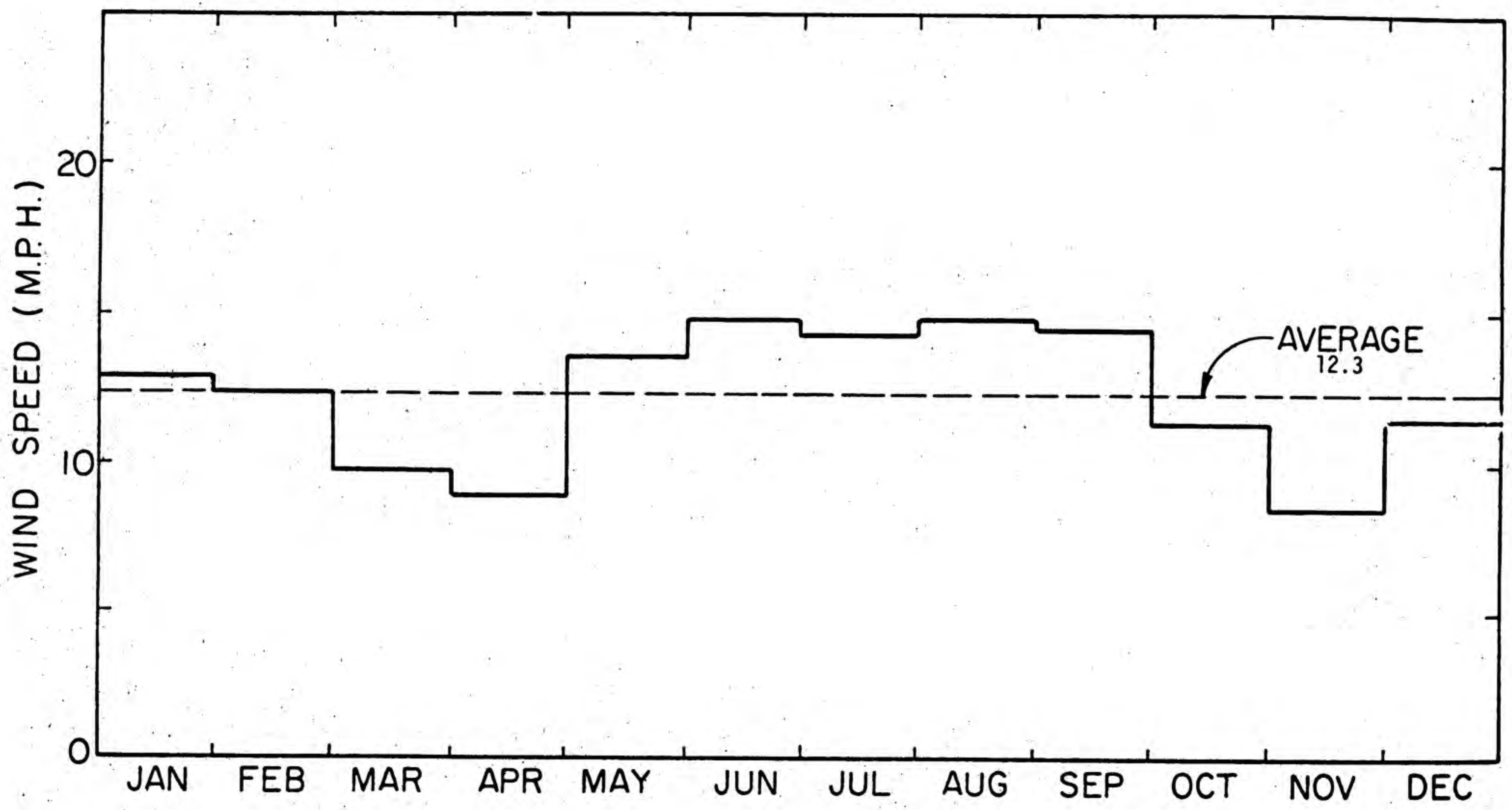

Figure Seven. Average Monthly Wind Speed At Hambantota (1911-1960)

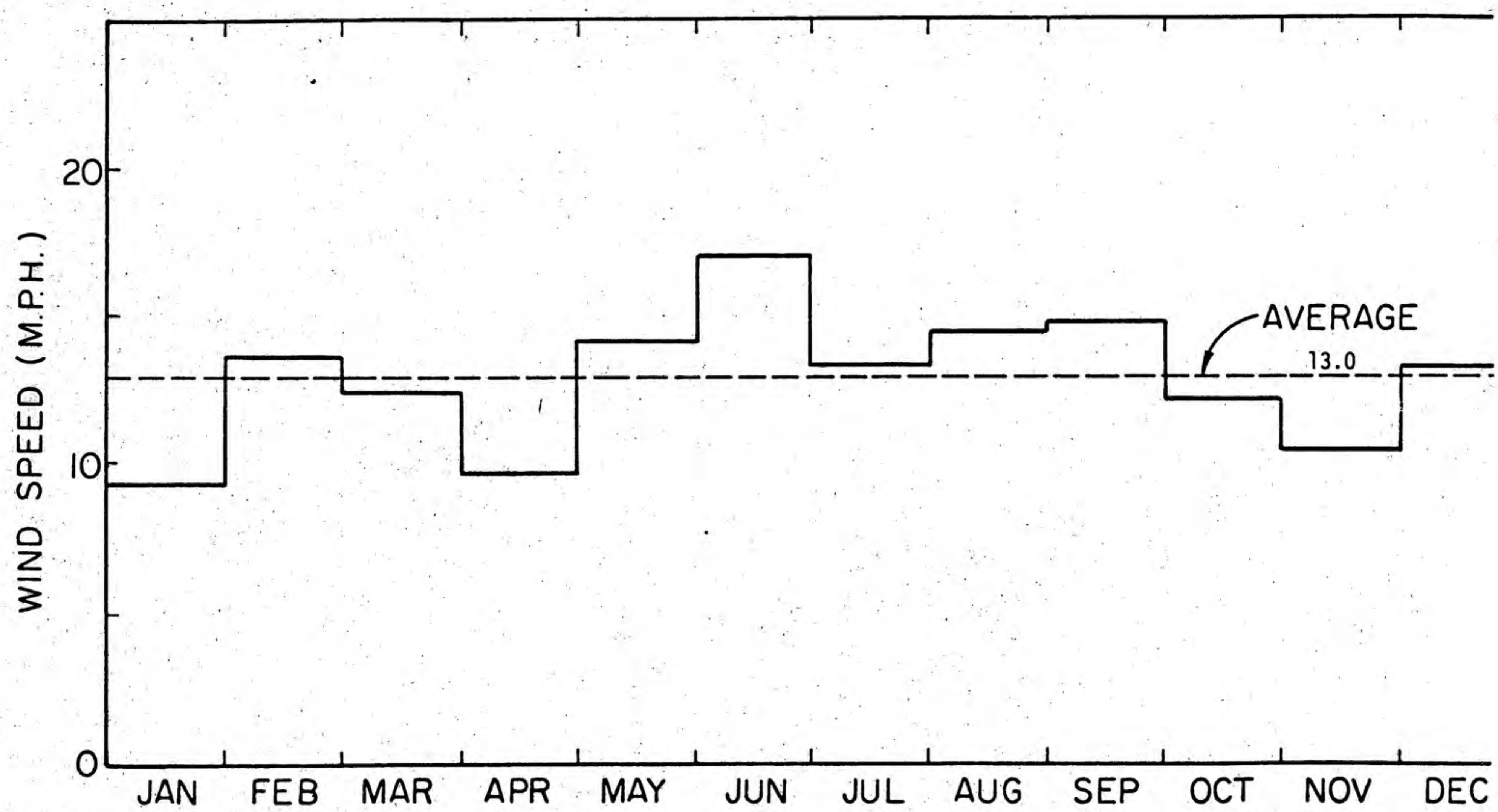

Figure Eight. Average Monthly Wind Speed At Hambantota (1967)

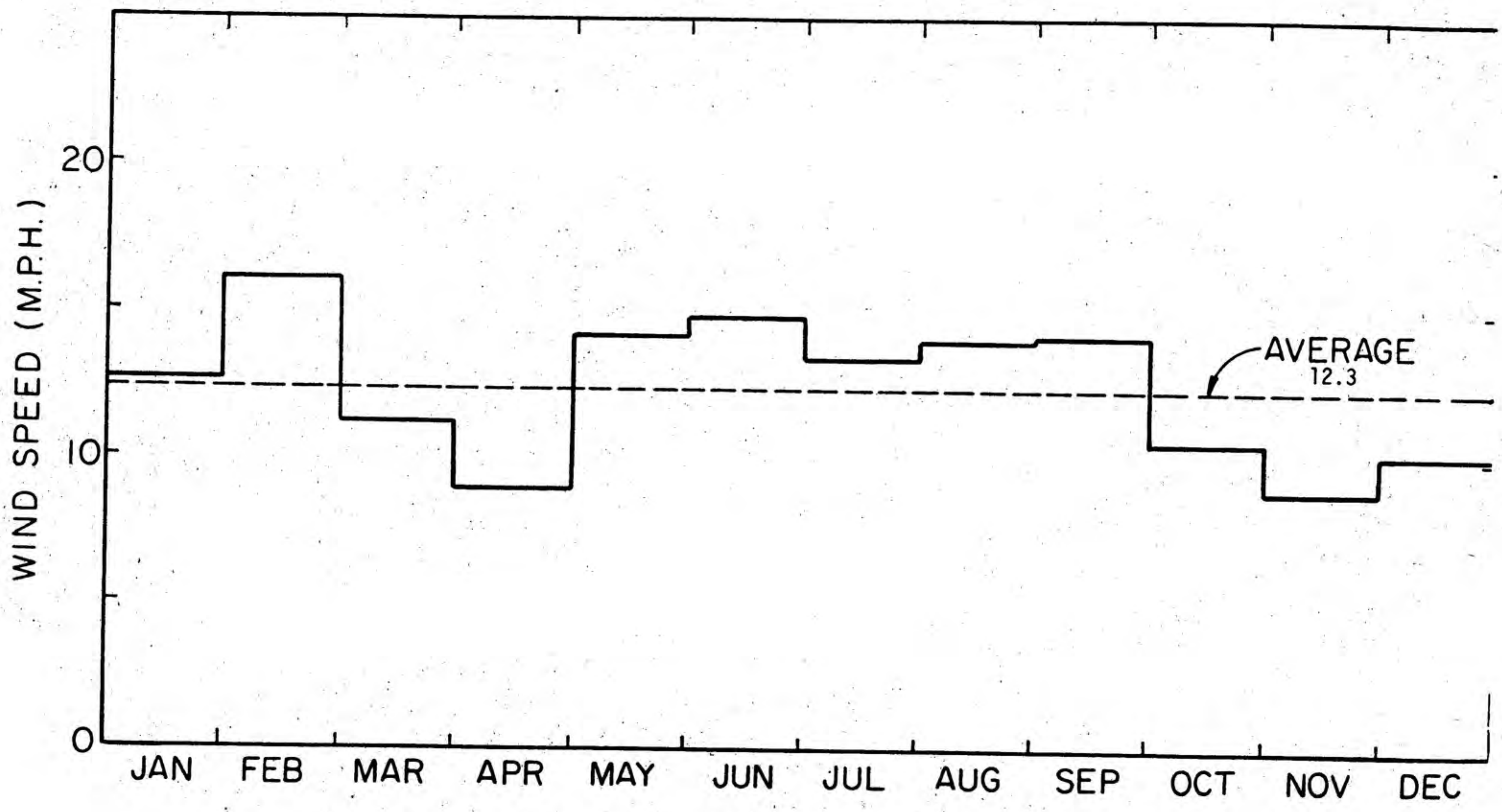

Figure Nine. Average Monthly Wind Speed At Hambantota (1975)

% per day/mph	3.1	7.75	10.85	13.95	17.05	20.15
January			37.5	62.5		
February			41.7	33.3	25.0	
March		29.2	37.5	25.0	8.3	
April	33.3	29.2	20.8	16.7		
May			41.7	20.8	16.7	20.8
June			29.2	29.2	12.5	29.2
July			45.8	25.	29.2	
August			45.8	16.7	16.7	20.8
September			45.8	16.7	12.5	25.0
October	4.2	45.8	16.7	25.0	8.3	
November	20.8	41.7	29.2	8.3		
December		41.7	37.5	20.8		

Figure Ten. The Percent Average Wind Speed in an Average Day of a Month.

number of days in a row in which the solar energy will not be available at the site, it does indicate the relative dryness (for Sri Lanka) of the area. The solar energy data accumulated at Hambantota over a fifty year period can be considered an excellent indication of the solar characteristics which will be present at Pattiyapola, since solar insolation is far less critical of topography than wind energy.

A basic premise of the Rural Energy Center design is that the use of both solar and wind energy as inputs to an unconventional energy system can provide a more reliable source of power than would be possible if only one of these resources was used in the system design. As shown in Figure Fourteen, the complementary nature of wind and solar energy at Hambantota gives validity to that premise. The plots shown in Figure Fourteen represent normalized plots of solar and wind energy available at Hambantota for each month of the year. With the exception of the month of November, the plots do indicate that the solar and wind energy regimes at Hambantota are, indeed, complimentary.

It must be noted that the Hambantota station is located on the southern coast of Sri Lanka, and that Pattiyapola village is several miles inland and approximately thirty miles to the east of the meteorological station. There is, therefore, the possibility that the meteorological information which was accumulated during the data collection phase of this feasibility study might not be totally representative of the conditions prevailing at the Rural Energy Center site. Total confirmation of the wind and solar characteristics associated with the site would require the erection of a fully instrumented meteorological station at Pattiyapola village. A time interval of several years would then be required for the accumulation of data from such a station before

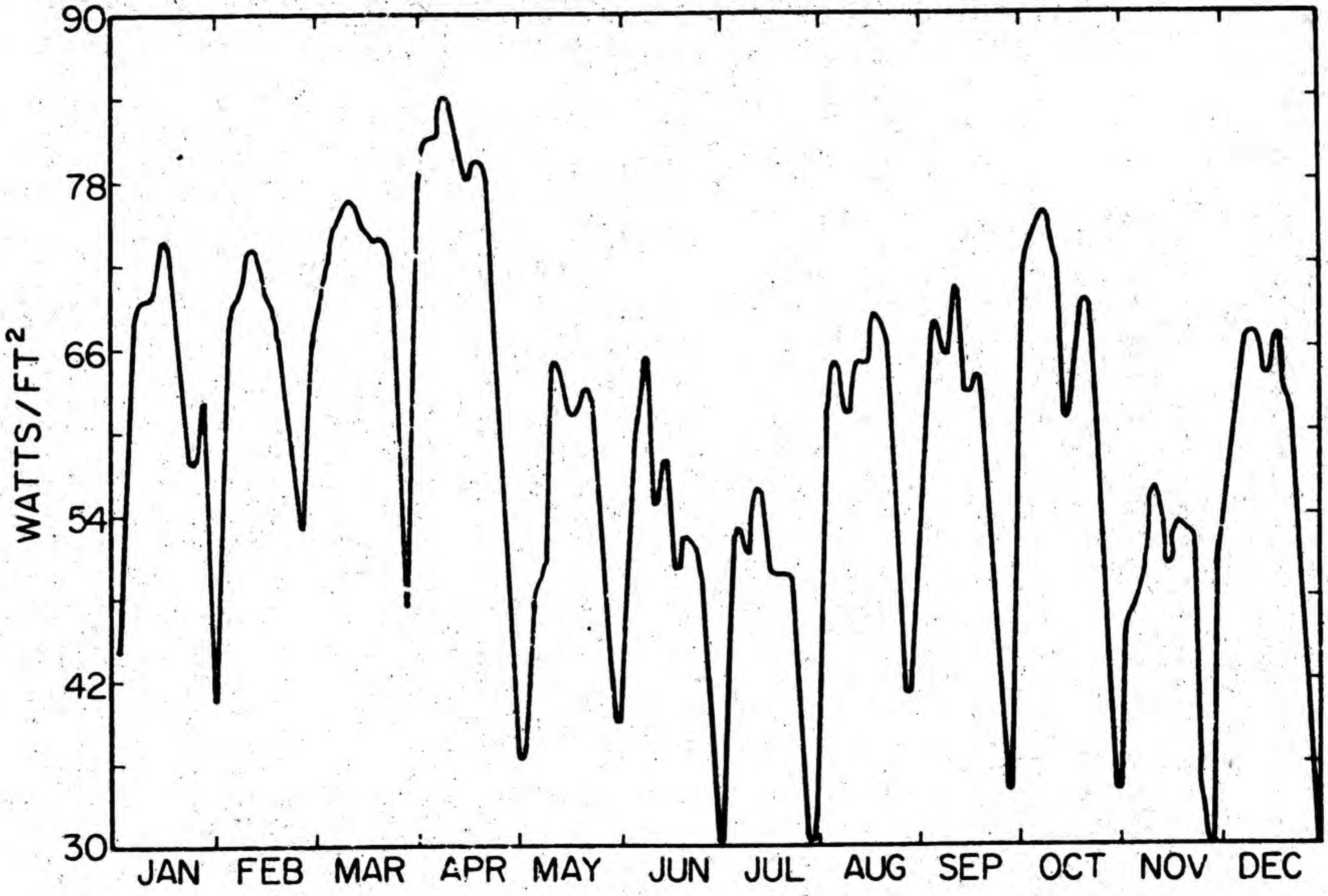

Figure Eleven. Average Solar Intensity Per 10 Hr. Day For Given Month.

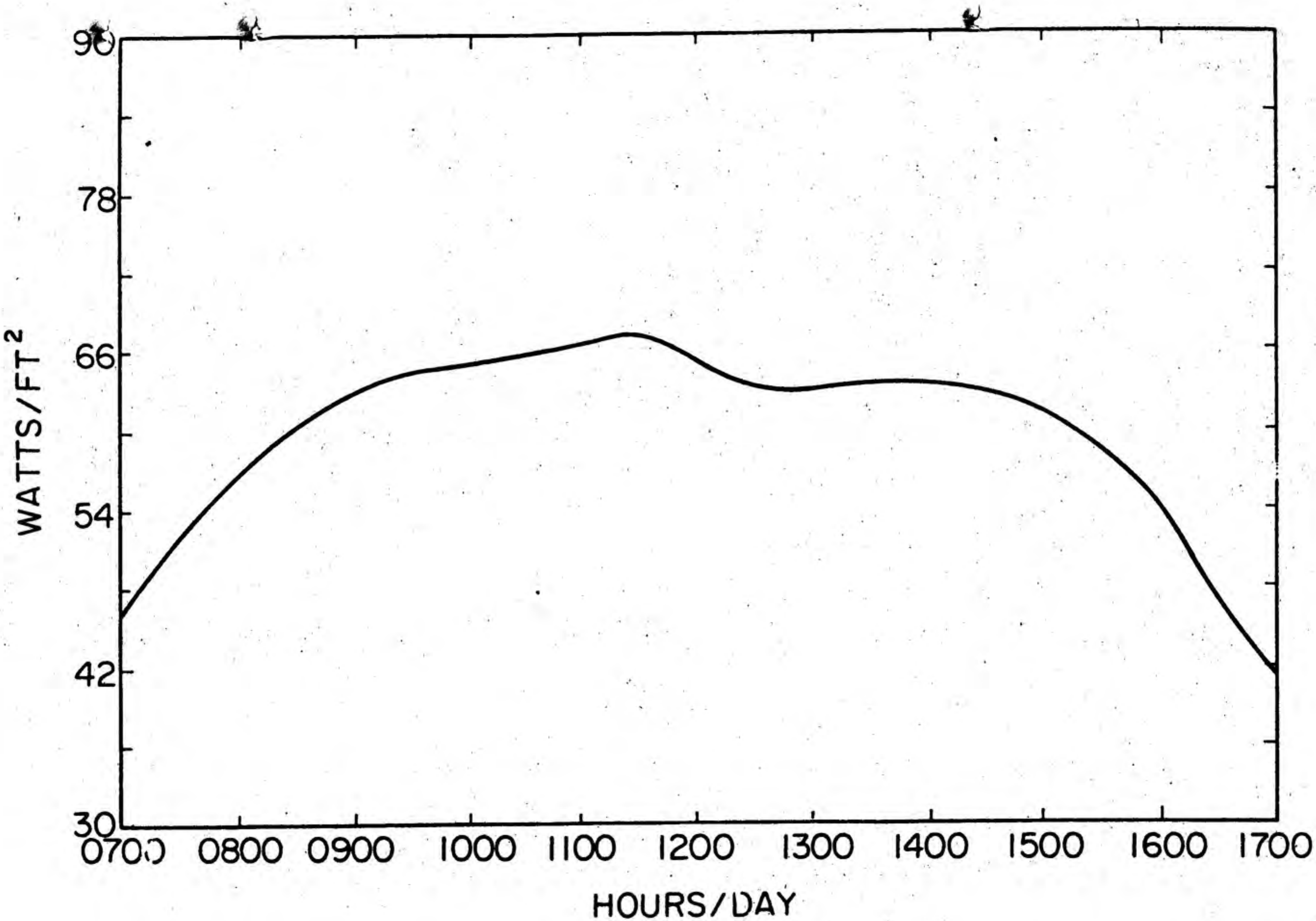

Figure Twelve. Average Solar Intensity Per 10 Hr. Day For Given Year (1965).

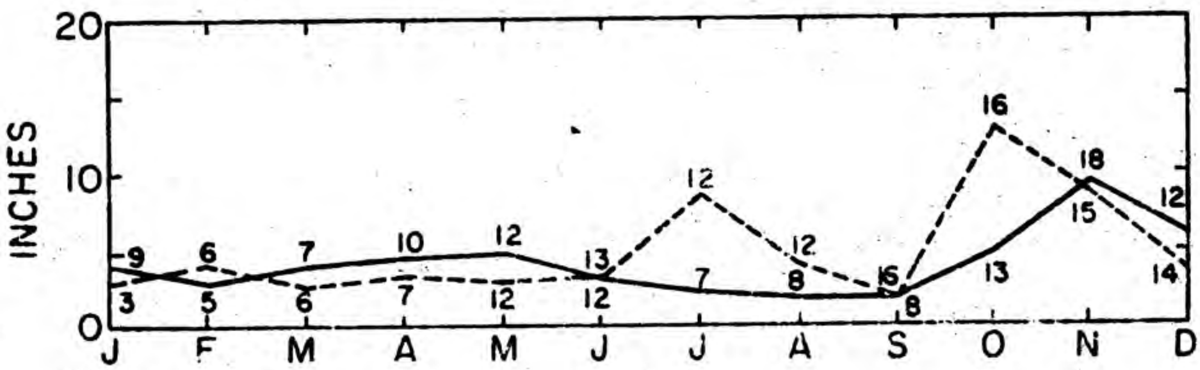

Figure Thirteen. Percentage Rain Days During 1967 (Chain Line) Offset From Average (Solid Lines) Figure Indicates Number of Rain Days.

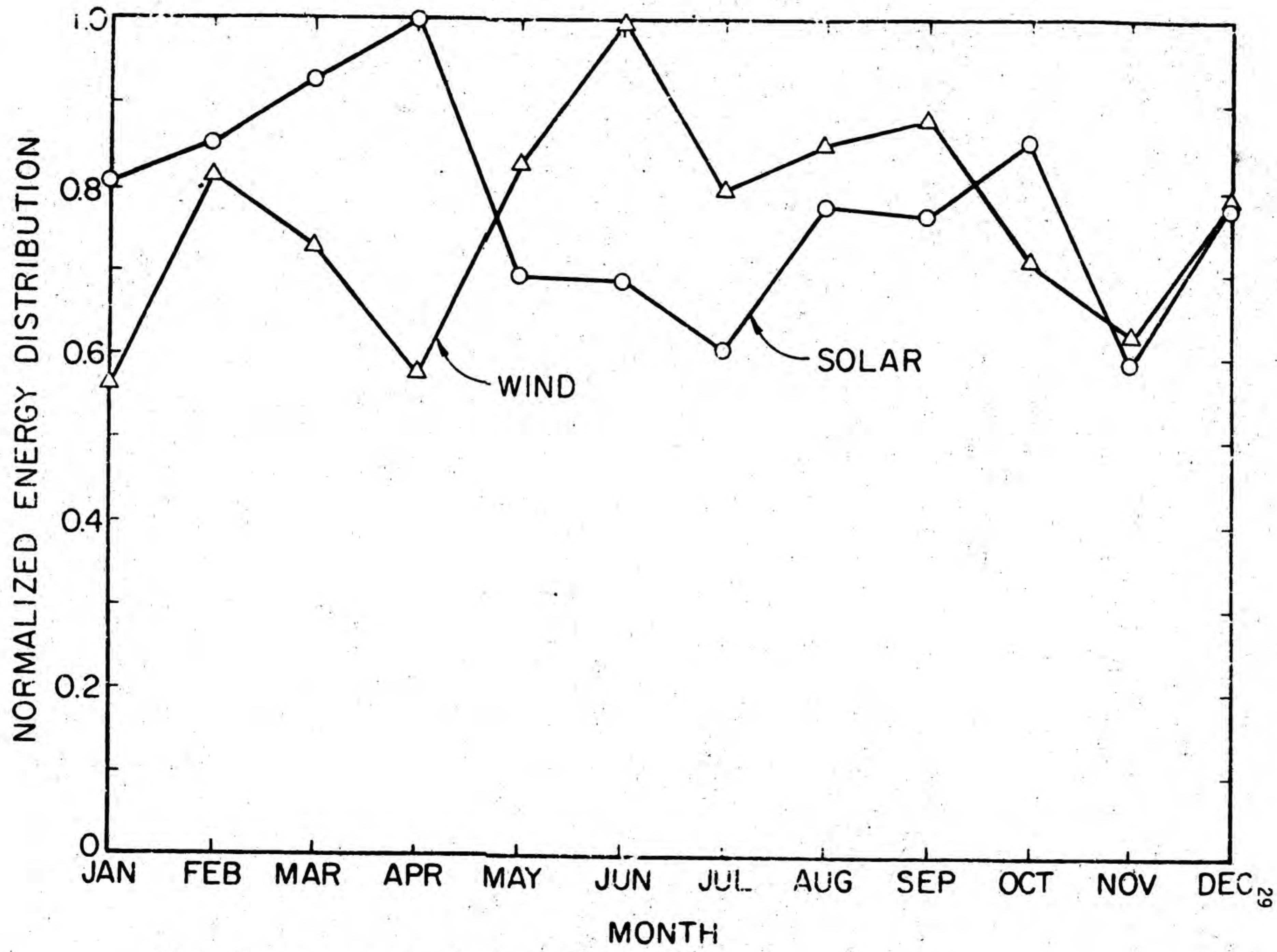

Figure Fourteen. Normalized Plot of Solar and Wind Energy at Hambantota the approximate meteorological character of the site could be documented. Since the contract between OSU and UNEP to develop plans related to the feasibility of an energy center in Sri Lanka covered a period of four months, it is obvious that such plans must be based on existing information, and not on data which requires several years to accumulate.

As previously noted, it is not possible to expect total documentation of the solar and wind energy characteristics to exist in a remote village in the developing world. Rather, it is necessary that a conservative interpretation of the data which is already available should be used in any predictions which are made of the energy resources available at the site. This philosophy was followed in the analysis of the Hambantota data.

The data which has been analyzed in this chapter, as provided by the Sri Lanka Meteorology department, is contained in Appendix A of this Feasibility Report. The solar energy data which has been discussed was derived from a tabular presentation of the mean percentage of sunshine at Hambantota. Such percentages represent fractions of the solar energy associated with the upper atmosphere of the earth, where cloud cover and other atmospheric disturbances do not interfere with solar insolation. The accepted figure for the solar constant, which is an indication of solar insolation in the upper atmosphere, is .135 watts per square centimeter, or 125 watts per square foot. On an absolutely clear day, at sea level, with the sun at zenith, only .100 watts per square centimeter, or 93 watts per square foot of solar insolation can be expected. The latter figure was used to obtain the data presented in Figure Eleven and Figure Twelve. The information which relates to solar energy resources, as presented in this section, is, therefore, conservative by at least 25%.

(HAMBANTOTA, SRI LANKA, 1975 WIND DATA)

$$P = 3.95(10^{-6})\ D^2\ V^3\ E$$

$$E = .3 \quad D = 30$$

	KWH PER MONTH		
MONTH	MODE 1	MODE 2	MODE 3
JAN	1,670.9	1,606.8	1,573.0
FEB	2,054.9	1,860.3	1,573.0
MAR	1,309.4	1,090.6	1,573.0
APR	664.2	375.8	1,573.0
MAY	3,974.4	2,848.8	1,573.0
JUN	4,874.9	3,551.2	1,573.0
JUL	2,082.8	1,860.3	1,573.0
AUG	3,929.0	2,750.6	1,573.0
SEP	4,273.2	2,972.03	1,573.0
OCT	1,165.6	864.0	1,573.0
NOV	613.3	423.4	1,573.0
DEC	950.6	815.0	1,573.0
KWH/ YEAR	27,562.0	21,019.0	18,876.0

MODE 1 Calculated by Percent Distribution of Wind Speed in an Average Day of a Month

MODE 2 Calculated on Per Month Average Wind Velocity

MODE 3 Calculated by Yearly Average Wind Velocity (12.7 MPH)

Figure Fifteen. A Comparions of Three Methods of Predicting the Energy Available from a Windmill.

Since the power available from the wind increases with the cube of wind velocity, estimating the performance of a wind energy system on the basis of average wind velocities will result in a conservative figure for the power which can be derived from such a system. The table shown in Figure Fifteen illustrates this point. Three methods were used in calculating the number of kilowatt hours of electricity which could be expected from a typical windmill at Hambantota in 1975. Data showing the variations in wind speed for an average day for each month of the year was available. When such variations were considered, a value of 27,562 kilowatt hours per year was obtained. The calculations were repeated, using the monthly average wind velocity, and a value of 21,019 kilowatt hours per year resulted. Finally, the calculations were completed by using the average yearly wind velocity, resulting in a figure of 18,876 kilowatt hours per year. In each case, the equation used was

$$P = (3.95 \times 10^{-6})D^2V^3E,$$

where P = power in kilowatts, D = windmill diameter in feet, V = wind speed in miles per hour, and E = windmill efficiency. The resulting figure was then converted into kilowatt hours per month, and kilowatt hours per year through the use of standard procedures.

Note that the results based on monthly average wind speeds are always less than the results obtained through the use of actual wind speed distribution data. On average, monthly average wind speed data produced a result approximately 25% less than would actually be obtained at the Hambantota station. Obviously, using the yearly average wind velocity in determining the performance of a windmill would represent an even more conservative approach to the problem of analyzing such data. However, as shown in Figure Fifteen, such an approach would not be conservative in estimating the number of kilowatt hours per month which would be available from a windmill. Therefore, the system design used in this feasibility study was based on monthly average wind speed data.

The preceding discussion has indicated the nature of the meteorological data collected by the OSU UNEP team. The conservative approach used in analyzing this data was described. It is predicted that similar approaches will have to be employed in analyzing the data from any part of the developing world. It is important that the validity of the approach presented be tested at the site for the Energy Center in Sri Lanka. The installation of a fully instrumented meteorological station in Pattiyapola village as part of the construction phase of the UNEP program can provide such a test. Figure Sixteen consists of a list of equipment recommended for installation at Pattiyapola village. The list was compiled by the Sri Lanka Meteorological Department. The Sri Lanka Meteorological Department has agreed to assist in the monitoring of the facility, using personnel from the Hambantota station.

List of Equipment Recommended by Sri Lanka Meteorological Department for Installation in Pattiyapola Village

Name of Instrument	Specification	Approx. Price	Number Required
Anemometer	As per Casella Catalogue No. 120811	$ 100.00	1
Bimetallic Acti - nograph & charts	As per Casella Catalogue No. W-6300	400.00	1
Planimeter for Measuring Chart Area	As per Casella Catalogue No. W-6314	80.00	1
Combined Direction & Velocity Indicator & Accessories	As per Casella Catalogue No. W-1404 W-1154 W-1306 W-1152 W-1212 W-1406	1200.00	1
Electrical Recorders for Wind Direction & Velocity & Accessories	As per Casella Catalogue No. W-1762 W-1784 W-6566 W-1790 W-1792 W-1794	100.00	1

Figure 16. List of Equipment Needed for Meteorological Data.

Chapter IV

PATTIYAPOLA VILLAGE - GENERAL CHARACTER

Pattiyapola village, the site selected by the Government of Sri Lanka for the UNEP Rural Energy Center, consists of 376 families, according to a 1970 census. The village is entirely Buddhist in character. Approximately 1850 people live in the Gramma Sevaka Division of the village, of whom 931 are over 18 years of age. The average family size in the village is between five and six individuals, which is higher than the average for Sri Lanka.

The only fuel imported into the village is kerosene, which is used entirely for illumination. Average consumption of the village per day is one and one-half barrels of kerosene. The village has no industries which use either kerosene or diesel oil. The villagers are primarily involved in agriculture, and rice is the principal crop of the village. A secondary crop is citronella, a fragrant grass that yields an oil used in perfumery and as an insectifuge. The village has a factory for processing the citronella. The energy source for the factory is firewood and citronella grass.

The primary cooking fuel for the village is firewood, which is found in abundance near the village. The fertility of the soil in the area is high, and water resources are sufficient to guarantee the availability of firewood without ecological damage to the surroundings. In some areas, harvesting of firewood is necessary to prevent jungle encroachment into the village. During the non-monsoon periods, some of the cooking for the village is done over open fires outside the huts. No community cooking facilities were observed.

Sufficient water resources are available to the village in the reservoir and in wells to accommodate the basic needs for irrigation and drinking. A series of channels provide for a controlled flow of water from the reservoir to the rice paddy area, which is separated from the reservoir by a dam. The presence of an artesian well in one of the paddys was noted. A survey of the artesian potential of the area would be desirable. There appeared to be a high probability that artesian wells could be located in the area to supplement the irrigation process and act as a new source of fresh, potable water for the villagers.

The wells used by the villagers are the open type which is characteristic of Asian villages. The probability of intrusion of organic waste material which effects the quality of water from such wells is high. The village experience with the wells which provide drinking water has caused the villagers to be suspicious of the water obtained from the wells. As a health precaution, most of the villagers boil the well water prior to drinking, due to a seasonal variability in the quality of the water.

The village has approximately 1000 animals, primarily cattle and water buffalo, which provide a source of milk, meat, fertilizer, and motive power. The animals are allowed to graze freely throughout the village area. Stable-bound animals are not generally found in rural areas of southern Sri Lanka, unless those areas are part of an experimental government farm or commercial dairy. This means that the collection of animal wastes required for the operation of a biogas facility in the village will have to be done manually, and that carts will have to be used to transport the biogas raw material to the biogas plants used in the Rural Energy Center.

The availability of plant material which might be useful as a supplement to the solar, wind, and animal waste resources of the village was found to be limited. As indicated previously, the two crops of the village are citronella and rice. Although rice is harvested two times per year, the by-products of such harvesting would only be available for a small percentage of each year. Further, no rice mill is located within the village, indicating that by-products such as rice husks would require transport from the rice mill three miles away back to the village for use. The citronella factor was found to be a highly efficient user of resources, in that the citronella grass was burned with wood to produce the heat required for withdrawing the oil from the grass. The residue from the thermal reaction forms a char, which some of the villagers use for cooking.

Photographs of Pattiyapola village are included as Figure Seventeen through Figure Twenty-Three to give an indication of the character of the village. Ninety percent of the village houses have cadjan roofs. The others have tile roofs. Both the school buildings and the temple in the village have tile roofs. No other public buildings were noted in the village. An aerial photograph of the village is contained in an Appendix at the end of this report. The aerial photograph provides a view of the entire village and associated agricultural land. The photograph shows the proximity of the rice paddy area to the reservoir, indicating the ease with which the majority of the rice paddy area can be irrigated. The paddy area in the lower right of the aerial photograph was not under cultivation during the site visit, apparently due to a problem with the water channel immediately above that portion of the paddy. The two school buildings can be seen at the south west end of the main dam for the reservoir. These buildings are on a slight elevation, overlooking the paddy and reservoir area. Slightly more than an acre of land adjacent to that area, owned by the government of Sri Lanka, would represent an ideal location for the major components of the proposed Rural Energy Center. Most of the trees visible in the photograph are coconut trees, and the village houses are generally located beneath them. The road linking Pattiyapola village to the main road between Hambantota and Matara is shown entering the village from the right side of the aerial photograph.

Interviews with officials involved in the activities of the village, coupled with an on-site inspection, made possible a judgment as to the type of services needed in the village. These include illumination, water pumping for irrigation, water purifcation, and alternatives to the use of firewood for cooking. The configuration of the village is such that approximately seventy percent of the houses are isolated from the remaining thirty percent by the village reservoir. This offered the possibility that some services might be provided to only a part of the village if economic considerations made such an action necessary. The villagers interviewed by the OSU UNEP representative were enthusiastic about the prospects of having a facility installed which could supply them with energy, as well as focus attention on them from the outside world. The Gramma Sevaka, or village elder, expressed the view that the villagers would not object if only a part of the village received direct benefit from the proposed system, if they could receive some assurance that all the village could benefit from the system in the future.

Numerous meetings were arranged in Colombo for the OSU UNEP representative after the site inspection visit was completed. Some of the information presented in this chapter was provided during those meetings. The desirability of having more information about the village was discussed, and various governmental groups agreed to assist OSU and UNEP in acquiring additional data. It was, however, observed that detailed data concerning the social structure of the village, the nature of impurities in the village water supply, the specific location of each structure in the village, and additional meteorological information would take time to accumulate and transmit to the United States. These meetings took place in early February, 1976. At that time, the deadline for submitting this Feasibility Report was known to be inflexible. March 31, 1976 was that deadline, and it was fixed by the necessity of making the Feasibility Report available to the Governing Council of UNEP in its April, 1976, meeting in Nairobi, Kenya. It was, therefore, understood that the system design proposed in this Feasibility Report would have to be based primarily on information available to the OSU UNEP representative during his visit to Sri Lanka. The fact that sufficient information was collected, on a tight time schedule, to allow the system design to proceed is a tribute to the enthusiasm and interest of the people of Sri Lanka in the UNEP concept of a Rural Energy Center. The prior visit of Dr. I. H. Usmani to Sri Lanka made many people aware of the type of information which would be required, and thus facilitated its collection by the OSU UNEP representative during his visit to Sri Lanka.

Chapter V

A RURAL ENERGY CENTER FOR SRI LANKA

The energy system concept advanced by UNEP is unique in that it uses a combination of renewable energy resources to accomplish its basic objectives. Two basic problems are associated with the design of such a system. First, there is the problem of selecting the proper component for each part of the system. Then there is the problem of determining an optimum interconnection of the system components which will guarantee safe, reliable, and economical operation over a period of years. Both problems were subjected to an intensive examination by researchers at Oklahoma State University.

Energy systems which operate from an input of wind energy have been in operation for many years, primarily as a source of mechanical power. Such systems are generally designed to perform a single task, such as water pumping, and their output is usually a direct function of the vagaries of nature. Systems which operate from an input of solar energy have, in the past, been designed for specific applications which require low grade heat energy . Such applications include the heating of buildings, the drying of crops and fish, desalination of water, heating water, and cooking food. Again, such systems have an output only when solar energy is available as an input.

It is obvious that an energy system which has an input of solar or wind energy must have some mechanism of energy storage if it is to supply reliable power to its consumers. Further, it is apparent that an energy system with both solar and wind energy as inputs will require less storage than an energy system which uses only one of these resources as an input, because of the complimentary nature of wind and solar energy.

However, the complimentary character of these resources can be fully exploited only when the mechanical energy output of a wind energy system and the heat energy output of a solar energy system are converted into a common output which can satisfy the output requirements of either system. That common output is electricity, and the search for components and systems which would convert solar and wind energy into electricity comprised a major part of the research effort to design an energy system for Pattiyapola village.

The third energy resource to be used in the proposed energy system, biogas, can be obtained from organic waste material by using techniques such as pyrolysis, hydrogasification, or anaerobic fermentation. The gas which results from such processes is rich in methane, and it represents a non-polluting fuel which has a high heating value. It can be used for cooking, heating, illumination, and power generation. The useful size for a system which produces biogas is limited by the availability and problems of collection of the organic wastes required for its operation. Problems of transporting the gas over long distances, either by pipes or pressurized containers, represent other limits to the effectiveness of a biogas system in a large, dispersed village such as Pattiyapola. Conversion of biogas into electricity minimizes such problems, and allows this resource to feed into a common grid with the solar and wind energy components of the system.

The Rural Energy Center for Pattiyapola village will emphasize the production of electricity from the available solar, wind, and biogas resources. Development and implementation of such a system will provide a comparision with the two conventional schemes of providing electricity to remote villages, both of which are electrical in nature. It is well known that an energy system which provides electricity offers an ease of transmission and a flexibility of uses unmatched by any other power source. Devices which generate electricity from solar, wind, or biogas inputs are in various stages of development and manufacture in research and development centers throughout the world. Their acceptance and multiplication on a large scale awaits only the sponsorship and encouragement of an international organization with the stature of the United Nations. These are the primary reasons for emphasizing the production of electricity in the Sri Lanka Energy Center.

The basic structure of the energy system can now be described. Windmills will be used to generate electricity. A solar energy system capable of generating electricity will act as a compliment to the wind energy components of the system. The electrical components of the solar and wind energy system will be connected to a storage system which will insure that energy from these intermittent sources will be available when wind and solar energy is not present.

Since a storage system will be used to buffer the input and output energy rates associated with the solar and wind energy components of the system, some method of inversion is required to produce alternating current from the direct current stored in the system. Various approaches for converting DC into AC were considered, including motor generator sets, large solid state inverters, and multiple sets of small solid state inverters.

The size of the storage system required for the proposed system would be prohibitively large if only solar and wind energy systems were used as inputs of the system. Since biogas units will be a part of the system, they will be used as a back up when the solar and wind energy resources are unavailable, and when the battery storage unit is depleted. Thus, the systems have the capability of more reliable and economical operation when interconnected than would be possible if each energy input was separately implemented. Again, this represents the primary strength of the UNEP concept of using a multiplicity of renewable energy resources for the system.

A schematic of the system which is proposed is shown in Figure Twenty-four. Five different windmill designs will be used, each of which has been proven reliable in extensive field tests. The windmills will produce direct current, which will be used to charge a large battery bank. The batteries chosen are the combined lead antimony and lead calcium type used by NASA in its energy storage studies. The solar energy component of the system consists of a moderate temperature solar collector which drives a Rankine Cycle engine that produces direct current for charging the battery bank. The biogas unit previously discussed serves a multiple role. It can operate on biogas or diesel fuels to produce electricity which can charge the main battery bank or be inserted directly into the transmission grid shown in Figure Twenty-four. The three inputs to the system will each provide approximately the same number of kilowatt hours per year, and the battery bank was designed to store energy for one 24 hour period. Diesel fuel will be used to supplement the energy storage system if necessary.

As indicated in Figure Twenty-four, a motor-generator set will be used to convert direct current into alternating current suitable for insertion into the power grid. The reliability and simplicity of this type of inversion system was considered to be more important than its relative inefficiency. Fluorescent lamps are recommended as a source

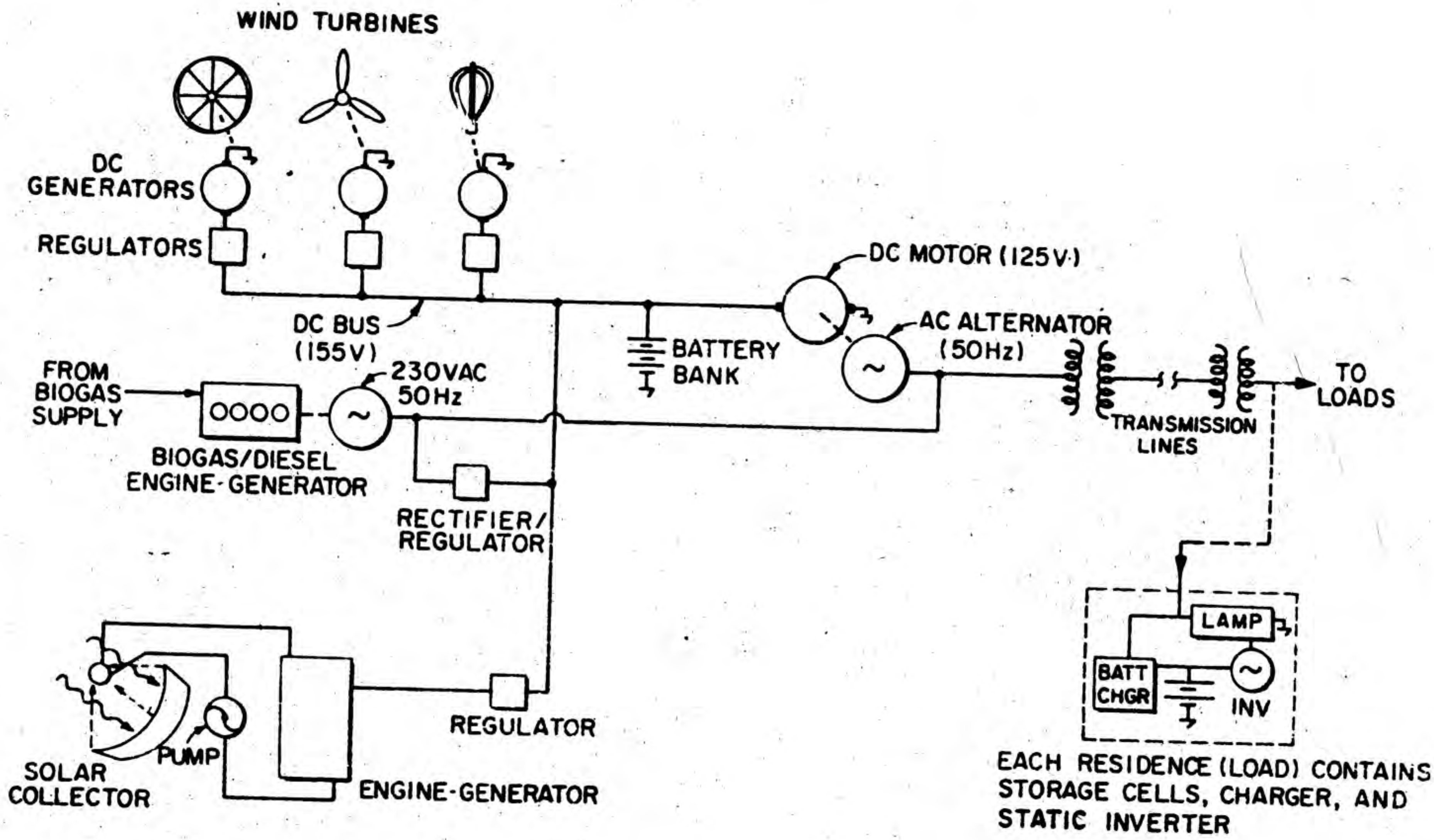

Figure Twenty-Four. Schematic of Proposed System.

of illumination for the village houses. The high efficiency of such lamps, coupled with low temperature operation, make them more desirable than conventional incandescent lamps, which are inefficient and represent a fire hazard in houses which have cadjan roofs.

The preceding discussion has summarized the general character of the proposed energy system. The system can be scaled to meet the needs of any village where the three basic input resources are available. As the energy needs of a village grow, additional windmills and solar components can be added to accommodate that growth. However, the size of the biogas component of the system is limited by the availability of organic waste material. The system shown in Figure Twenty-four can be expected to perform satisfactorily when the biogas component of the system can contribute at least ten percent of the total generating capacity of the system. A lower contribution by the biogas component of the system would require increasing the size of the battery storage facility or increasing the use of diesel fuel in the system. An estimate of the maximum feasible size of the proposed system must, therefore, begin with an analysis of the biogas resources available in the vicinity of the site chosen for an energy center.

As previously indicated, three different technologies can be used to convert organic wastes into biogas. The technique of pyrolysis is most effective when plant wastes are used as inputs, because it breaks cellulose molecules into smaller molecules under high temperature conditions in the absence of oxygen. Since no commercially available pyrolysis unit suitable for a remote village exists, this technique cannot be recommended. However, Georgia Institute of Technology, USA, has developed several large, sophisticate pyrolysis units, and has expressed willingness to develop a unit suitable for use in the UNEP program. A copy of their proposal is contained in Appendix B.

The technique of hydrogasification, or hydrogenation, produces biogas by a high pressure and temperature reaction of carbon-contai materials with hydrogen. The technique is relatively sophisticated, requires an availability of hydrogen, and has not yet been incorporated in a commercial unit. Work on this concept has been conducted at OSU for the past several years, as part of an effort to develop an energy system based on hydrogen storage for use in the developing world. At present, this technique cannot be recommended. However, a paper describing its use in the advanced energy system under development at OSU is included as Appendix C of this report, as an indication of the type of energy system which might be used in future UNEP efforts.

The technique of anaerobic fermentation, in which organic material is converted into biogas by bacterial action, is recommended for use in the UNEP Rural Energy Center. Systems operating on this principle have been shown to be highly reliable and cost effective in many areas of the developing world. The system developed by the Khadi and Village Industries Commission of Bombay, India is recommended, because it has been successfully operated in areas of southern India which have organic waste resources and climatic conditions identical to those associated with Pattiyapola village. Statements of co-operation from the Khadi and Village Industries Commission have been received for the UNEP effort. The proximity of that organization to Sri Lanka will greatly facilitate the construction of the biogas components of the proposed energy system.

Mr. H. R. Srinivasan, Assistant Director of the Gobar Gas Scheme of the Khadi and Village Industries Commission was retained by OSU as a consultant on biogas for the UNEP program. Mr. Srinivasan visited

Sri Lanka from March 13 to March 18, 1976, and he compiled a report on his evaluation of the biogas resources of Pattiyapola village. His report verified the fact that the distribution of houses in the village eliminated the possibility of piping biogas into individual houses, by showing that the cost of such piping would add at least 50% to the system cost. He concluded that the maximum initial size for a biogas unit in the village was one which could produce 1800 cubic feet of biogas per day. Such a facility requires the animal wastes of 200 animals, which is approximately 20% of the total number of animals associated with the village. This low utilization factor was based on the fact that the village animals are not stable-bound in a common area, but are allowed to graze freely throughout the village area. Thus, a large portion of the biogas resources will not be available, until the villagers become aware of the advantages associated with a biogas system. In his report, Mr. Srinivasan included plans for a 900 cubic feet per day facility and a 3000 cubic feet per day facility. A copy of his report is included in Appendix D of this Feasibility Report.

It is recommended that a biogas facility having a capacity of 3000 cubic feet per day be constructed as part of the UNEP system. It is expected that the system will be fed initially at a rate which will allow 1800 cubic feet of biogas per day to be produced, and that it will be able to reach its capacity of 3000 cubic feet per day when the villagers become familiar with its advantages, and with the problems associated with its operation. It is further recommended that the system be used entirely for the production of electricity, for reasons previously discussed, and that a fifty kilowatt diesel-biogas generator should be obtained for that purpose. Initially, such a system will produce approximately 30,000 kilowatt hours of electricity per year. Maximum capacity for the system will be approximately 50,000 kilowatt hours per year.

As previously discussed, the energy range set by the biogas component of the proposed energy system was used to establish bounds for choosing the size of the solar and wind energy conversion components of the system. The following discussion will demonstrate how those bounds, coupled with other constraints, resulted in recommendations for the solar and wind energy components of the proposed system.

Three methods of using solar energy to generate electricity were examined. The methods were compared on the basis of current and projected economics, technical complexity and sophistication, and proven capability. Systems considered included photovoltaic panels, low and moderate temperature flat plate collectors coupled to a heat engine, and high temperature concentrating panels coupled to a heat engine.

Photovoltaic devices provide for the direct conversion of solar energy into electricity. Highly purified silicon, gallium arsenide, or cadmium sulfide materials are used in such cells, and conversion efficiencies in the range of 10% to 20% have been reliably established. Photovoltaic devices cannot be recommended for the proposed system because their present cost, approximately $25.00 per peak watt, is totally prohibitive. However, many research groups are confidently projecting costs of less than one dollar per watt for solar cells within the next five years. If such projections approach reality, then photovoltaic conversion systems will revolutionize energy systems in both the developing and the developed areas of the world.

Solar energy systems which use solar heat to produce electricity have two basic components: A configuration which collects solar energy and converts it into heat, and an engine which converts that energy into electricity. Solar collectors were found to have an increasing cost and degree of sophistication with increasing operational temperature. Engines which convert relatively low grade heat energy into electrical energy were found to have an efficiency which increased dramatically with increasing boiler temperature. The selection of the recommended solar components of the proposed system was based on a compromise between solar collector cost and heat engine efficiency. The largest commercially available Rankine Cycle capable of operating efficiently at boiler temperatures which can be provided by moderate temperature solar collectors is a ten kilowatt unit, manufactured by Sun Power Systems, Incorporated of Sarasota, Florida, USA. This engine, coupled with the solar collector manufactured by Owens-Illinois of Toledo, Ohio, USA, is recommended for installation as part of the Rural Energy Center in Sri Lanka. This recommendation was made by Georgia Institute of Technology, USA, which was contacted by OSU for assistance in selecting the solar components of the proposed system in response to a specific request from UNEP. The Georgia Tech proposal is included as Appendix E of this Feasibility Report. Additional information about the solar components of the proposed system is contained in Appendix F.

The proposed solar energy system is capable of producing approximately 40,000 kilowatt hours of electricity per year. This energy level could, of course, be multiplied by adding additional units of the type recommended. When the performance of this system is properly documented at the proposed site, additional units should be installed to increase the capacity of the system.

Windmill manufacturers throughout the world were contacted in an effort to determine an optimum configuration for use in the proposed system. Information was received from manufacturers in Australia, Germany, Canada, Switzerland, France, and the United States. The systems developed by many manufacturers have not been developed beyond the prototype stage to a point where their performance can be properly documented. These systems were rejected. No windmill exists which can deliver its rated power at the average wind velocity associated with the site. The performance of each candidate system was processed from the rating of the manufacturer into a rating which is representative of conditions prevailing at the proposed site, using the conservative techniques developed in Chapter III of this Feasibility Report. A list of windmills which indicates the approximate number of kilowatt hours they can be expected to generate at the proposed site is presented in Figure Twenty-five.

It must be noted that the windmills listed in Figure Twenty-five are of various configurations and sizes, and that many other factors influenced the choice of units recommended for installation in the proposed system. The recommended units are identified by asterisks in Figure Twenty-five. Five different manufacturers are recommended, primarily because no single unit could be shown to have a clear superiority over any other. Installing six different windmills at the site will provide approximately 42,000 kilowatt hours of electricity per year which will compliment the solar energy component of the system at the desired energy level. Testing each of the proposed windmills at a single site could also lead to competitive discounting of some of the units. A determination as to which windmill configuration best lends itself to fabrication in Sri Lanka will also be facilitated by making available a multiplicity of windmill designs

Windmill Type		Kilowatt Hours Per Year at Site	
Dunlite 2000*	2kw	3200	1600
D.A.F. 4kW		4300	
A.W.T*	2kw	4900	2450.
Elektro WVG50G*	6 kw	5300	883
Aerowatt 1100 FP7		5300	
D.A.F. 8kW*		7600	950.
Elektro WVG120G*	10kw.	9300	930.
Windstream 25*	15kw.	12000	800.
Aerowatt 4100 FP7	4.1.	18000	

(The symbol * represents a recommended unit)

Figure Twenty-Five. Candidate Windmill Systems for study by scientists and engineers in that country. Additional information about the windmills which have been selected, and the methods used in the selection process, is contained in Appendix G.

As previously noted, energy storage is a fundamental component of an energy system which operates from an input of solar and wind energy. Techniques of energy storage which involve superconduction, flywheels, compressed air, hydrogen, or advanced batteries are currently under development by research groups throughout the world. At the present time, however, none of these techniques have reached the point of development where they can be recommended in the proposed energy system. At the present time, energy storage through the use of commercially available batteries represents the only technique which can be recommended in the proposed system.

The choice of a battery storage system for use in Sri Lanka was based on several constraints, including cost, maintenance, cycle efficiency, and cell lifetime. It was determined that lead acid batteries were most suited for the desired application. The most common lead acid battery is the lead-antimony system which has been in use for many years. It has a relatively long lifetime, and is inexpensive. Antimony is used in the electrodes in such batteries as a structural agent, and it causes a high rate of gassification and associated maintenance requirements to be characteristic of such cells. Another cell found in the lead-acid grouping is the lead calcium cell. This cell replaces antimony with calcium as an alloying agent, resulting in extremely low rates of gassification. However, lead calcium cells do not adapt well to deep discharge and cycling operations which will be required in the energy center. A hybrid cell which incorporates the best features of lead antimony and lead calcium cells was determined to be the best choice for the desired application. Two sixty cell battery banks of hybrid cells with a storage capacity of approximately 300 kilowatt hours are recommended. The batteries are capable of discharging at a 100 kilowatt rate for three hours, then recharging for twenty-one hours at a cycle efficiency of approximately 80%. With routine maintenance, the battery storage system is expected to have a lifetime in excess of ten years. An extensive analysis of battery storage systems was conducted in preparation for this recommendation. A summary of that analysis is included as Appendix H.

The energy storage system recommended for use in the UNEP Energy Center was designed to deliver peak energy for three hours each day and to store energy when it is available from the solar, wind, and biogas inputs to the system. This energy cycle is consistent with actual use patterns in remote villages in the developing world. A table provided by UNEP which estimates the basic energy needs of a typical village community of 200 families in a developing country is shown in Figure Twenty-six. As shown in the table, the energy required for cooking food represents 76% of the total energy required in a typical village. An energy system designed to satisfy a two hour cooking load must be capable of satisfying such a load even if all of the villagers choose to cook at the same time. Further, the system must be able to accommodate the lighting load and the cooking load simultaneously in anticipation of the probability that primary cooking in the village will take place in the evening hours. It was for this reason that the proposed energy system was designed to deliver energy at peak levels during a three hour period for each day.

ESTIMATED BASIC ENERGY NEEDS OF A TYPICAL VILLAGE COMMUNITY OF 200 FAMILIES IN A DEVELOPING COUNTRY

A rough estimation of the quantum of energy required for a village community of 200 families (comprising 5 persons per family on an average) is given below:

	BASIC NEEDS	BASIS	QUANTUM OF ENERGY REQUIRED
i)	Energy required for cooking food	0.6 KW/family (for 2 hours per day)	87,600 KWH per year
ii)	Energy required for pumping drinking water	2 gallons/6 litres per person per day or 10 gallons/30 litres for family	1,000 KWH per year
iii)	Energy required for lighting	2 bulbs of 60 watts per home used for 3 hours per day	26,280 KWH per year
	Total Energy required for Basic Needs ...		114,880 KWH per year
	Or Say ...		115,000 KWH per year

/NOTE: 115,000 KWH/Year can be produced by an electric power station of a generating capacity = $\frac{115,000}{8,000 \text{ Hrs.}}$ = 14.375 KW, operating at 100% plant factor for 8,000 hours per year or of 28.75 KW (or say 30KW) capacity operating at 50% plant factor.

Figure Twenty-six. UNEP Estimates of Energy Needs of a Typical Village in a Developing Country.

It was decided that the output of the battery bank storage system should be processed into an alternating current waveform compatible with the electrical transmission facilities in common use in Sri Lanka. This approach will make possible the wiring of the village by personnel available in Sri Lanka, using familiar equipment and components. Since the electricity available to the villagers will be identical to the electricity which can be generated by conventional power systems, devices such as electric cookers or lights can be used in the system without modification.

Two techniques of converting direct current into alternating current were considered for the proposed system. Static inverters, which convert d-c into a-c through the action of high power electronic circuitry, were found to be the most efficient system for use in the proposed system. However, such systems are highly sophisticated, and the possibility that they could be fabricated in a developing country, or maintained in a remote village, was determined to be so low that their use could not be recommended in the proposed system. Additional information about the static inverter systems which were examined as a part of this research effort is summarized in Appendix I.

A fifty kilowatt motor generator set which converts the direct current associated with the battery storage system into alternating current is recommended for use in the proposed system. Such a system is rugged, reliable, and is relatively unsophisticated, when compared to a static inverter. The technological base required for its construction and maintenance is well within the capability of a developing country such as Sri Lanka. Additional information about this component of the proposed system is summarized in Appendix J.

The interconnection approach recommended for the Sri Lanka Energy Center, as shown in Figure Twenty-four, is one of several approaches investigated as part of this research effort. The variety and scope of the other interconnection options which were examined is illustrated in Appendix K.

The preceeding discussion has shown that the recommended system will have a generating capacity of approximately 120,000 kilowatt hours per year, with the solar, wind, and biogas components of the system contributing approximately equal units of energy to that total. It is interesting to note that this generating capacity would supply the needs of a village of 200 families, as estimated by UNEP, if all of it could be made available for use by the villagers. Unfortunately, the energy which will actually be available by use of the villagers will be less than this figure, because of the losses associated with charging and discharging the main battery bank of the system, d-c motor/a-c generator conversion, and distribution. The efficiency of these components is estimated as 80%, 70%, and 90%, respectively, and the product efficiency of these losses is approximately 50%. Therefore, the total energy available from the system can be estimated to be 60,000 kilowatt hours of electricity per year, assuming that all of the energy generated passes through the storage system represented by the battery bank.

The energy system recommended for installation in Pattiyapola village has now been described. The electrical output of the system can be used to satisfy a wide variety of human needs, which are limited only by the power rating of the system. Since UNEP has established the fact that the basic energy requirements of a remote village are associated with cooking and illumination, it is recommended that the proposed system should be used primarily to satisfy those needs.

At present, illumination of houses in Pattiyapola village is provided by kerosene lamps. Each family in the village uses approximately 1½ bottles of kerosene per day to fuel their lamps. The rapidly rising cost of kerosene, and the logistics of delivering the fuel to the villagers represent significant problems which can be eliminated if electricity is provided to the houses for illumination purposes. Incandescent lights can be installed in the village. However, special precautions must be observed if such lights are used in houses which have cadjan roofs. The waste heat which is characteristic of incandescent bulbs is a serious fire hazard when they are mounted near such a highly combustible roof material. It is also an indication of the extremely low efficiency of this source of illumination. Fluorescent lights are generally recommended in applications where low temperature and high efficiency illumination sources are required. Fluorescent lights which have self contained ballasts and can be mounted into a conventional light socket are presently being developed and tested in the United States, in an effort to eliminate the wasteful energy consumption of incandescent light sources in that country. An analysis which compares fluorescent and incandescent lighting systems is presented in Appendix L. Fluorescent lights can be packaged in compact, battery powered units that can serve as a portable light source which can supply significantly more illumination than kerosene lamps. Such a unit was developed at OSU specifically for this program. A description of the unit is contained in Appendix M.

As previously discussed, firewood is the principal fuel used for cooking in Pattiyapola village. In many areas of the developing world, the use of firewood as a fuel for cooking has resulted in considerable damage to the environment, through erosion or desert encroachment. Such is not the case in Sri Lanka, where extensive jungle areas provide a source of firewood which is self renewing. The principal environmental hazard associated with cooking with firewood in Sri Lanka is the smoke from the fires which often is contained within the village houses. Electric cookers can eliminate this health hazard. At present, the Government of Sri Lanka discourages their use, because of the limited capacity of the existing hydroelectric generating stations in that country. Assurances were obtained that the Government attitude toward electric cookers would not affect their use in the UNEP Energy Center, because that center will not be connected to the existing electrification system in Sri Lanka. Multiple step cookers which can provide low, medium, and high temperature heat are recommended for use in the center. Such electric cookers are presently available in Sri Lanka.

Since the energy required for cooking in the proposed center represents approximately 76% of the total energy used in the center, alternatives to electric cooking were explored. Solar cookers were investigated, then discarded because of the fact that the inconvenience associated with their use would make them unacceptable in a village where firewood is so conveniently available. Smokeless stoves suitable for use in a developing country were also considered, and information related to such stoves is contained in Appendix H. This information was provided by the Brace Institute of Montreal, Canada, which has a history of developing working energy systems in the developing world that is unmatched in North America. It is recommended that the information contained in Appendix M be made available to experts in Sri Lanka, in the hope that it may stimulate interest in smokeless cookers in that country.

In addition to cooking and illumination, the third service listed by UNEP as a basic village need is associated with the water resources available to the village. The energy required for pumping drinking water, as estimated by UNEP in Figure Twenty-six, is extremely small, and it represents only a small percentage of the basic needs of the village. The proposed energy system could easily satisfy the water pumping requirements of the entire village. However, no sanitary storage facility for the water supplies in the village exists at present. Further, no piping system is presently in use to transport water to individual houses. It is, therefore, recommended that UNEP should consider installing a water system in the village as an adjoint to the proposed energy system. The UNICEF presence in Sri Lanka for the purpose of installing such systems is already significant, and the assistance of that organ of the United Nations in developing the water system for Pattiyapola village would be most helpful in this regard.

Additional energy will be required for a water supply system for the village if a water purification system is necessary in the system. The water supply of the village is currently being analyzed by the Government of Sri Lanka, in an effort to determine the nature of the contaminants which may be associated with the village water supply. The results of that analysis are not yet available. However, an analysis of the impurities in some wells in villages near the site has been provided. It has been used as part of a study to determine the energy requirements of various water purification systems which might be necessary in the village. This study was undertaken by OSU in addition to the contract with UNEP which provided for the design of a Rural Energy Center. It concluded that a chemical treatment system coupled with a modified charcoal filter combined the advantages of energy efficiency, reliability, and safety in a manner which makes that type of purification system more desirable in a developing village than more sophisticated systems, such as those which use reverse osmosis membranes to purify water. That study is included as Appendix O in this Feasibility Report.

The size recommended for the proposed system was based entirely on technical considerations. It is recognized that the fifty kilowatt rating of the system is inadequate for the needs of the entire village which was chosen by the Government of Sri Lanka as the site for the UNEP Energy Center. In point of fact, the village is nearly twice as large as the maximum size set by UNEP in its contractural arrangement with Oklahoma State University. The contract between OSU and UNEP specified that the system design should satisfy the basic needs of a remote village of between 25 and 200 families. With the exception of the biogas components of the proposed system, which are fixed in size by the availability of animal wastes, the system components can be expanded to satisfy the total energy requirements of practically any village in the developing world. The size of the system which can be installed in Pattiyapola village is not limited by technical or scientific considerations. Rather, it is limited by the funding level considered appropriate by UNEP for establishing a prototype Rural Energy Center for Asia. In the absence of a directive from UNEP regarding this matter, it was decided that the size of the system to be recommended should be based on technical considerations, and that sufficient information regarding the character of the system should be presented in a manner which would allow the system to be enlarged to any level desired by UNEP and the Government of Sri Lanka.

The energy system which has been described was designed to operate in a village much more widely distributed than anticipated from information provided by UNEP about typical villages in the developing world. An alternating current transmission system is desirable in areas where electricity must be transmitted over a significant distance. For smaller, more compact villages which more closely fit the UNEP descriptions of a typical village, direct current transmission of electricity to individual loads is recommended. Such a distribution system eliminates the need for a d-c to a-c conversion component in the energy system. The cost of the system is thereby reduced, and the power which can be made available to the consumers will be increased by 30%, through the elimination of the efficiency of the d-c to a-c conversion system from the overall efficiency of the system.

Chapter VI

GENERATION COSTS AND ECONOMIC ANALYSIS

Each of the components which have been recommended in the proposed energy system was chosen from considerations involving technical merit, compatibility with other components, environmental impact, social acceptability, and economic viability. This section is devoted to an analysis of the cost and economics associated with the proposed system. The cost of each component of the system is given in US Dollars and Sri Lanka Rupees, based on an exchange rate of 0.121, which was valid on June 20, 1976. Duty costs and Foreign Exchange Entitlement Certificate figures are not included in the analysis. Assurances were given that the Government of Sri Lanka will give favored treatment on these aspects of the system cost.

As previously indicated, commercially available components were recommended for all of the major parts of the proposed system. The cost of these components is summarized in Figure Twenty-seven. The total cost indicated is $156,220.00 (rs 1,291,074). It must be stressed that the costs indicated were obtained over a six month period and are, therefore, subject to variations. Most of the manufacturers contacted showed extremely high interest in the UNEP program, and strong inferences were obtained that many of the components listed could be obtained at prices substantially lower than those quoted when the program approaches the reality of a construction phase. It is even possible that some of the manufacturers can be persuaded to contribute some of the items at a financial sacrifice, to gain the publicity and recognition which might result when this program is completed.

	COMPONENT	COST IN DOLLARS	COST IN RUPEES
Wind Energy Components	Windstream 25	$19,750.00	Rs 163,223
	Elektro WV G120G	9,200.00	76,033
	Elektro WV G50G	6,580.00	54,380
	D.A.F. 8 Kw	6,170.00	55,455
	A.W.T.	1,664.00	13,752
	Dunlite 2000	3,200.00	26,446
	Tower Costs	4,736.00	39,141
Solar Energy Components	Owens-Illinois Collectors	25,000.00	206,612
	Sun Power Rankine Engine	10,000.00	82,645
	Buffer Thermal Storage Unit	5,000.00	41,322
Biogas Energy Components	Basic 3000 ft^3/day Unit	11,458.00	94,694
	50 Kw Biogas/Diesel Set	7,260.00	60,000
Energy Storage Components	Two 60 Cell Battery Banks 4 Type 15C145-25 4 Type 15C145-31 (from C&D Battery Division, Eltra Corporation)	24,375.00	201,446
D-C to A-C Conversion	62 KVA @ .8 pf Generator (rate 50 Kw at unity pf)	21,287.00	175,926
	TOTAL	$ 156,220.00	Rs 1,291,074

Figure Twenty-Seven. Cost of Major Components for the Proposed System.

Although the components listed in Figure Twenty-seven are commercially available, none have ever been connected into a configuration of the type which has been proposed. Obviously, this is because no such configuration has ever been constructed. Several modifications are necessary when the commercially available components are interconnected in the proposed system. For example, the output voltage of each of the windmills must be made compatible with the 155 volt d-c charging voltage recommended for the battery unit. This will necessitate slight modifications in the generators which are standard equipment with some of the windmills, alternate voltage regulation schemes, and provisions to prevent power from flowing from the battery bank into the generator, all of which have been anticipated and designed by OSU. Such items will undoubtedly be standardized for the windmills which will be used as the energy systems multiply throughout the developing world.

Another interface problem is related to the connections between the recommended solar panels and the Rankine Cycle engine components of the system. This interconnection has never been made, and sufficient funds must be made available to guarantee a successful wedding between these two components of the system. Again, this cost will not recur when the systems are implemented on a large scale.

Shipping costs and special packaging costs to guarantee satisfactory arrival of those components which will be experted to Sri Lanka have not been included in the components costs shown in Figure Twenty-seven. It is strongly recommended that UNEP should budget the construction phase of the program at $190,000, which is approximately 20% greater than the values quoted, to account for the above contingencies, as well as labor costs and inflation.

It is recognized that the proposed system will be competitive with more conventional schemes of rural electrification only if it can be shown to have performance characteristics and cost figures which can be competitive with such systems. At present, conventional methods of supplying electricity to remote villages involve either an extension of existing electrification grids or the use of autogeneration devices such as diesel generators. In Sri Lanka, rural electrification by extending existing grids is proceeding at an extremely slow rate of between ten and twenty villages per year. The Government recognizes the need for rural electrification. However, officials in Sri Lanka are aware that any significant increase in the number of villages which are tied to existing grids will soon exceed the existing capacity of the generation system in Sri Lanka. Until the hydroelectric potential of Sri Lanka is fully developed, no significant rural electrification system depending on the existing grid can be planned or implemented. Therefore, an autogeneration system represents the only competitive system for the proposed system in Sri Lanka. The economic analysis which follows is based on this fact.

As previously discussed, a direct current system is recommended for these small, compact villages which have been described by UNEP as typical in character of remote villages in the developing world. The system proposed for Pattiyapola village is an alternating current system, with a fifty kilowatt rating at a load factor of 0.125. It was designed on an extremely conservative basis with regard to the generating capability of the solar, wind, and biogas components of the system. When the d-c to a-c conversion components of the system are removed, the power rating of the system will increase and the cost of the system will decrease.

Further, the remaining components of the system are subject to a cost reduction of at least 30%, when the units enter into a mass production phase, based on estimates given to OSU by most of the manufacturers of the proposed components. Further, consider the fact that the energy generated by the wind energy components of the system, which was determined in a wind energy regime averaging approximately 12 miles per hour, would be doubled if the system were placed in a site where the wind velocity averaged 15 miles per hour. This fact is an indication of the sensitivity of the proposed system to meteorological variations. When these and other factors are considered, it is apparent that the cost and power rating of the system can be expected to be significantly lower than similar values which are associated with the prototype system.

Based on the above considerations, reasonable values for the cost and peak rating of the proposed system when the systems begin to multiply throughout the developing world are $100,000 and 125 kilowatts respectively. These values will be used in the economic analysis to be presented in this chapter.

UNEP provided OSU with a World Bank study of Rural Electrification which was published in October, 1975, for use in comparing the economics associated with the proposed system with those which relate to autogeneration units with a similar rating. This document is basically concerned with pricing policies, management, and identifying areas for World Bank investment. In relation to rural power plant projects, the World Bank report states that "Economic aims require a forward-looking view with prices [to the consumer] related to the marginal costs of expanding investment and output, ignoring the large initial sunk costs."

Diesel-engine autogeneration is covered in the World Bank publication, using 1972 oil price data. Costs contained in tables in the book

Annual Cost Comparisons

Network capacity		25 kilowatts			50 kilowatts		
Load factor	%	10	25	50	10	25	50
Autogeneration costs							
Capital	$	3,300	3,300	3,300	4,500	4,500	4,500
Running[1]	$	2,300	4,300	7,600	4,600	8,600	15,200
Total	$	5,600	7,600	10,900	9,100	13,100	19,700
Total	cents per kilowatt-hour	25	14	10	21	12	9

[1] Kilowatt-hour of output per kilowatt capacity = 876 kilowatt-hour at 10 percent load factor.
= 2,190 kilowatt-hour at 25 percent load factor.
= 4,380 kilowatt-hour at 50 percent load factor.

Note: These figures are only approximate and may change enormously according to the country and the date. Inflation and changes in oil prices, in particular, make precise estimates very difficult.

Figure Twenty-Eight. Cost Analysis of Auto-Generation Systems (A World Bank Publication).

are based on oil prices before the recent energy crisis. Acknowledging this in their introduction, the World Bank concedes "The recent rise in oil prices has had particularly serious effects on the cost of electricity from diesel-powered autogenerators (increases of roughly 50 percent to 100 percent, depending on use)." A chart from the World Bank publication is shown in Figure Twenty-eight. It presents a cost analysis of autogeneration systems, based on pre-inflated expenses, which indicate a maximum rate of 25 US cents per kilowatt-hour using a load factor of 10 to 12 percent (or .10 to .125). These figures are also based on the practice of having one spare diesel generator unit in the system due to the problems of breakdown and maintenance. Unfortunately, the publication does not contain sufficient information to fully justify the information shown in Figure Twenty-eight. It does, however, present sufficient inforamtion to justify the use of a cost figure of $500 US per kilowatt for a diesel generating system.

An analysis of the economics associated with an electrical power generation plant can range form a superficial treatment to a detailed study. Considering the prototype system of the project in Sri Lanka, an evaluation of moderate complexity is desired in order to include such characteristics as fuel costs, load factors, and initial investment costs. Two intermediate methods have been adapted for this study. One was developed using fundamental capital cost and fuel analysis by Dr. R. G. Ramakumar of Oklahoma State Univeristy for comparing such pioneering energy generation systems as the wind/solar/biogas generator systems with conventional power plants available in mass-production; i.e., the diesel-engine autogenerator. This analysis is supported by the Federal Energy Administration in its treatment of conventional generating systems compared with solar and wind oriented plants. Judicious use of either of those methods with relation to the size and composition of the proposed system enables an orderly discussion of the economy-determining factors in different types of generation schemes. The comparison examples used in this research inherently involve the advantages and disadvantages of each power system.

Since the main thrust of the self-contained generation plant includes a rural area site location, the initial and continual problems of shipping equipment and fuel into interior zones must weigh as a heavy consideration. Diesel fuel is a continuing shipping difficulty. In the wind/solar/biogas combination, the dilemma of initial equipment handling could be eased, after the prototype setup, if the participating country is able to manufacture many items for delivery in that area. For this analysis, the diesel system is amortized over a ten year period, which is an extremely optimistic estimate of the effective lifetime of a diesel unit. The wind/solar/biogas system will be amortized over a fifteen year period, which is a conservative figure for the lifetime of the major components of that system. The ever-increasing cost of fuel, however, is not included in the formulas. This facet of the analysis is bracketed by several fuel cost examples in this investigation.

Load factors, defined as a ratio of the hours generating to the total hours in one day, are crucial to the economic results. Due to the complimentary nature of the wind/solar/biogas system, a reasonably constant output power is available for storage in a one-day battery storage bank. This enables a smaller system with a unity load factor to accomplish the same power output on a three hour per day demand as a larger diesel-engine plant having a load factor of .125. Other conditions peculiar to each example are given below along with an explanation of the economic methods employed. The Ramakumar and FEA analyses are presented in detail in Appendix P and Appendix Q, respectively.

As a guideline prediction of diesel system operation expenditures, three calculations are given, starting at the present cost of diesel fuel at 60 cents US per gallon. The Ramakumar equation, including the efficiency loss due to heat radiation and fuel consumption is given by,

$$C = \frac{r(1+r)^n}{(1+r)^n-1}\left(\frac{P}{8.76k}\right) + \frac{mP}{8.76k} + \frac{3.413\ f}{\eta} .$$

Since the present cost of diesel fuel in Sri Lanka is $25.00 US per barrel, or approximately 60 cents per gallon, this starting point is used as a base for a cost analysis of the diesel-engine autogenerator. In the above equation, a 10 percent annual interest rate is adopted ($r = .10$) along with an amortized life of 10 years ($n = 10$). According to the World Bank and other sources, the average capital cost of a diesel system is $500.00 per kilowatt ($P = 500$) and the fraction of the capital cost needed per year for operation and maintenance is 5 percent ($m = .05$). The load factor of the diesel engine generator in this system is three hours per day, or .125 ($k = .125$) with the diesel engine operating at an efficiency of 33 percent ($\eta = .33$). For the fuel cost of 60 cents per gallon, the fuel expense in dollars per million Btu is 4.09 ($f = 4.09$). Utilizing these factors, the generation cost in mills per kilowatt-hour is 139.5 ($C = 139.5$ mills per Kwh).

With the recent and dramatic increases in fuel prices, it is certainly prudent to consider the effects of even further increases. It is for this reason that the following examples are given as indications of future costs which may be characteristic of such systems. All other factors corresponding to the diesel system will remain constant. At 120 cents US per gallon, the charge in dollars per million Btu equals

8.18 (f = 8.18). The generation cost under these considerations is 181.7 (C = 181.7 mills per KwhP. As a final illustration, consider the generation costs if the price per gallon of diesel fuel is set at 180 cents US. The 160 cent price per gallon of gasoline in many European countries is an indication of the fact that such a figure may be relevant in the future. Applying all other factors in the equation as established in the initial calculation, and with the fuel cost at 12.27 dollars per million Btu, the calculated cost of generation is 224 mills per kilowatt hour. It is interesting to note that the numbers given in each of these examples produce cost estimates lower than those given in the World Bank study recommended by UNEP as an authoritative source of information about the costs of diesel powered systems.

The Federal Energy Administration method presented in Appendix Q uses a general cost equation to estimate the price of electricity for power at centralized base-load plants, centralized peak-load plants, and distributed plants. Since the energy patterns associated with developing villages correspond to a demand for energy for three hours per day, the base-load for such power systems is zero, and the peak-load of the system is the actual output value. The FEA routine also includes a fixed charge rate which indicates the rate of billing to the consumer. Using the same constant factors employed in the Ramakumar routine and utilizing estimated costs given in examples in the FEA reference, the 60 cents per gallon example results in a consumer price of electricity of 141.7 mills per kilowatt hour. The 120 cent and 180 cent per gallon calculations produce costs of 178.5 mills and 219 mills per kilowatt hour, respectively. These cost figures are essentially identical to those obtained from the Ramakumar analysis.

The preceeding examples indicate a variation of ten to twenty cents per kilowatt hour of electricity for a rural power plant employing diesel autogenerators. This fluctuation has been further substantiated by other economic methods, such as those employed by the World Bank which show a range from nine cents to twenty-five cents per kilowatt hour, depending on fuel costs and other variables. Obviously, difficulties encountered by a continuous necessity for importing fuel must be considered in addition to the problems associated with increasing diesel fuel costs. The fact that this type of electrical generation system has been economically feasible in the past does not guarantee its economic viability in the future. It is apparent that a system which requires no fuel for operation will ultimately represent the only real solution to the problem of supplying energy to rural areas of the developing world.

Energy independence is a desirable criteria for any country or power generation plant. Fuels which are nondepleting and abundant in nature are the essential foundations for the production of the proposed solar/wind/biogas system. The wind and solar energy components of the system have no fuel costs. A biogas generator takes advantage of the stored energy of animal wastes. In addition to electrical production, a useful by-product of the biogas facility is a fertilizer which can be sold as an additional means of income for the generating plant. This fertilizer has more available nitrogen and humus material than the animal wastes which are used as an input to the system. The profits associated with this product of the biogas system will not be included in this analysis.

Another important related aspect of the proposed system is that the diesel generator carries the continuous cost of increasing fuel prices, while the wind/solar/biogas plant outlay is contained in the initial non-inflated capital expenditure. This investment is, therefore, relatively independent of an inflationary economic environment. Adapting the Ramakumar routine to account for a negligible fuel cost leads to the following equation

$$C = \frac{r(1+r)^n}{(1+r)^n-1} \left(\frac{P}{8.76k}\right) + \frac{mP}{8.76k} .$$

For a wind/solar/biogas system cost of $800 per kilowatt, a fifteen year amortization period, and an interest rate, maintenance charge, and load factor identical to values used in the diesel examples previously considered, a generation cost of 132.5 mills per kilowatt hour results (C = 132.5 mills per Kwh). This figure is slightly lower than the 139.5 mills per kilowatt hour which was determined for the diesel example with a fuel cost of 60 cents per gallon. When processed from the same boundary conditions, the FEA procedure confirms this conclusion.

The preceeding analysis has demonstrated that the proposed solar/wind/biogas system can generate energy on a competetive basis with an autogeneration system. Two complementary approaches were used in this analysis, in an effort to provide a definitive reference for analyzing conventional and unconventional energy systems, using any desired combination of assumptions. Both procedures result in cost figures for the proposed system which are significantly lower than comparable diesel generation costs listed in the World Bank report recommended by UNEP. It is apparent from this analysis that systems of the type which have been proposed in this Feasibility Report offer the promise of becoming competetive with conventional systems in the very near future, as they spread throughout the developing world.

One basic fact remains. Millions of people live in areas of the developing world which have not yet been touched by the technological benefits of the past hundred years. It is imperative that programs be developed to assist these people in their efforts to improve the quality of their lives and their environment. To quote Dr. I. H. Usmani, Senior Energy Advisor to UNEP, these people must have energy "not at a price, but at any price."

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Chapter VII

CONCLUSIONS AND RECOMMENDATIONS

The technical feasibility of the system proposed in this report has been demonstrated. It was designed from information which should be readily available in most developing countries. The procedures used to analyze the performance of the system are sufficiently flexible to allow its operational characteristics to be predicted in areas of the world which have solar and wind energy resources which differ from those associated with the site. An alternating current system was recommended for installation in Sri Lanka because of a combination of factors peculiar to the site chosen by the Government of Sri Lanka. A direct current system was recommended for the small, compact villages which more closely reflect the character of typical villages in the developing world. Procedures for adjusting the size of either system to accommodate the needs of larger villages have been described.

Although the benefits of the insertion of modest amounts of technology in a rural or village situation of a developing country may seem straight-forward to many, opposition to this sort of "western intrusion" is being heard more frequently. In the face of discontent with some of the consequences of burgeoning technology in the developed world and the disappointment over the frequent failures of attempts to transfer "western" technology to the developing world, there has evolved a school of thought that says technology should be developed locally, with local capabilities, tools, materials, and local understanding of the problems. As appealing as this approach may seem at first, it effectively condemns the large rural populations of the developing world to endless years of struggle - probably fruitless in most cases - to develop the materials to fabricate devices that can be used to ease their burdens and improve the quality of their lives [1].

This Feasibility Report was prepared by OSU with full knowledge of the fact that the acceptance and successful implementation of the system which has been proposed depends totally on the co-operation and interest of the people of Sri Lanka. Extensive documentation relating to each aspect of the proposed system has been included in this report, to supply the scientists and engineers of Sri Lanka with a record of the technology which can be provided to assist them in their efforts to enhance the quality of life in the rural areas of Sri Lanka. The English system of units was used in this report as a convenience to the technical community in Sri Lanka. Western technology can supply the technology which can generate electricity from locally available renewable energy resources. The responsibility for adapting that technology to local materials and capabilities must be given to the scientific and technical community in Sri Lanka.

Sri Lanka does not suffer from a shortage of highly qualified and dedicated scientists and engineers who can contribute significantly to the UNEP program. Representatives of the Ministry of Planning and Economic Affairs, the Ceylon Electricity Board, the Industrial Development Board, the State Engineering Corporation, the Sri Lanka Meteorology Department, and the Katubedde and Peradeniya campuses of the University of Sri Lanka should be involved in the construction, testing, and adaptation phases of this program. Scientist and engineers from some of these groups are presently involved in research related to solar, wind, or biogas systems. That research should be supported by UNEP and enlarged to complement the activities associated with the UNEP Rural Energy Center.

Proper technician support is an essential ingredient for reliable operation of any energy system. The technical competence required for maintaining the equipment required in the proposed system is no greater than that which is required of those who maintain the many diesel systems in Sri Lanka. Men capable of handling the electrical and mechanical routine maintenance requirements will have to visit the site periodically to monitor the performance of the system. They can be selected from the technical work force available in Hambantota. Some of the villagers must be trained to operate the biogas system, with regard to the proper procedures for feeding animal wastes and water into the system and mixing the output products of the digestor with plant material for the production of humus. It is recommended that these personnel be selected by the Government Agent for the Hambantota District, with advice from the Gramma Sevaka of Pattiyapola village, and that the introduction of these technicians to the maintenance and operation of the Energy Center should begin during the early phases of construction of the system.

Mr. M. Sanmagaraja, Head of the Ceylon Electricity Board, has visited the site on several occasions. His recommendations as to the type of wiring system which should be used in the village should be followed. A three-phase low tension line costs Rs. 60,000 per mile, while a single phase low tension line costs Rs. 45,000 per mile. A house with five electrical outlets can be wired for approximately Rs. 600, and a service connection to the house would cost approximately Rs. 400. If the system rated at fifty kilowatts is adopted, the cost of wiring the part of the village which can be serviced by that system will be approximately Rs. 120,000 ($14,520). Conventional electric meters of the type used in Sri Lanka should be used to monitor the output of the power system. Recording ammeters should be used to monitor the energy flow associated with the battery storage system. The cost of these instruments is not expected to exceed Rs. 20,000 ($2,420).

Consultants from Oklahoma State University and Georgia Institute of Technology can be made available, as required, to assist the scientists and engineers of Sri Lanka during the construction and testing phases of the UNEP program. It is recommended that the involvement of the consultants in this program should be for one year, beginning when UNEP decides that the proposed system should enter into a construction phase. The cost of this technical service is approximately $75,000, including salaries for 1½ man-years, overhead, travel, and per deim. This cost is, of course, subject to negotiation between the Universities involved, UNEP, and the Government of Sri Lanka, and it will be a function of the specific responsibilities which will be assigned to the consultants by UNEP and the Government of Sri Lanka.

It is recommended that the total budget for the construction and testing phases of the UNEP Rural Energy Center program in Sri Lanka be $300,000. As previously discussed, many of the expenses associated with the program can be expected to be significantly lower than those which have been used to obtain this maximum budget figure. The OSU experience with the present contract with UNEP, in which the time and requirements associated with the contract were increased significantly without increasing the funds available for the work which had to be done dictated that a cautious approach toward estimated costs should be taken with respect to future phases of this program.

This report has emphasized the technical and economic considerations ssociated with the proposed UNEP Rural Energy Center. It is beyond the scope and intent of this study to attempt to add to the wealth of published information relating to the sociological and environmental considerations which influenced the design of the system. Rather, this report is a consequence of the awareness of the Governing Council of UNEP of the impact which the proposed system might have on the environment and quality of life associated with rural areas throughout the developing world. A selected bibliography of some of the references which deal with the social and environmental aspects of energy in the developing world is included at the end of this chapter.

The format of this report was patterned after a detailed outline suggested by Dr. I. H. Usmani, Senior Energy Advisor to UNEP, who has been a driving force for all of the activities described in this report. It is fitting that this Feasibility Report should conclude by quoting from his publication, Review of the Impact of Production and use of Energy on the Environment and the Role of UNEP.

". . . In the literature available upto date, usually the importance of a particular device based on a particular resource for a particular purpose is emphasized. Wind energy for pumping water, solar energy for space heating and water heaters, and methane from wastes for lighting are discussed and recommended for small scale use by individual families. But what is required is the development of the technology of harnessing one or more renewable resources for the production and supply of a versatile form of energy like electricity which the villagers in their homes and on their farms can receive from a village energy centre, and switch it off and on at will, without bothering about the operation and maintenance of the energy producing contrivance on their premises. It will be only then that the program of "rural energization" would be as successful in the developing countries as was the programme of rural electrification in the developed countries in the 1930s and 40s, and only then that the pollution from poverty will be arrested. The choice lies with the governments of the developing countries concerned to create the motivation for such a programme and for the developed countries to assist them by promoting the research and development on the renewable resources and to transfer the requisite technology as it develops. The international organizations within and outside the United Nations systems can play a catalytic role in ensuring close cooperation between the developing and the developed countries, and for providing the means for the exchange of information on the progress made in developing the technologies suitable for transfer and adaptation."

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I. H. Usmani.
5 August 1976

EXECUTIVE SUMMARY OF THE FEASIBILITY REPORT ON THE REC FOR PATTIYAPOLA VILLAGE IN SRI LANKA.

REC Concept

1. The analysis of data relating to the availability of solar, wind and biogas (SWB) sources of energy at the Pattiyapola village (having 376 families with dwellings longitudinally spread over 11 km.) and the review of the existing and developing technology of harnessing them, by a group of researchers at the Oklahoma State University, show that the REC concept of integrating the energy output from each of them in the form of electricity to meet the basic domestic needs of about 50 families is, within certain limitations, technically viable and economically feasible. As for social acceptability, it may be pointed but that the REC concept is unique in that it aims at converting diffuse, intermittent and variable sources of energy into a system of firm supplies of power, which has not been tried anywhere in the world on any scale-big or small. Hence it is felt that the social acceptability of the technological devices and the end-uses of electricity, particularly cooking, can only be assessed after and not before the establishment of the REC.

All Electric REC

2. In view of the fact that electrical energy is clean, safe, transportable, and easily adaptable for a variety of applications, the programme of "rural electrification" has been universally adopted as the key to socio-economic development in all countries of the world. The two conventional methods adopted for rural electrification are (a) the extension of transmission and distribution lines of a grid interconnecti ng a network of central power generating stations and (b) the establishment of decentralized diesel power generators in isolated villages. The REC concept of utilizing the locally available renewable SWB sources of energy for rural electrification offers a third alternative which according to the analysis made in the feasibility report for Pattiyapola Village appears to be particularly suitable for small rural communities.

SWB Sources in Pattiyapola

3. In Pattiyapola Village, the average incidence of solar energy is of the order of 500 Watt hrs./sq.ft.; the average wind velocity is 12.3 m.p.h. and for most days of the year is in excess of 10 m.p.h. for at least half a day. Further, as the village has a population of nearly 1,000 cattle and raises two rice crops per year having a high residue coefficient of more than 2.5, the availability of animal and agricultural wastes to feed a biogas plant capable of producing up to 3,000 c.ft. of biogas per day (60 - 65 per cent methane through anaerobic fermentation of the wastes) is assured. On the basis of the solar and wind regimes and potential of biogas mentioned above, the utilization of all the three SWB sources to generate electricity has been found to be feasible and advantageous compared to diesel power generation.

Limitations of Technology

4. A review of the technological devices which are commercially available or could be depended upon for harnessing each of the SWB sources shows that there are certain constraints which at the present "state of the art," limit the use of such devices for producing energy beyond a certain scale. Accordingly, it is suggested that the proposed REC at Pattiyapola be designed to supply power to 50 families (average of 5 persons per family) living in dwellings within a radius of about 1 mile from the centre of the proposed REC.

Basic Energy Needs

5. The basic energy needs of the 50 families are estimated to be as follows:

Basis of the Estimated Needs	Energy Required for 50 families per Day.	Energy Required for 50 Families per Year.
(i) For cooking of food over an insulated electric stove of 1.5 kw capacity - used for 3 hrs per day (including morning and evening cooking).	1.5 kw x 3 hrs x 50 families = 225 kwh (e)	82,125 kwh (e) - I
(ii) For lighting of homes each using 3 bulbs of 40 W for 4 hrs per day/night.	40 W x 3 bulbs x 4 hrs x 50 Families = 24 kwh (e)	8,760 kwh (e) - II

	Basis of the Estimated Needs	Energy Required for 50 Families per day	Energy Required for 50 Families per Year.
(iii)	For pumping of water allowing for a domestic consumption of 10 gallons per family per day from a well 35 ft deep to an overhead tank of 3,000 gallons capacity at a height of 50 ft.	= 1 kwh (e)	365 kwh (e) - III
(iv)	For miscellaneous purposes such as street lighting, lighting of village community centre, dispensary and operating a refrigerator for preserving lifesaving drugs.	= 25 kwh (e)	9,125 kwh (e) - IV
	Total Energy Requirements of 50 families.	275 kwh (e)	100,375 kwh (e) - V

The REC Energy Supply System

7. An analysis of the performance characteristics of the technological devices for the generation of power from the SWB sources available at Pattiyapola mentioned in paragraph 3 above, shows that the energy needs of the segment of 50 families to be selected could be met by integrating the following at the REC:

Solar (i) A solar electric power generator having a rated capacity of 10-20,kw employing 1,500 sq.ft. of concentrating type of solar collectors connected to a Rankine cycle engine using Freon. With the incidence of about 500 Watt hrs/sq.ft. per day of 8 hrs (9 a.m. to 5 p.m.) of solar energy on 1,500 sq.ft. of solar collectors, 273,750 kwh (t) of thermal energy can be collected per year with 8 hrs of sunshine per day. A temperature of about 250 degrees F. can be reached to operate the Rankine engine so that with even a low efficiency of about 11 per cent, the 273,750 kwh (t) could be converted into about 30,000 kwh (e) per year.

*/ The incidence of solar energy at Pattiyapola is about 65 Watts/sq.ft. per hour, or 520 Watts/sq.ft. per day of 8 hrs, which may be rounded off to 500 Watts/sq.ft. per day. Solar energy collected by 1,500 sq.ft. of collectors = 500 x 1,500 =750 kw per day = 750 x 365 kw per year = 273,750 per year. With an efficiency of 11 per cent of the Rankine engine, the average production of electric power could be about 30,000 kwh (e) per year.

/Note: The calculations and assumptions are on a conservative basis because on an average there is sunshine for 10 hours per day, and in practice the Rankine cycle efficiency could be more than 10 per cent./

(ii) An insulated tank of 2,500 gallons capacity - containing mineral/vegetable oil which will serve as thermal storage for providing heat for 12 hours operation on a cloudy day.

Wind (iii) A series of 7 wind generators, capable of generating about 32,000 kwh per year split between different types as shown below:

Type of wind generator	Number Of Wind Generators to Be Installed	Power Rating	Power which Can Be Extracted at Pattiyapola	Energy Production per Year.
(1) A.W.T. bicycle wheel type extracting power from the periphery of the wheel by a belt connected to a generator (American).	4	4 x 2 = 8 kw (2 kw per wind generator)	4 x 0.56 = 2.24	19,622kwh
(2) Electro 50 G-Propellor blades with vertical axis mounting (Swiss-German).	1	6 kw	0.60 kw	5,256kwh
(3) D.A.F. 4 kw with vertical axis mounting (Canadian)	1	4 kw	0.49 kw	4,292kwh
(4) Dunlite 2000 Multivanes with horizontal axis mounting.	1	2 kw	0.37 kw	3,241kwh
Total	7	20 kw	3.70 kw	32,411kwh

/Note: Suitable open spaces exist in the village for installing the modern wind generators on towers whose height may vary from 30 - 50 feet./

Biogas (iv) One plant capable of producing up to 3,000 c.ft. of biogas (60-65 per cent methane)per day obtained from anaerobic fermentation of animal wastes from about 200 cattle (each yielding 2 kgms of solid wastes per day with a collection efficiency of 50 per cent) is envisaged as part of the REC. The plant design has been made by an expert from India who has already visited Pattiyapola. Assuming a calorific value of about 600 Btu per c.ft. of gas, it is estimated that the biogas plant could operate a conventional diesel generator and produce about 40,000 kwh (e) per year with a maximum capacity going up to 50,000 kwh (e). Experience has shown that the efficiency of conversion of thermal energy of biogas into electric power is of the order of 25 per cent. This can be improved if the waste heat could be efficiently utilized for recirculation to optimize the fermentation process in the plant (it gives a maximum yield at about 30° C.) or used for crop drying or providing hot water or helping desalination of brackish water, etc.

/Note: Biogas will be available almost continuously. Provision has therefore been made in the design for storage of quantities of biogas surplus to the requirements of the generator./

Storage Batteries Bank.

(v) All the electrical energy generated will be stored in a battery "Bank" which will be the Centre of supplies of power to the individual homes. The "Bank" will consist of two sets of 60 hybrid cells (lead-antimony/acid and lead-calcium/acid) which will have the following characteristics:

(a) Storage capacity ---------------------- 300 kwh per day
(b) Discharge rate ---------------------- 100 kw every 3 hrs.
(c) Recharging rate ------------------- every 21 hrs at 80% cycle efficiency.
(d) Charging voltage ------------------- 155 Volts.
(e) Life of the cells ------------------- 15 yrs.

/Note: The D.C. supplies from the battery bank could be converted into A.C. supplies by introducing a motor-generator or a solid-state device, but this would add to the capital cost and loss of power. A D.C. System is, therefore, recommended particularly because the distribution losses on lines leading to 50 dwellings within a radius of 1 mile will not be appreciable./

Capital Cost of the REC and Cost of Power from SWB Sources

8. A statement of capital cost of establishing the REC a system of protected water supply for the village, and the net cost of generating electric power from the devices used for harnessing SWB sources, at various rates of interest is given below. As the project can be completed in parts (e.g. biogas in first 6 months) totalling one year, the interest during construction will be nominal and has, therefore, been ignored in the cost calculations.

Statement I

Cost Involved in Establishing the REC at Pattiyapola.

Part A

1. Capital Costs of SWB Devices

	Item	Estimated Cost	Life	Annual Amortization Cost.
(a)	Solar: (Rated 10-20 kw capacity)			
(i)	Collectors	$30,000	20 yrs	$1,500
(ii)	Rankine Engine	$10,000	25 yrs	$ 400
(iii)	Components	$ 8,000	25 yrs	$ 330
(iv)	Thermal Storage	$ 5,000	25 yrs	$ 200
(v)	Shipping and Insurance	$ 2,000	-	-
	Total Solar (Rated 10-20 kw capacity)	$55,000	Average 22 yrs	$2,430
(b)	Wind: (Rated 20 kw capacity)			
(i)	4 A.W.T. wind generators(8 kw)	$ 7,000	20 yrs	$ 350
(ii)	Dunlite--1 unit (2 kw)	$ 3,500	25 yrs	$ 140
(iii)	D.A.F. --1 unit (4 kw)	$ 4,500	25 yrs	$ 180
(iv)	Electro 50 G--1 unit (6 kw)	$ 6,500	25 yrs	$ 260
(v)	Towers	$ 2,000	25 yrs	$ 80
(vi)	Shipping and insurance	$ 2,500	-	-
	Total Wind (Rated 20 kw capacity)	$26,000	Average 24 yrs	$1,200
(c)	Biogas: (50 kw)			
(i)	Biogas plant with storage	$15,000	30 yrs	$ 500
(ii)	Biogas generator (50 kw)	$ 8,000	10 yrs	$ 800
(iii)	Shipping and insurance	$ 250	-	-
	Total Biogas (50 kw)	$23,250	Average 20 yrs	$1,300
(d)	Battery Bank (300 kwh per day)			
(i)	Two sets of 60 cell hybrid batteries (lead-antimony-calcium cells)	$25,000	15 yrs	$1,670
(ii)	Shipping and insurance	$ 750	-	-
	Total Cost Battery Bank (charging 300 kwh/day)	$25,750	15 yrs	$1,670
(e)	Integrated SWB Devices at REC Site			
	Solar (10-20 kw)	$55,000		$2,430
	Wind (20 kw)	$26,000		$1,200
	Biogas (50 kw)	$23,250		$1,300
	Batteries	$25,750		$1,670
	Total Capital Cost of Devices	$130,000	20 yrs	$6,500

	Item	Capital Cost	Life	Annual Amortization Cost.
2.	Power Distribution			
	(a) D.C. Power Lines	$10,000 */	30 yrs	$ 333
	(b) Control Room	$ 2,500 */	25 yrs	$ 100
	Total Cost of Power Distribution	$12,500		$ 433
3.	Total Capital Cost of SWB Energy System			
	(a) Cost of SWB system	$130,000		$6,500
	(b) Cost of D.C. Distribution	$ 12,500		$ 433
	Total Capital Cost of SWB Energy System	$142,500		$6,933
4.	Water Supplies			
	(a) Overhead tank of 3,000 gallons capacity at 50 ft. with a communal distribution reservoir fitted with taps.	$15,000	30 yrs	$ 500
	(b) Water Purification Plant	$ 5,000	25 yrs	$ 200
	Total	$20,000		$ 700
5.	Meteorological Observatory			
	(a) Building	$ 1,000	30 yrs	$ 33
	(b) Instruments	$ 2,000	30 yrs	$ 66
	Total	$ 3,000		$ 100
6.	Miscellaneous Items			
	(a) Fencing round the REC	$ 5,000 */	30 yrs	$ 10?
	(b) Contingencies	$15,000 ($10,000 + $5,000) */	-	-
	Total	$20,000		
7.	Services and Training			
	(a) Consultants (3 trips and total stay 6 weeks)	$12,000 ($9,000 + $3,000) */	-	-
	(b) Training of 2 local Engineers abroad for 3 months	$ 5,000	-	-
	Total	$17,000		

*/ * represents cost in local currency in terms of dollars.

Grand Total Investment in the Project.	Foreign Exchange	Local Currency.
$202,500	$160,000	$42,500

Part B

Cost of Electricity from SWB Sources.

		Annual Cost Towards			
Rate of Interest	Interest on Capital Cost of SWB System of $142,500	Amortization of Capital Cost	Operation Maintenance	Total Cost of 100,000 kwh (e)	Cost of Electricity per kwh (e)
10%	$14,250	$4,250	$2,000	$20,500	20.5 cents
5%	$ 7,125	$4,250	$2,000	$13,375	13.37 cents
21/2%	$ 3,562	$4,250	$2,000	$ 9,812	9.81 cents

According to the Indian biogas expert's estimate on p. 148 of CSU report, a 3,000 c.ft. biogas plant will yield nearly 650 tonnes of organic manure per year which can be sold at $5 per tonne, giving an annual income of about $3,250. The cost of collection of animal wastes will be about 70 cents per million Btu (according to Arjun Makhijani and Alan Poole, Energy and Agriculture in the Third World, p. 102) which works out to about $500 per year. Thus, the net income from the sale of manure will be about ($3,250 - $500) = $2,750 per year If this is set off against the annual amortization cost of the SWB energy system, the net annual amortization cost would work out to ($7,000 - $2,750) = $4,250.

Cost of Power Generation from Diesel Oil

9. Based on the figures given in the Annex to the World Bank's Paper on "Rural Electrification" (October 1975), the cost estimates of power generation from a diesel oil - fired generator of 35 kw rated capacity (including a spare unit of same capacity as a back-up) operating at about 12 per cent capacity factor to produce 100,000 kwh (e) per year as produced by SWB sources at the RSC are shown in Statement II below:

Statement II.

Cost Estimates of Diesel Power Generation

Part A.

Item	Estimated Cost	Life	Annual Amortization. Cost.
1. Twin 85 kw diesel power generator operating at 12% capacity factor	$19,000 1/	10 yrs	$1,900
2. Distribution lines	$14,000 2/	30 yrs	$ 470
3. Sub-station	$ 5,000 2/	25 yrs	$ 200
Total	$38,000	-	$2,570

1/ From World Bank Paper on "Rural Electrification" (October 1975), Table 2, (Annex on p. 76).

2/ Ibid., Table 3 (Annex on p. 77).

Part B.

Cost of Electricity from Diesel Oil.

Price of Diesel Oil	Annual Costs: Amortization	Operation Maintenance	Oil	Interest Rate	TOTAL	Cost of Electricity per kwh(e)
60 cents per gallon	$2,570	$2,000	$6,000	10%--$3,800	$14,370	14.37cents
	$2,570	$2,000	$6,000	5%--$1,900	$12,470	12.47cents
	$2,570	$2,000	$6,000	21/2%--$ 950	$11,520	11,52cents
80 cents per gallon	$2,570	$2,000	$8,000	10%--$3,800	$16,370	16.37cents
	$2,570	$2,000	$8,000	5%--$1,400	$14,470	14.47cents
	$2,570	$2,000	$8,000	21/2%--$ 950	$13,520	13.52cents
100 cents per gallon	$2,570	$2,000	$10,000	10%--$3,800	$18,370	18.37cents
	$2,570	$2,000	$10,000	5%--$1,900	$16,470	16.47cents
	$2,570	$2,000	$10,000	21/2% --$ 950	$15,520	15.52cents

<u>Cost Comparison between SWB and Diesel Oil Generation of Power</u>

10. For a fair cost comparison of the two energy systems based on SWB and diesel oil, only the cost of the power-generating equipment and power distribution lines has been taken into consideration, rather than the cost of the whole project which includes cost of other items like water supplies, etc. Proceeding on this basis it will be seen from Parts B of Statements I and II that the cost of power generation from the SWB sources and diesel oil are competitive and almost break even when the price of diesel oil is 60 cents/gallon and the rate of interest is 5 per cent. <u>At a 2 1/2 per cent rate of interest, power from SWB sources is cheaper than power from diesel oil at all rates of interest and at all prices of oil from 60 cents/gallon onwards.</u>

11. Here two points are worth mentioning. One is that in all countries which have completed schemes of rural electrification by either extending the grid or autogeneration by diesel generators they were invariably subsidized by the Governments concerned. Even in the United States rural electrification was financed at an interest rate of 2 per cent. The other point is that whereas the technology of diesel generators is at least 50 years old and they are mass-produced, the technology of the SWB devices is still in the nascent stage of development, and they are not yet produced on a large scale. If, however, in the next 10 to 15 years a market develops for the SWB devices and large-scale manufacture is started, their cost is bound to go down by as much as a factor of 4 if not 5. Meanwhile in this period, the prices of oil are bound to go up still further. In fact, in many poor countries and even in countries of Western Europe the diesel oil prices are already more than $1 per gallon. On purely economic considerations, therefore, a case of demonstration of the REC concept of harnessing the SWB sources in an integrated manner under the auspices of UNEP is more than justified. It is expected that due to the simplicity of technology of the SWB devices, most of the components could be made locally for future REC's and the engineering designs modified in the light of actual performance under field conditions.

<u>Other Advantages of the REC System</u>

12. Apart from purely economic considerations there arer other advantages of the REC system which are summarized below:

(i) If for some reason electric cooking is not accepted, then the solar energy device (a Rankine cycle-engine-generator) proposed for the REC could be used for pumping water for irrigation as a supplementary source to the water from the Pattiyapola irrigation tank. It could also be considered for irrigating those lands which due to their location above the tank, cannot be commanded by the tank. A consequence of releasing the solar device for irrigation would be the availability of a big surplus of the wind and biogas energy remaining unutilized after meeting the demand for lighting and pumping of drinking water because wind and biogas generators at the REC could produce about 70,000 kwh (e) (30,000 kwh (e) from wind and 40,000 kwh (e) from biogas) against a demand of only 9,000 kwh (e) for lighting of homes of 50 families and pumping water for drinking. Either of the two courses would be open. One would be to retain the power supplying devices and extend power to a larger number of families (practically the whole village) or to drastically reduce the size of the biogas plant and the number of wind generators to the extent that they generate only about 10,000 kwh (e) needed for 50 families. This flexibility of approach is a great feature of the REC system. Naturally, the alternatives will cause a change in the economics of power generation. Rough calculations show that whatever the scenarios, the REC system at low rates of interest would produce energy at a cost cheaper than that produced by diesel oil-fired generators of equivalent capacity.

(ii) Establishment of an REC is more labour intensive than diesel generators.

(iii) Technology of the SWB devices is simpler than that of diesel engines. An industrial infrastructure could therefore be started for large-scale manufacturing of the SWB devices in the light of the data collected on the results obtained from the successful demonstration of the REC. Despite more than 50 years of usage very few developing countries can claim to produce efficient diesel generators. The SWB system can therefore encourage development of industries with consequent increase in employment and overall economic development.

(iv) Even the remotest of the villages of the developing countries need not be starved of energy, as by using the locally available SWB sources rather than imported oil, they could become more self-reliant in matters of energy production.

(v) The production of manure from biogas plants as a by-product will add fertility to the soil and result in increased food production.

(vi) The SWB devices are non-polluting in character, and the sources they harness are renewable. The multiplication of the REC's therefore will not tap the fast depleting fossil fuel resources of the world.

(vii) The successful demonstration of a decentralized power-roducing system could, with advantage be adopted even in the small communities of the developed countries without any perceptible change in their standard or quality of life. Reliance on local SWB sources could lead to conservation of conventional sources of energy which are at present used in centralized power-generating systems to meet the energy needs of the small communities in the developed countries. The central supplies of energy saved due to the switch of small communities to SWB sources, could be diverted to more productive uses leading to more employment and better socioeconomic environment - a problem so far unsolved--in the developed countries.

Universality
of REC's

13. What is true of Pattiyapola, could be true of other villages in different parts of the world. A demonstration of the REC concept could, therefore, be publicised for adoption elsewhere where SWB regimes are good and the rural communities are small, yet willing to transform their quality of life from one of degradation caused by lack of energy to enhancement through the harnessing of energy from sources available at their door day after day, month after month, and year after year without fear of depletion.

APPENDIX 3(e)

From : The Secretary,
Ministry of Planning & Economic Affairs,
Government of Sri Lanka
Colombo.

To: The Executive Director,
U.N.E.P.,
Nairobi (KENYA).

Sir,

Subject : Establishment of a Rural Energy Demonstration Centre (R.E.C.) for Asia at Pattiyapola Village in the Hambantota District of Sri Lanka.

I am directed to state that the Government of Sri Lanka are pleased to know that in their feasibility report, the experts of the Oklahoma State University have found the concept of harnessing the renewable Sources of Solar, wind and biogas (S.W.B.) energy in an integrated manner, at a Rural Energy Demonstration Centre (R.E.C.) for Asia in the Pattiyapola Village of Hambantota District of Sri Lanka, is technically feasible and under certain conditions economically viable. The Socio-economic impact on the quality of life of the people of Pattiyapola can only be determined after the establishment of the R.E.C., but the enthusiasm with which the local people have welcomed the availability of supplies of energy for lighting their homes and pumping of water for drinking purposes from the proposed R.E.C. shows, that the Socio-economic impact on their lives will be quite significant and favourable. The Government of Sri Lanka will, however, undertake a comprehensive socio-economic study including the question of substituting imported equipment and materials by locally manufactured items as far as possible with a view to reducing the cost which would enable the multiplication of the R.E.C.'s on a large scale.

2. I am further directed to state that on the basis of the study in depth of the feasibility report of the Oklahoma State University made by the members of the inter-ministrial standing Committee of

this Ministry, an all-electric system, (based on the harvesting of S.W.B. sources, at the R.E.C., at Pattiyapola) providing about 60,000 KWh(e) of A.C. supplies, is acceptable to the Government of Sri Lanka. Further, in the light of the experience gained in Sri Lanka in more than 500 villages covered by the Scheme of Rural Electrification, the Government is satisfied that the A.C. electric power supplies of 60,000 KWh(e) per year from the R.E.C. will be sufficient to meet all the reasonable demand for lighting of houses and for pumping of water for drinking purposes, of a large number of families (upto about 200) of Pattiyapola living in a compact area within a radius of at least 1½ miles from the R.E.C. site. The flexibility of the S.W.B. system will permit the utilisation of any surplus energy for running of small agro-based industries, wherever possible. This aspect will also form part of the study of the socio-economic impact of the R.E.C's on the lives of the rural Communities concerned. As the population of the Village is scattered, the Government of Sri Lanka is aware that some homes may not be covered by the R.E.C. facilities but this will not cause any social disruption or confusion.

3. The Government of Sri Lanka have had the benefit of exchange of views not only with the Consultants engaged by U.N.E.P. to prepare the feasibility report of the proposed R.E.C., but also with the members of the U.N.E.P. delegation (consisting of Dr.I.F. Usmani, Dr.A. Reddi and Mr.A. Bournajuti) who during their stay (September 7 - 13) helped to resolve many technical, financial and administrative issues to mutual satisfaction. In the light of these discussions, I am directed to request you kindly to provide technical assistance to the Government of Sri Lanka for the establishment of the R.E.C. at Pattiyapola by way of financing the foreign exchange cost of (a) importing the hardware, equipment, instruments, and components required for the installation of the various devices for the S.W.B. system (b) Consultancy Services of foreign experts and (c) training of local personnel abroad, to the extent of U.S.$..121,477...in foreign exchange. On their part the Government of Sri Lanka will be prepared to incur the local costs towards the acquisition of land, construction of Civil Works involved, procurement of local materials and payment of labour etc., to the equivalent of $ 42,000 in local currency for which a

budgetary provision exists. This contribution will be in addition to the cost of administrative support by way of salaries of staff and overhead charges to be incurred during and after the R.E.C. establishment.

4. With a view of expediting the implementation of the R.E.C project at Pattiyapola, it has been decided by the Government of Sri Lanka to submit herewith a project document in the format prescribed by U.N.E.P., for your favourable consideration and approval. The project document gives a complete description of the project, its cost estimates for budgetary purposes, the allocation of the time schedule for the implementation of various phases of the project and the understanding reached concerning the responsibilities and roles of the Government of Sri Lanka and U.N.E.P. I hope that on its approval by you arrangements will be made to enable the project document to be signed by you and the Government of Sri Lanka without delay.

5. In the end, I take this opportunity of thanking you for selecting Sri Lanka for the establishment of the first demonstration Rural Energy Centre in Asia and to give it that high priority which the Governing Council of U.N.E.P. - in their decision on the subject, wished to assign it, for enhancing the quality of life of the small rural communities living in isolation in the developing countries. The Government of Sri Lanka share the optimism of the Governing Council that the successful demonstration of the R.E.C. concept could go a long way to utilize the non-polluting renewable sources of energy for meeting the needs of the rural areas of Asia and thus enabling the conservation of the conventional sources of energy for utilisation in the development of other sectors of the economy of the developing countries.

With consideration of the highest esteem.

I remain,

Yours faithfully,

Secretary to the Ministry of
Planning & Economic Affairs.

UNITED NATIONS ENVIRONMENT PROGRAMME

PROJECT DOCUMENT

SECTION 1 — **PROJECT IDENTIFICATION**

1.1 Project Title	:	Technical assistance to Sri Lanka for the establishment of a Rural Energy Demonstration Centre at Pattiyapola Village utilising the available energy resources, as a demonstration centre for Asia.
1.2 Project Number	:	FP/0302-76
1.3 Priority Area	:	Technical Assistance
1.4 Scope	:	National Sri Lanka
1.5 Supporting Organisation	:	Government of Sri Lanka through the agency of the Ceylon Electricity Board.
1.6 Duration of Project	:	Commencing : November 1976 Completion : November 1978 Duration : 24 months
1.7 Cost of Project	:	Total cost of Project : $ 233,500 Cost to UNEP : $ 191,000

For the Supporting Organization	For the Fund of UNEP
Signature	Signature ....
....	Yusuf J. Ahmad Associate Director, Environment Fund
Date	Date ....

SECTION 2 **OBJECTIVES**

2.1 Long Term Objectives

During its Third Session the Governing Council requested "the Executive Director to accord high priority to the establishment in some of the typical rural areas of the countries of Asia, Africa and Latin America, in co-operation with the Governments of the countries concerned and such agencies within and outside the United Nations system as may be considered appropriate, of a few demonstration centres harnessing, individually or in combination, the renewable resources of energy locally available".

During its Fourth Session the Governing Council requested "the Executive Director, in co-operation with the relevant United Nations bodies, to accelerate an active programme involving the rational utilisation of renewable resources for energy generation which will have a positive impact on rural development, consisent with environmentally sound practices".

2.2 Immediate Objectives

To demonstrate the technical, economic and social feasibility of harnessing solar, wind and biogas energy resources in an integrated manner, to produce electricity (A/C) to meet the needs (mainly lighting and pumping drinking water) of a small rural community of the Pattiyapola Village.

SECTION 3 **PROJECT DESCRIPTION**

3.1 Background Data

This Project is the second phase of the Rural Energy Centres Project (RA/0700-75-05), by virtue of which a feasibility report was prepeared by Oklahoma State University for the establishment of a Rural Energy Centre in Sri Lanka, as a demonstration centre for an Asian region

After a study of the final feasibility report by the Government of Sri Lanka and UNEP., a UNEP Mission was sent to Sri Lanka to discuss the various issues and steps for the implementation of the Rural Energy Project. This Project document includes the agreements reached during such visit.

3.2 DESCRIPTION OF PROJECT

A. Rural Energy Centre

The three renewable resources of Solar, Wind and Biogas (SWB) energy will be harnessed in an integrated manner to produce electricity which will be used primarily for lighting the homes and pumping of drinking water for as many families of Pattiyapola Village as possible (about 200) living within a radius of about 1½ mile of the Rural Energy Centre site.

In Pattiyapola Village the average incidence of solar energy of any one year is of the order of 500 watts hrs./sq. ft. and the yearly average wind velocity is 12.3 mph. Further, there are about 1000 heards of cattle which, assuming a 20% collection of droppings can feed a biogas plant of 3000 cu. ft. at 60% of its capacity. As the Villagers become more familiar with the benefits of the system, the total production of gas should be increased to the plant's full capacity. The biogas energy will then be transformed into electric energy by means of a diesel/biogas Generator.

The solar energy will be harnessed by an array of solar collectors with an area of about 1500 sq.ft. The heat thus generated will pass through a heat exchanger to a Ranking Cycle engine capable of producing 10 - 20 KW of engine electric power. This system should produce about 30,000 Kwh/year with the yearly average incidence of solar energy at the site.

Wind energy will be harnessed by a series of wind turbines attached to generators. The total power output will then depend on the total number of turbines used.

The electric energy thus produced will be stored in a battery bank. When needed the energy will be withdrawn from the battery bank and will be transformed to A/C by an alternator. The energy in this form will then be consumed.

The system (with biogas plant working at full capacity) should provide about 60,000 Kwhr./year for consumption. This supply will be more than enough for lighting and pumping drinking water for a large number of families (upto 200).

The layout of the SWB system should be as shown in figure 24 of the OSU report. The devices will consist of :-

(a) Solar Collectors (about 1500 sq. ft.)

(b) Rankine Cycle generator (about 10 - 20 kw rated capacity)

(c) Wind generators of various types with a total rated capacity in the range of 20 kw.

(d) Biogas plant of 3000 cu. ft. capacity with a generator having a total capacity of about 50 kw.

(e) Battery bank of two sets of 60 hybrid (lead autimony and lead calcium) cells whose storage capacity should be in the range of 300 Kwh/day with a discharge rate in the range of 100 Kw for every 3 hrs.

(f) D/C to A/C converter.

(g) Distribution lines and wiring for the lighting the homes, streets and communal buildings such as schools and dispensaries.

(h) Drinking water pumping system including overhead tanks, reservoirs with taps and water purification devices.

(i) A small meteorological station to [illegible] the changes in weather which effect the performance of the Centre.

3. <u>Implementation</u>

The implementation of the Project will consist of the following phases :-

(1) <u>Design</u> - (i) Survey and selection of sites for solar, wind and biogas equipment, battery banks, etc. (ii) System design. (iii) Conceptual, preliminary and detailed engineering drawings. (iv) Schedule of quantities and cost estimates.

(2) <u>Procurement of materials and equipment</u> - (i) Procurement of imported materials and equipment. (ii) Procurement of locally available equipment and materials for construction. (iii) Fabrication of local components.

(3) <u>Installation</u> - (i) Site preparation. (ii) Civil Structures. (iii) Equipment installation.

(4) <u>Commissioning and Operation</u> - (i) Testing and commissioning of individual components. (ii) Integration into the designed system. (iii) Testing of system (iv) Operation of system.

(5) <u>Surveys</u> - Concurrently with the start of the Project surveys will be initiated by the Government of Sri Lanka to :-

a) Collect the meteorological data at the Rural Energy Centre site with reference to the number of sunshine hours, temperature, rainfall, solar intensity and wind velocity. These data will be used to optimise the output of the Centre.

b) Determine the socio-economic impact caused by the establishment of the centre in Pattiyapola with particular reference to the social acceptability of the facilities.

c) Provide UNEP with the need of the average rural village for lighting and drinking water, based over the past 7 yrs. experience, covering over 500 villages.

During these phases, the Government of Sri Lanka may require the help of Consultants, in which case the consultants will be chosen by the Government of Sri Lanka after prior consultation with UNEP.

C. <u>Responsibilities</u>

The responsibility for the establishment, operation and maintenance of the Rural Energy Centre [for the Asian Region] will be that of the Government of Sri Lanka, through the agency of the Ceylon Electricity Board and the support of UNEP. The Project Manager, who will be the focal point for liason with UNEP., will be the General Manager, of the Ceylon Electricity Board. The Project Manager will be assisted by competent groups. The Project Manager will appoint a Resident Engineer at the site. He will be in-charge of the execution of the Project at the site until smooth operation of the centre.

3.3 **WORK PLAN**

SEE ANNEX II

3.4 **BUDGET**

SEE ANNEX I FOR DETAILED BREAKDOWN.

	TOTAL	1976	1977	1978
UNEP	191,000	47,000	130,000	14,000
Sri Lanka	42,500	~~5,000~~	36,000	6,500

Note :- Sri Lanka shall meet all the local costs in Sri Lanka Rupees: inter-alia towards aquisition of land, construction of Civil structures required for the installation of the SWB devices and equipment, aquisition of locally available materials such as wires and light bulbs, salaries and allowances of locally recruited personnel, custom duties and taxes, if any and labour costs.

DISBURSEMENT SCHEDULE

UNEP shall pay the Government of Sri Lanka $ 30,000 upon signature of the Project document.

The balance after receipt and approval of reports 1 and 2 as specified in Section 4.1.

The funds shall be made available to Secretary, Irrigation, Power and Highways.

COUNTERPART CONTRIBUTION

All that portion of the Project expenses which will be incurred in local currency will be provided by the Government of Sri Lanka.

TION 4 REPORTS

Substantive Reports

UNEP should receive from the Government of Sri Lanka the following:-

(1) Results of the (a) Energy demand survey
(b) Confirmation of the availability of local renewable resources
(c) Preliminary socio-economic survey

(2) Blueprints of the Equipment and construction phase.

(3) Three letter reports

(a) After the procurement and fabrication stage.
This report should show what equipment was bought and for how much, what material was fabricated locally and difficulties encountered, civil engineering progress, who was selected for training.

(b) After the installation of the equipment

(c) After the commissioning phase.

(4) Final report after a preliminary evaluation.

(5) Quaterly reports during operations.

4.2 FINANCIAL REPORTING

Within 60 days of the completion of the project, the government of Sri Lanka will supply UNEP with a statement of accounts certified by Government auditors indicating that the resources provided by the Environment Fund have been expended in the manner agreed upon by this project document. Any portion of such resoucres remaining unspent or uncommitted by the Government of Sri Lanka on completion of the project will be reimbursed to UNEP within one month of the presentation of the financial statement. Upon request, the Government of Sri Lanka shall agree to facilitate the audit by the UN Board of Auditors of the accounts of the project.

4.3 TERMS AND CONDITIONS

Equipment

Non-expandable equipment purchased with UNEP funds shall remain the property of UNEP. The Government of Sri Lanka shall operate and maintain the Rural Energy Centre at maximum efficiency at their expense, and supply such information and data on its performance, as may be mutually agreed, to UNEP from time to time.

If the system fails completely to work for reasons pertaining to inadequacies of the imprted system components and/or system design, the equipment will be disposed of by a process of mutual consultation.

If for some other reason the Government of Sri Lanka decides not to operate and maintain the Centre, all the equipment paid for by UNEP, will be placed at the disposal of UNEP for such action as the Executive Director may decide to take in respect of them.

4.4 FACILITY

The Government of Sri Lanka shall give all reasonable facilities to the representatives of the various countries, particularly of Asia, to visit the REC and supply such information as may be of interest to them on different aspects of its installation, operation and maintenance.

SECTION 5 FOLLOW-UP ACTION

The Government of Sri Lanka shall operate and maintain the REC at maximum efficiency after the termination of the project and shall supply information to UNEP when requested. In particular socio-economic, technological and environment impacts of the REC as they are evaluated long after the termination of the Project.

ANNEX II

TIMETABLE

November	1976	-	Engagement and visit of Consultants.
		-	Survey and selection of site for equipment installation.
		-	Social acceptability study begins.
December	1976	-	System design.
		-	Engineering drawings.
		-	Schedule of quantities and accurate cost estimates.
January	1977	-	Blue prints sent to UNEP.
February	1977	-	Material and equipment procurement.
April, May	1977	-	Site preparation and civil structure building.
August	1977	-	Equipment installation.
January	1978	-	Testing of individual equipment.
March	1978	-	Integration of System.
May	1978	-	Commissioning of the system.
July	1978	-	System fully operational.

ANNEX I

3.4 BUDGET

	m/m	TOTAL UNEP $	TOTAL SRI LANKA $ equivalent	1976 UNEP	1976 SRI LANKA	1977 UNEP	1977 SRI LANKA	1978 UNEP	1978 SRI LANKA
10 PROJECT PERSONNEL									
11 Experts (Salaries)	6	20,000	-	8,000	-	8,000	-	4,000	-
16 Travel on official business of experts		13,000	-	5,000	-	5,000	-	3,000	-
30 TRAINING COMPONENT									
32 Training and / or Familiarisation		9,000	-	4,000	-	5,000	-	-	-
40 EQUIPMENT COMPONENT									
41 Expendable		-	2,500	-	-	-	2,000	-	500
42 Non-Expendable		140,000	35,000	-	-	128,000	30,000	12,000	5,000
50 MISCELLANEOUS COMPONENT									
53 Sundry		3,000	5,000	-	-	2,000	4,000	3,000	1,000
54 UNEP Participation		4,000	-	-	-	2,000	-	2,000	-
TOTAL :		191,000	42,500	17,000	-	150,000	36,000	24,000	6,500

APPENDIX IV

(a) An appraisal of the proposed UNEP Rural Energy Centre at Pattiyapola - Sri Lanka - T.L.Shankar April 1978 (copy submitted by Dr. K.G.Dharmawardena, Radio Isotope Centre, University of Colombo)

(b) Documents made available by the Ceylon Electricity Board (CEB)

   (i) Report of the Socio-Economic Survey Pattiyapola Village Hambantota District 1977 - compiled by the Government Agent Hambantota District

   (ii) Statement by Messrs. H.S. Subasinghe, B.P. Sepalage and D.S.R.Seneviratne of the CEB who man the REC

APPENDIX 4(a)

The UNEP Rural Energy Centre at Pattiyapola - Sri Lanka - T.L. Shankar

An Appraisal

1. There is a growing awareness of the problem of supplying the energy needs of rural areas in Sri Lanka. The UNEP demonstration project called the Rural Energy Centre, proposed to be set up in Pattiyapola village in Hambantota District of Sri Lanka has evoked considerable public interest. The UN aided project has given rise to the feeling that projects of the type proposed at Pattiyapola could be replicated in other villages so as to resolve the rural energy problem. This appraisal was undertaken to assess the relevance of the Rural Energy Centre experiment.

History

2. The Government of Sri Lanka and the United Nations Environment Programme (UNEP) have agreed (September 1976) to establish a Demonstration Rural Energy Project for the Asian Region in the village of Pattiyapola in Hambantota District of Sri Lanka. The objective of the Project is to demonstrate the technical, economic and social feasibility of harnessing solar energy, wind energy and bio-gas energy to meet the energy needs of a remote village and to prove that the existing state of the art of appripriate technologies for harnessing renewable energy resources under the conditions prevailing in rural areas of developing countries could justify the use of such technologies'. UNEP has selected three Demonstration Centres, one for African Region one for Latin American countries and one for Asian countries. REC at Pattiyapola would be the centre for the Asian Region. The proponents of this scheme have claimed that, if successful, the concept would revolutionize the life style of not less than 800 million people living in small isolated village conditions in the developing countries of Asia, Africa and Latin America. Under the agreement with Sri Lanka, estimated cost of the Project in US $ 191,000 in the form of equipment and expert services would be finaneed by UNEP and a further sum of US $ 42,500 equivalent to Sri Lanka Rs. 350,000 would be provided by the Government of Sri Lanka. The project report was worked out by Consultants chosen by UNEP, i.e., the Engineering Laboratory of Oklohoma State University. The project design was modified probably at the UNEP Head Quarters in Nairobi before the agreement was reached and is being changed in several details while it is currently under implementation. The cost configuration is bound to change with these modifications. It is difficult therefore to appraise the project, as there is no final delineation of the project.

Project Description

3. The project proposed in the report of the Oklohoma State University (hereafter referred to as OSU report) consists of three systems of energy production; electricity from wind energy, electricity form solar energy and bio-gas from the fermentation of cattle dung which would be used partly for generation of electricity along with 15% diesel oil and partly for providing directly heat for cooking. Capacities of the three systems would be as follows:

(i) The wind electric system would consist of seven windmills of five different makes having a total installed capacity of 20 kw.

(ii) The solar electric system would consist of solar collectors of 1500 sq.ft. connected to a freon based rankine cycle generator of capacity 10-20 kw.

(iii) The bio-gas plant will be of 3000 cu.ft. capacity of which 1000 cu.ft. could be used in the generator having a capacity of about 15 kw. and the rest connected to fifty household ovens.

4. The electricity produced by the three systems would be taken to a battery bank consisting of 60 hybrid lead-antimony cells whose storage capacity would be 300 kwh. per day. The electricity from the battery bank would be passed through a DC/AC converter and supplied as AC electricity to 50 households in the village for lighting purposes. The bio-gas generator would use 15% diesel oil besides 100 c.ft. bio-gas per day. A drinking water pumping system with an overhead tank of capacity of 3000 gallons with water purification facilities would also be constructed.

5. The project details worked out in the OSU report were altered in several ways in the UNED head quarters at Nairobi. The modified project hereafter called 'Approved Scheme' was accepted by Sri Lanka Government. On the supply system side, the approved scheme would consist of:

(a) a wind electric system consisting of four (in place of the original five) windmills having total capacity of 20 kw.

(a) a solar electric system as proposed in the OSU report; and

(c) a bio-gas plant of 3000 cu.ft. capacity; but all the bio-gas would be used for producing electricity in the generator using only bio-gas and no diesel and the capacity of bio-gas generator would be 50 kw.

6. The storage system is unaltered. On the distribution side, the project would supply no fuel for cooking but would supply only the lighting needs of 200 households plus the energy needs for water pumping as in the OSU Report. Surplus energy, if available, would be given to other uses, yet to be identified.

7. In the course of the implementation of the project, further changes are being introducted from time to time. As if now, the changes effected are reported to be:

(a) in the solar electric system, in addition to the collector and rankine cycle engine, there will be a photo-voltaic cell system of capacity 2 kw. which would directly convert solar energy to electricity, and

(b) in the wind electricity system initially only two windmills of one particular make (Dunlite 2000) would be installed of capacity 2 kw. each.

Evaluation of the Project Conceptualization

8. The OSU report states that the design of the project is based on a study of the energy needs of the village community of Pattiyapola and the locally available energy resources. The energy needs identified are for cooking food, for lighting households and for lifting water from a well to supply protected water to the population.

The energy needs for productive activities in the villages like agricultural operations and supporting household industries* or the recreational needs of the village are not considered. The assessment of even these simple needs have been done indifferently. In the OSU report it is assessed that the cooking needs of households where electric ovens are used would amount to 1.2 kwh. per day per household i.e. all the cooking could be accomplished with a 600 watt hot plate in two hours. This is patently inadequate. In the approved scheme this was changed to 4.5 kwh. per day per household which is probably too high. The assessment of energy needs for cooking, has however become redundant now, as the 'approved scheme' does not provide for any energy for cooking. The lighting needs of the villages are assessed to be 03.6 kwh. per household per day in the OSU report, 0.48 kwh. per day per household in the revised report of Nairobi. The OSU report states that a typical household in Pattiyapola would use 1.5 bottles of Kerosene per day for lighting alone** The indifference with which the estimation of energy needs of the village has been made in this report makes one wonder how much time was spent in Pattiyapola in understanding the local conditions before the OSU report was formalised.

9. An energy supply system designed to serve as a model for the rural areas of the developing countries should be based on a reasonable understanding of the causes for large sections of the rural community being denied access to efficient and convenient forms of energy like electricity. The study of rural electrification programmes of several countries show that even when generating capacity is available (as in Sri Lanka today) the Governments are unable to extend the electricity grid to rural areas as fast as they would like to, for want of public investment funds required for extending lines to the villages. Further, the procedures of computation today of the return on investment,(the criteria for approving rural electrifications schemes) make the electrification of several villages uneconomical as the loads comprise merely household need without other needs for industries or agriculture. In villages which have been 'electrified' only a fraction of the households avail themselves of electricity as the majority of the population lack the private investment funds for wiring the houses and setting up the connection facilities and also lack the money to pay for even the concessional rates of electric tariffs. Furthermore, electricity distribution regulations in several countries do not permit the extension of electricity to households which do not come up to certain minimum building standards. In the light of these, anyone who suggests the electricity solution to rural energy problems would have to come out with a supply system which would involve lower cost both in terms of public and private investments and could also overcome the restrictions imposed by the safety regulations governing the electricity supply to houses constructed with poor material like cadjans. Neither the OSU report nor the Agreed Scheme address themselves to these problems. In fact, they have come out with a supply solution which would be about ten times costlier than the conventional methods of electrifying villages. The average public investment cost for electrifying one household comes to over Rs. 17,000 per household to supply only the lighting needs.The operating cost of the system has not been quantified in any of these documents. Even if the consumers are required to pay only for the operating costs, the cost of electricity might prove to be higher than what they would have to pay if they were to receive electricity from the central grid.

* There is mention of a citronells oild factory in the village which uses firewood and the report concludes that this will continue to use firewood.

** Enquiries in a wide cross section of the people reveals that the lighting needs are met by the use of about 2 bottles of kerosene per week. An estimation of the total energy needs of a village for all purposes inclusive of productive uses is set out in the paper 'Energy Consumption in Domestic Sector of Sri Lanka' - Chapter IV.

10. A central objective of the project design is to take advantage of the complementarity in the availability of the solar and wind power so as to have a reliable system capable of giving a steady output throughout the year. However, as discussed below neither the complementary nature of the two sources has been assessed adequately nore the capacities of the two systems determined so as to equalise output under all circumstances. In the months of April and November, the system may prove to be unreliable.

11. It is well known that any transformation of one form of energy to another involves a certain loss of energy. Any conservationist approach to energy problems would attempt to utilize different forms of energy available in a situation for different purposes with the minimum of transformation. Rural Energy Centre design concept has however, visualised the conversion of energy to one form viz. electricity, and 'storing' it. As the conversion efficiencies are very low for the new technologies adopted, the 'storage' stage leads to the loss of nearly 40% of the energy produced, the whole system has a very low efficiency. In other words, the energy resources are wasted at the decentralised level.

Wind Electric System:
A Techno-Economic Appraisal

12. The wind regine at Pattiyapola has been determined from the data collected at the Hambantota Meteorological Centre. While the average wind velocity for the year is computed as 12.3 miles per hour there is a marked seasonal variation, i.e. the wind velocity during the months, October to April, is significantly lower than the wind velocity in the other months. In the months of April and November, the wind velocity is below 10 miles per hour on the average while in the other months of the lean period, it is about 10 miles per hour. A wind electric system is designed to produce electricity when the wind is at a particular minimum speed (cutting speed) and give the maximum of output at a particular higher speed. As the energy produced varies with the cube of the wind speed, at speeds lower than the maximum speed for which the machine is designed, the level of power generation gets reduced drastically. In the OSU report, five types of wind mills were chosen which have cutting speeds of 8-10 miles and give the maximum design capacity at speeds varying between 16 - 30 miles per hour. For the windmill which has the maximum reliability like Dunlite 2000 of 2 Kw. capacity and a cutting speed of 10 miles per hour, the average level of power generation in the different months would vary from 0.093 kw. In April to 0.62 Kw. in June. For the year as a whole, this equipment of 2 Kw. capacity will deliver power at the average rate of 0.37 Kw. As the electricity produced from wind electric system would vary in the different hours of the day and as electricity is needed only in the evening hours, it is inevitable that the system includes a storage system where electricity produced from the wind electric system at different parts of the day could be stored and drawn when needed. It is a costly proposition to have any storage system which can carry over the requirements for a number of days. In Pattiyapola the design is for carrying about one day's need. It is therefore necessary to analyse the daily availability of pwer from the wind electric system to ascertain the reliability of the system. The table over-leaf gives the month-wise Kwh. and daily Kwh. of electricity that might be generated from one windmill of Dunlite 2000 with a name plate capacity of 2 Kw.

Monthwise/Daily Electricity Generation at Hambantota for 2 KW. Wind Electric System

Month	Generation in Kw hours per month	per day
January	231	9
February	309	11
March	201	6
April	67	2
May	409	13
June	447	15
July	342	11
August	402	13
September	309	13
October	156	5
November	79	3
December	149	5
Total	3101	

13. It is important to note that in the process of storage, nearly 30 - 40% of the electricity generated is lost and in the whole system, betwwen generation and consumption, the loss might be as high as 50%. Thus useful electricity available from the wind electric system would only be half of the daily Kwh. indicated in the Table above. As Wind electric system is to have a capacity of 20 Kw. in the months of October, November, December and April, the daily energy available from the Wind electric system for use would be less than 25 Kwh.

The cost of power from the wind electric system could be calculated as follows:

	Life of equipment	Cost in US$	Cost in Rupees $ = Rs. 16	Annual Cost in Rs.
Windmill	25 years	3500	56,000	2,240
Tower	25 years	300	4,800	192
Maintenance (painting & greasing)				400
Total A				2,832

As the total electricity generated in a windmill of 2 Kw. capacity would be around 3100 Kwh. per year, the cost per Kwh. would be Rs. 1.40 per Kwh. at the point of generation. In a wind electric system used to supply lighting needs, storage of electricity becomes absolutely necessary. Even if it is assumed that storage losses are 40% only, the cost of electricity delivered for use would be Rs. 2,303 per kwh. This costing is the minimum as the salary for the Operators who would be in charge of the establishment has not been included and as the interest rate on the investment is calculated at 2½% p.a.

15. It is claimed that there is a possibility of reducing the cost of this equipment when it is produced on a mass scale locally. As this is an important issue, the designs of different wind electric systems should have been examined with reference to the possibility of producing the windmills and generators locally.

In the OSU report there is no examination of indigenous capability in Sri Lanka to manufacture the wind electric system or the possibilities of reducing the costs. A component by component analysis of the equipment needed for wind electric systems suggest that the possibilities of cost reduction are somewhat limited. The chances of manufacturing windmills which could be used to lift water appear to be fairly bright in Sri Lanka, but the manufacture of wind electric system might not be feasible for a number of years to come.

In sum, the use of windpower to produce electricity would tend to be a very costly proposition in any country and would be meaningless in a developing country which is not likely to manufacture windmills within the country. The foreign exchange component of the investment on imported wind-electric system, if compared in terms of foreign cost per Kwh. of energy might be higher than the foreign exchange cost of power generated from a diesel set.

Solar Energy System - A Techno Economic Appraisal

16. In the Approved Scheme the solar electric system is described as follows: "The solar electric power generator has a rated capacity of 10 to 20 kilowatts employing 1500 sq.ft. of concentrating type of solar collectors connected to a rankine cycle engine using freon. With the incidence of about 500 watt hours per sq/ft. of solar collectors, 273,750 kilowatt hours of thermal energy can be collected per year with 8 hrs. of sunshine a day. A temperature of about 250 degrees can be reached to operate the rand engine so that even at a low efficiency of about 11% the 273,750 kilowatt hours (Th) could be converted to about 30,000 Kwh.(e) per year". The OSU report stated that the proposed solar energy system is capable of producing approximately 40,000 killowatt hours of electricity per year, and would use 1500 sq.ft. of concentrators. The computation of the electricity output from the system is not given anywhere except in the para extracted above. In fact, most of the appendices concerning solar electric system consist of reproduction of printed brochures published by the manufacturers without any analysis. The claim in the OSU Report that the proposed solar electric system could produce 40,000 Kwh. a year is a shocking miscalculation and is inconsistent with the data in the report itself. In the OSU report, the manufacturers of the proposed collectors namely Owen Illinois, state that a maximum efficiency of 40% of the incident solar energy could be expected. In the proposed system heat concentrated from the collectors would be stored in a huge thermal storage consisting of a tank of coonut oil to be fabricated locally. It is obvious that such storages would involve some heat losses. The available heat from the storage tank would be used in a rankine cycle generator whose efficiency for the temperature differences possible in the system can only be 12 to 13% at the maximum. The overall efficiency of conversion therefore should be around 3 to 4% which itself is higher than what is quoted for similar systems elsewhere. Starting from a 1500 sq. ft. solar collector, 40,000 kwh of electricity cannot be generated. The claim that such a simple system well known for its overall efficiency can give a 11 to 12% conversion of incident solar energy raises doubts about the technical care that has gone into the preparation of this report.* It is stated in the

* In a subsequent communication to me, Dr. Allison of OSU has conceded that the equipment specified for the project with 1500 sq.ft. of collectors cannot produce 30,000 Kwh. of energy per year.

OSU Report that in almost all the months there are rainy days and in several months like April, May, June there are more than ten rainy days and in the months of October, November, December there may be as many as 15 rainy days. There is no discussion of the level of solar energy that could be exploited on rainy days. Consultants have had occasion to re-examine the figures and are now introducing 2 kilowatt photo-voltaic cell at enormous expense and are also proposing to change the whole solar-electric system! It is necessary at this stage to obtain from the Consultants a clear statement setting out the various stages of conversion from solar energy incident on the collectors to electricity at the point of delivery for use with details of the loss and dissipation at each stage.

The new equipment proposed should be capable of being easily maintained and operated in a rural set up and be capable of being manufactured within Sri Lanka in a reasonable period.

17. Solar electric system would cost US $ 80,000 and is expected to produce 30,000 Kwhr. of electricity per year. As electricity for lighting is needed when sunshine is not available, storage of electricity produced from solar sources is absolutely essential. Normally 40% of the electricity is lost during storage and re-use. The net usable electrical energy from the solar - electric system would only be 18000 Kwhrs per year. If we assume for the sake of this calculation, the solar electric system as designed in the OSU Report and the Agreed Scheme, costing about US $ 80,000/- could produce the quantity of electricity as claimed, the cost of the electrical energy produced whould be as follows:

	List of Equipment	Cost in Us$	Cost in Sri Lanka Rupees.	Annual Cost in Rupees
Investment of solar electrical system	30 years	80,000	1.28 million	42,666
Maintenance 1% of investment				12,800
Total Cost A				55,466
Interest at 2½%				32,000
Total Cost B				87,466

Cost of useful Kwh. would be Rs.3.08 if interest is not taken into account and Rs.4.86 if interest at 2.5% p.a. is also included. These costs are hypothetical as the system would hardly produce one fourth of the anticipated energy i.e., hardly 7000 Kwhrs. per year and the cost of electricity would be over Rs.15,0C per Kwh. Note that the costs do not include any salary for the operatives and the rate of interest is kept at 2.5% per year. Even if the life of the equipment is assumed as say 50 years and the maintenance cost ½% per year, the cost of electricity from the solar electric system is likely to be several times higher than the cost of electricity from other sources. The foreign exchange cost per Kwh of energy would be much higher than the foreign exchange cost of producing electricity from diesel!

Bio - Gas Electric System:

18. A Techno Economic Appraisal

The bio-gas system as proposed by the OSU Report consist of a gas plant which at 100% utilization can generate 3000 cu. ft. of bio-gas of which 2000 cu.ft. was to be directly used for cooking in 50 households and the remaining 1000 cu. ft. will be used in a 10 h.p. engine along with 15% diesel oil. This was expected to deliver 36 kilowatt hours of electricity per day. Normally 16. cu. ft. of bio-gas can work a one horsepower engine for one hour which would produce 0.6 Kwh. In the Approved Scheme the whole of 3000 cu. ft. is proposed to be utilised in diesel engines of about 85 h.p. so as to produce 50 kilowatts of capacity. The 3000 cu. ft. of gas can produce about 112 kilowatt hours of electricity. The dung requirements for full utilization of capacity of this plant would be 2.4 tonnes per day. In the Approved Scheme Report loss of power generation from the bio-gas generator has been under-estimated by over-valuing the gains in converting cowdung to odourless slurry. It is assumed that the bio-gas plant would yield 650 tons of slurry organic manure which could be sold at $5 a ton while the cost of collecting a tonne of cowdung is assumed as about $1.7. In other words anyone who could dig a hole in the ground and allow the fermentation of cowdung and take out slurry could make a gain of $3 per ton of slurry sold: This assumption is wholly untenable. Inquiries on Pattiyapola indicate that a cartload of cattle dung cost Rs. 10/- during certain periods of the year and Rs. 20/- in certain other periods. A cartload may contain 0.3 to 0.5 tonnes of dung. As the organic manure is used in open fields, there is no marked preference for odour-free manure. At best, a 10% to 20% higher price over that of raw cattle dung could be obtained for slurry but part of that gain would be lost in transport and storage charges. In such calculations, it would be reasonable to assume that the price at which the slurry could be sold, would more or less cover the costs of collection and transport of the dung to the plant.

19. Unlike the solar and wind systems the bio-gas plant would need constant attention. A gas generator plant should have at least one attendant who would account for the dung in storage and feed appropriate quantities into the gas plant at least one operator to be in charge of the generator plant of 80 h.p. capacity. The minimum salary for these two operators would be Rs. 300/- and Rs. 500/- per month. The quantity of usable electricity that could be generated from the bio-gas plant would depend on the level of its operation and the system to which the bio-gas generator is linked. As the gas storage itself provides a means of storing energy potential and gas could be used to generate electricity at any point of time when it is required, it would not be necessary to produce electricity from the bio-gas generator and "store" it in batteries, though such a wasteful stage is incorporated in the Agreed Scheme set out in the Executive Summary as well as the project document. * We will therefore assume electricity produced from the gas generator is directly used without "storage". As this generator is a stand-by capacity to be used only if the solar and wind systems don not function, the number of days during which this element would work would be limited. If 35 days a year is taken for maintenance, reporting etc., the bio-gas generator can work, if necessary for a maximum of 330 days. As a standby capacity it might work for say 150 days in a year.

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* In a communication one of the consultants to the REP Dr. Allison states that this part of the design is absurd. It is not explained anywhere as to who suggested this feature and why.

...e cost of power generated from the gas plant can be calculated ...ows:

	Life of equipment	Cost in US$	Cost in Rupees	Annual cost in Rupees.
Gas Plant	30 years	15,000	240,000	8,000
Gas Generator	10 years	8,000	128,000	12,800
Operators	Rs.800 x 12 per year			9,600
Maintenance (as in OSU Report painting, replacement of walls etc.)				4,000
Total A				34,400
Interest at 2.5% p.a. of interest				9,200
Total B				43,600

Case I	Electricity Generated in 330 days @ 112 Kwh. per day	= 39960 Kwh/year
Case II	Electricity generated in 150 days	= 16800 Kwh/year
Case I	Cost of Electricity per Kwh.	= Rs. 1.18
Case II	Cost of Electricity per Kwh.	= Rs. 2.60

21. The cost of power generation from very small bio-gas generator schemes is also not low. Further there are operational problems in maintaining a bio-gas generator as a standby facility. It would be activised on rainy windless days and the gas formation on such days might be sluggish. What would be the procedure for keeping the 'gas' as well as slurry in the bio-gas pland in 'cold reserve' without gas production for weeks or months and suddenly activising the plant at short notice? What are special problems of collecting and transporting cowdung to the plant on the rainy days? These problems are not discussed in the Report.

22. Combined System.

In designing the project it is claimed that the complementarities of the availability of sun and wind power is fully exploited and bio-gas plant is provided as a further back-up. But neither the OSU Rep··t nor the Executive Summary has established the reliability of the system with reference to the adverse conditions that the project might face, especially in the months of April and November, when there are many rainy days and the wind velocities are low. On such days the gas formation rate might be low. Further, if the solar and wind resources cannot form the basis for a reliable supply of electricity and a bio-gas plant has to be provided as a back-up the purpose of attempting to utilise the sun and the wind energy are not clear. A bio-gas plant does not waste any resources, but takes the manure and upgrades it. Why then should one attemt to use any other resources? What is the knowledge or experience that this project would give, that would make it possible to eliminate one or the other systems included in the solar-wind-bio-gas SWB system as designed: These are important issues which are not discussed in the report.

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APPENDIX 4(b)(i)

Socio-Economic Survey - Pattiyapola Village-1977 compiled by Government Agent Hambantota District

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STATISTICAL TABLES

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INTRODUCTION

1. General Features & Objectives

This project is the second phase of the Rural Energy Centre Project (UNEP Project No.R.A./0700-75-05), by virtue of which a feasibility report was prepared by the Oklahoma State University (U.S.A.) for the establishment of a Rural Energy Demonstration Centre in Sri Lanka. After the study of the final feasibility report by the Government of Sri Lanka and UNEP, an agreement was reached for the establishment of a Rural Energy Demonstration Centre at Pattiyapola Village.

The main objective of the project is to demonstrate for the benefit of the countries of Asia the technical, economic and social feasibility of harnessing solar, wind and biogas energy resources in a integrated manner, to produce electricity, to meet the needs (mainly lighting and pumping drinking water) of a small rural community.

2. Project Description

The three renewable resources of Solar, Wind and Biogas energy will be harnessed in an integrated manner to produce electricity which will be used primarily for lighting the houses and pumping of drinking water for as many families of Pattiyapola Village as possible (about 200) living within a radius of about 1½ miles of the Rural Energy Centre site. Any surplus energy could be used for such agro based industries as may be considered appropriate by the Government of Sri Lanka.

In Pattiyapola Village the average incidence of solar energy is of the order of 500 watt hrs./sq.ft. and the yearly average wind velocity is 12.3 m.p.h. Further, there are about 1,000 cattle which, assuming a 20% collection of droppings can feed a biogas plant of 3,000 cu.ft. at 60% of its capacity. As the villagers become more familiar with the benefits of the system, the total production of gas could be increased to the plant's full capacity. The biogas energy will then be transformed into electricity energy by means of an engine coupled to a Generator.

The solar energy will be harnessed by an array of solar collectors with an area of about 1,500 sq.ft. The heat thus generated will pass through a heat exchanger to a Ranking-Cycle engine capable of producing 10 -20 KW of electric power. This system should produce about 30,000 Kwh year with the yearly average incidence of solar energy at the site.

Wind energy will be harnessed by a series of wind turbines attached to generators. The total output will depend on the total number of turbines used, but on the basis of the wind regime as extrapolated from the data available at Hambantota Observatory it will be of the order of 17,000 to 32,000 Kwh per year.

The electric energy produced by the three above mentioned sources viz: Solar, Wind and Biogas will be stored in a battery of bank of adequate capacity. When needed the energy will be withdrawn from the battery bank and will be transformed to A/C by an alternator, and/or electronic inverter device. The energy in this form will then be distributed in the conventional manner to the various homes.

It is estimated that the system (with biogas plant working at full capacity) would be capable of supplying about 60,000 Kwhr/year (AC)which will be more than enough for lighting and pumping drinking water for a large number of families (up to 200).

For the purpose of lighting a village home, 4 bulbs, two of 25 watt each and two of 40 watt each is to be provided to be used 4 hrs. per day/night per family, and drinking water is estimated at 2 gallons per person per day. Any surplus energy from the Rural Energy Centre will be used to power small agro based industries like ~~rice husking~~ paddy milling, rope ~~making~~ twisting, coir, cloth weaving looms, etc.

The devices that will be used in the REC project will consist of :-

(a) Solar collectors (about 1,500 sq.ft.)

(b) Rankine Cycle generator (about 10 - 20 kW rated capacity),

(c) Wind generators of various types with a total rated capacity in the range of 20 kW.

(d) Biogas plant of 3,000 cu.ft. capacity with a generator having a total capacity of about 15 kW.

(e) Battery Bank of the sets of 60 bybrid (load antimony and lead calcium) cells whose storage capacity should be in the range of 300 kwh/day with a discharge rate in the range of 100 kW for every 4 (three) hours

(f) D/C to A/C) convertor.

(g) Distribution lines and wiring for the lighting the homes, streets and communal buildings such as schools and dispensaries.

(h) Drinking water pumping system including overhead tanks, reservoirs with taps and water purification services,

(i) A small meteorological station to monitor the changes in weather which effect the performance of the Centre.

The total cost of the project is estimated at U.S.$ 233,500. The foreign cost component amounting to U.S. $ 191,000 will be met by the UNEP and the balance local cost is to be met by the Sri Lanka Government.

The project is expected to be completed in November 1978.

3. Pattiyapola Village

The basic premise for the establishment of a Rural Energy Centre is that the basic resources of solar, wind and biogas energy should be available. The selection of a suitable village for the implementation of the rural energy concept is not expected to be critical as the systems expand. However, it was considered important that the site selected for the first demonstration centre be carefully considered, with special emphasis on such constraints as (a) accessibility to a major transportation artery (b) Isolation from a conventional electrical distribution grid, (c) Availability of all three basic energy resources.

An examination of the meteorology of Sri Lanka is indicative of good solar and wind regimes in the southern part of the Island. This area of Sri Lanka being in the dry zone possesses high degree of solar insolation. Further, the combination of inland mountains and energy ocean create the necessary temperature gradient for strong reliable winds.

Based on the general constraints of basic need, availability of solar wind, and biogas energy resources and accessibility, Pattiyapola Village was chosen for the establishment of the first Asian Demonstration Centre. The village is located a few miles inland near the southern tip of the Island. It is easily approached from the road between Matara and Hambantota. The specific location of the village is indicated on the Map of Sri Lanka appended.

Pattiyapola Village is somewhat isolated from other villages in the area. The village is distributed around an artificial reservoir covering an area approximately 1000 acres. The history of the reservoir dates back to approximately 200 A.D. and said to have been built by one of the Commanders named "Gotaimbara" of King Dutugemunu's Army. The history of the village can be traced to its formation. The reservoir and the steel blue mountains in the background contributes to the scenic beauty of the village and this was also a significant factor in the selection of the village for the proposed energy centre.

2. GENERAL FEATURES OF SURVEY AND SUMMARY OF FINDINGS

(A) GENERAL FEATURES OF SURVEY.

A preliminary Survey of Households was carried out in February 1977. This covered a sample of ten Households selected at random, and these were visited by the Statistical Officer and the Project Engineer (Rural Energy Centre), with a view to, (a) testing out the suitability of the survey questionnaire, and (b) obtaining preliminary Socio - Economic data on this village.

The listing of households prior to the Survey proper which was done by Statistical Officer and the Grama Sevaka indicated that there were 383 housing units, out of which 27 were unoccupied. The final survey thus covered a total of 356 households. All these households were visited, for purposes of the survey, during a two week period commending 15th February, 1977 by a team of nine Statistical Investigating Officers, and the survey questionnaire was filled up for each household. A detailed field check was conducted by the Statistical Officer himself on 10% of households, already surveyed by the Statistical Investigating Officers to ensure that the data in the survey questionnaire had been accurately and adequately entered by Statistical Investigating Officers.

(B) SUMMARY OF FINDINGS.

2.1 DEMOGRAPHIC AND SOCIAL CHARACTERISTICS OF THE POPULATION.

2.1.1. Sex : The population living in Pattiyapola as in March, 1977 was 2102. The ratio of males to females is in the order of 52 : 48. This shows a higher male population as compared with the all Island figure of 51 : 49.

2.1.2 Age Structure : As in the age structure of the island's population, a heavy concentration can be seen at the lower age levels in the case this project area too. Approximately 34.7% of the total population in Pattiyapola were found to be less than 19 years of age. However, only 12% of the population were found to be in the age group of 5 years and below.

2.1.3 Marital Status: A classification of population of the age group of 5 years and over by marital status indicates that 60.3% of the total population were unmarried, 35.3% were married and only 4% had widowed, divorced or separated. The age/sex breakdown by marital status shows that more females have married at a younger age than males, and the average age at marriage for women was 25 years. As indicated in table 10 the proportions of marriages at lower ages were very high. Nearly 40% of married females have married under 20 years of age and 83.5% were married under 25 years of age. The percentage of marriages at higher age levels (at 25 years and over) is only 16.4%.

Note :

Conjugal Condition : Investigating Officers were asked to collect information in respect of each person over 5 years of age either unmarried, married, widowed or divorced.

The entry "married" was made in the case of every person claiming to be married according to custom or repute, though the marriage had not been registered according to Law.

The entry "divorced" was made only if a legal divorce had been obtained. Divorced persons who had married again were entered as "married" not as divorced. A person who was not divorced but legally separated was regarded as married. In most cases, without being married legally.

2.1.4 Literacy : From the data collected during the survey it was observed that a high rate of literacy is prevailing in Pattiyapola village. Nearly 81% of the population over 5 years of age were literate and this figure compares very favourably with the corresponding literacy rate of 82% ofor the whole island population over 10 years of age as worked out at the Socio-Economic Survey of 1969/70. The most salient feature in the literacy rate of the people of Pattiyapola is the substantially higher degree of literacy observed at lower age levels. The literacy rate of the age group of 6 to 18 years was found to be 83%, whilst it was only 62%, for the age group of 50 years and over. These observations of the rate of literacy can be favourably compared with the level of education.

2.1.5 Level of Education : Educational Attainment statistics of the population over 5 years of age reveals that 19% have had no schooling at all. This shows a slight improvement over the position revealed at the 1969/70 Socio-Economic Survey as the corresponding proportion of the rural sector was only 17%. Women form more than 63% of the no-schooling population. The bulk of the population (72.1%) was seen to have received an education in primary or junior secondary schools. Only 8.8% had passed the G.C.E. or higher examinations. It is heartening to note that there were 6 graduates and one post-graduate holder too in this village. School enrolment statistics shows that males dominate in the general formal education system. However this educational gap between sexes had gradually diminished, among the younger generation.

2.1.6 Principal activity or occupation : Table 12 given in appendix will show that 35% of the population, over 5 years of age comprises the labour force or the economically active population and the rest 65% constitute the economically in-active or dependant population. The ratio of males to females in the labour force is 4 : 1. The employed category constitutes 28.5%, 6.5% were unemployed, 29.1% were engaged in household work, 25.5% were students and 1.4% were retired or disabled, or too young to work and other. An analysis of the composition of the labour force shows that 81.4% were employed, and 18.6% were unemployed. This indicates that 19% of the manpower resources of the village remain unutilized or under-utilized. This unemployed rate is substantially higher when compared with the national rate (13.4%) obtained from the 1969/70 Socio-Economic Survey. Even among the employed the actual participation in full-time activities had been extremely low. Thus it is note worthy that more than 45% of the total available man days had been lost due to impaired health conditions alone. Malaria had been the prime cause, with infective hepatitis too having its share.

An analysis of the occupational pattern reflects the predominant role of agriculture in the village economy. Nearly 72.7% of the employed population is engaged in agricultural activities. The rest are white collar workers whilst those engaged in the manufacturing sector are negligible.

2.2. ECONOMIC CHARACTERISTICS OF THE POPULATION

2.2.1 Household Income : In an average household size of 5.9 persons there were 1.5 income receivers. This is slightly lower than the national average of 1.7 income receivers for the same size of average household as disclosed at the Socio-Economic Survey estimate of 1969/70. As indicated in table 16, the distribution of households by income size shows that nearly 7.9% of the households earn less than Rs. 100 a month, 78.3% of them have incomes of over Rs. 100 and less than Rs. 500 per month, and only 13.2% have incomes of Rs. 500 and over. The average income of a household per month is estimated to be Rs. 321.74. The average monthly income of an income receiver was Rs. 212.40. Nevertheless, the per capita income falls to as low a level as Rs.54.49, due perhaps partly to a very high dependency ratio recorded which was of the order of 4.8 persons per household.

2.2.2 Source of Household Income : The bulk of the household income is received from earnings from own - account enterprises. This accounted for nearly 77% of the total income. Wages and salaries accounted for only 12% of the total income, while the share of non-monetary income amounts to 11% including the rental value of the owner occupied dwellings. A classification of income receivers by major industry shows that 78.3% of income receivers have earned their incomes from agricultural activities, 6.8% from services, and 2.1% and 0.4% of them have derived their earnings from Industry and Trade respectively. It was also observed that 83.6% of the income receivers were males.

Note : It should be noted that most of the Households tend to understate their income for fear of taxation and fear of loss of subsidies etc. It is also extremely difficult to assess a definite income from the agricultural produce which forms a bulk of the household income, due to the uncertainity of rain and due to the lack of proper markets and wide fluctuations in the market prices. Practically the entire chillie cultivation carried out in this season had been lost due to failure of expected rain. Citronella Oil which fetched as much as Rs.40/= to Rs.50/= for a bottle about an year ago, now fetches only a meagre Rs.10/= to Rs.15/=.

2.2.3 HOUSEHOLD EXPENDITURE (CONSUMPTION)

The average monthly household expenditure on consumptio was estimated at Rs.458.40. It should also be noted that the average varied expenditure quite significantly with the level of income.

A classification of household expenditure by major expenditure groups shows that 76.5% of total expenditure is spent on food. This shows the normal pattern of a high food-ratio in an economically less developed society. The share of expenditure on food out of total expenditure varies from 87.4% of the income group of below Rs.100 to 73.5% of the income group of Rs.500 and over. This pattern could also be seen in expenditure on clothing. Expenditure on household services and recreations increases absolutely with the increase in the income level.

2.2.4 Land and Land Utilization : In the ownership of land, it is observed that on an average each household owned or held approximately 1.6 acres of high land and 0.5 of an acre of paddy lands. About 41.1% of high lands were used for cononut cultivation and about 5% of this was mixed with citronellagrass. Chena cultivation including minor crops occupy about 32.2% and citronella is cultivated in about 9.5% of the available land. Nearly 10.5% of the cultivable land is not cultivated. Almost all the paddy lands are cultivated only one season in an year. This may be attributed to the shortage of water.

2.2.5 Livestock : It was observed that cattle and buffaloe farming takes an important place in the agricultural enterprise. A household has an average number of 2 head of cattle/buffaloes. A fair amount of poultry livestock are also owned by farmers of this village. Households owning goats were negligible.

2.3 HEALTH AND VITAL STATISTICS

2.3.1 Health Statistics : During the course of the survey some basic information was obtained from households regarding the sickness of the people in the village. It was observed that 28.7% of the population suffered from some kind of illness. It would be noted that the prime disease from which the largest number of people fell sick was malaria. Approximately 89.7% of patients reported during the reference period suffered from malaria. 93.7% of all patients have been taken western treatments and only 4.8% have resorted to ayurvedic treatment.

2.3.2 Marriage Statistics : Statistics relating to marriage are so inadequate that it is impossible to study the marriage rate or fertility trend. However from available data it can be noticed that 55% of marriageable females have married and the mean age of marriage is 25 years. Table 10 given in appendix indicates that the proportions of marriage at lower ages are very high. Given the age distributions of married women in Pattiyapola, it is seen that this has induced a particularly high fertility rate in that area.

2.4 HOUSING CONDITIONS

2.4.1 General Characteristics : The total number of housing units available in the village is 356 out of which 203 are permanent, 12 are temporary, and the balance 141 being of improvised structures. A large number, as much as 345, are observed to be single houses. Nearly 75.8% of the houses are roofed with cadjan and the rest with tiles or asbestos sheets. The majority of the houses, totalling to a number of 207 were found to be in the floor area range of 200 to 500 sq.ft. amounting to a total of 58.1%. Only 24.2% of the houses were of a floor area greater than 500 sq. ft.

The average number of occupants for a single housing unit was 5.9 which is identical with the figure at national level value as worked out in the Socio-Economic Survey in 1969/70.

2.4.2. Water Supply : More than 95% of the households obtain their requirements of water for drinking and cooking purposes from wells, scattered around the village and only a few depend on the tank for their supplies of water. Most of the households make use of the village tanks for bathing purposes.

2.4.3. Fuel and Energy : Almost all the households depend on firewood for cooking and kerosine oil for lighting.

2.4.4. Toilet Facilities : An analysis of housing units by type of toilet facilities available shows that nearly 66% of the housing units had toilet facilities. It was also observed that 58.6% had cesspits, 3.7% had water seal and 37.7% had no toilet facilities of any type.

2.4.5. Household Equipment : Information collected on the availability of selected items of household equipments revealed that 25% of households had sewing machines, 34% had battery operated radios, 25.8% had petromax type lamps. 26.1% had bicycles 15.7% had a bullock cart. There were also one four wheeled tractor, 4 hand tractors (2 wheel tractor), 3 cars and 1 van for the entire village.

T A B L E - 1

GENERAL CHARACTERISTICS OF MEMBERS OF HOUSEHOLD

AGE GROUP (Years)	MALES		FEMALES		BOTH SEXES	
	NUMBER	%	NUMBER	%	TOTAL NUMBER	%
0 - 5	147	13.38	114	11.36	261	12.42
6 - 18	389	35.40	340	33.90	729	34.68
19 - 49	442	40.22	449	44.77	891	42.39
50 & Over	121	11.00	100	9.97	221	10.51
TOTAL (ALL-AGES)	1099	100	1003	100	2102	100
%	52.28	-	47.72	-	100	-

T A B L E - 2

LITERACY BY AGE GROUP

(POPULATION OVER 5 YEARS OF AGE)

AGE GROUP (YEARS)	LITERATE	ILLITERATE	TOTAL
6 - 18	605	128	733
%	82.54%	17.46%	100
19 - 49	756	138	894
%	84.56%	15.44%	100
50 & OVER	136	84	220
%	61.82%	38.18%	100
TOTAL	1497	350	1847
%	81.05%	18.94%	100

TABLE - 3

MARITAL STATUS BY AGE GROUP

(POPULATION OVER 5 YEARS OF AGE)

AGE GROUP (YEARS)	NEVER MARRIED	MARRIED	WIDOWED	DIVORCED	SEPARATED	TOTAL
6 - 18	719	10	-	-	-	729
19 - 49	375	491	13	-	12	891
50 & OVER	12	153	50	-	6	221
TOTAL	1106	654	63	-	18	1841
%	60.08	35.52	3.42	-	0.98	100

TABLE - 4

MARITAL STATISTICS BY AGE GROUP AND SEX

(POPULATION OVER 5 YEARS OF AGE)

AGE GROUP (YEARS)	NEVER MARRIED				MARRIED				WIDOWED		DIVORCED		SEPARATED		TOTAL	
	M	%	F	%	M	%	F	%	M	F	M	F	M	F	M	F
6 - 18	384	62.54	335	68.09	5	1.52	5	1.52	-	-	-	-	-	-	389	340
19 - 49	222	36.16	153	31.19	213	66.56	278	83.23	1	12	-	-	6	6	442	449
50 & OVER	8	1.30	4	0.81	102	31.88	51	15.27	8	42	-	-	3	3	121	100
TOTAL	614		492		320		334		9	54	-	-	9	9	952	889

T A B L E = 5

LEVEL OF EDUCATION BY AGE GROUP AND SEX
(POPULATION OVER 5 YEARS OF AGE)

AGE GROUP (YEARS)	NO SCHOOLING		PRIMARY		MID SCHOOL		PASSED G.C.E.		PASSED AD.LEVEL/ H.S.C.		UNDER-GRADUATE		PASSED DEGREE		POST GRADUATE		T O T A L	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
5 - 18	71	57	197	156	105	105	18	14	2	-	-	1	-	-	-	-	393	333
19 - 49	38	100	166	165	170	122	51	52	6	5	1	3	4	2	1	-	437	449
50 & OVER	20	64	86	33	18	5	3	-	-	-	-	-	-	-	-	-	127	102
TOTAL	129	221	449	354	293	232	72	66	8	5	1	4	4	2	1	-	957	884
TOTAL OF BOTH SEXES	350		803		525		138		13		5		6		1		1841	
%	19.01		43.62		28.52		7.50		0.71		0.26		0.33		0.05		100	

TABLE - 6

VOCATIONAL OR TECHNICAL TRAINING BY AGE GROUP AND SEX

AGE GROUP (YEARS)	PROCTORS ADVOCATES		PHYSICIANS NATIVE/WEST		ENGINEERS		TECH. OFFICERS: AG.INSTRUCTORS		OTHERS		TOTAL	
	M	F	M	F	M	F	M	F	M	F	M	F
5 - 18	-	-	-	-	-	-	-	-	-	-	-	-
19 - 49	-	-	-	-	-	-	-	-	1	2	1	2
50 & OVER	-	-	2	-	-	-	-	-	-	-	2	-
TOTAL	-	-	2	-	-	-	-	-	1	2	3	2

T A B L E - 7

STUDENT POPULATION CLASSIFIED BY AGE GROUP & SEX

AGE GROUP (YEARS)	MALES	FEMALES	TOTAL
5 - 18	212	211	423
19 - 45	24	22	46
TOTAL	236	233	469

T A B L E - 5

STUDENT POPULATION CLASSIFIED BY AGE GROUP, SEX AND LEVEL OF EDUCATION

AGE GROUP (YEARS)	NO SCHOOLING		PRIMARY		MID SCHOOL		PASSED G.C.E.		PASSED ADVANCED LEVEL		UNDER GRADUATE		TOTAL	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
5 - 18	2	2	133	109	66	85	11	14	-	-	-	1	212	211
19 - 49	-	-	-	-	8	4	15	16	1	-	-	1	24	21
TOTAL	2	2	133	109	74	89	26	30	1	-	-	2	236	232
TOTAL OF BOTH SEXES	4		242		163		56		1		2		468	
%	0.9		51.7		34.8		12.0		0.2		0.4		100	

TABLE - 9

HEALTH STATISTICS BY NUMBERS

NUMBER SUFFERED FROM ANY ILLNESS	ILLNESS			NUMBER WHO TOOK TREATMENT		
	MALARIA	HEPATITIS	OTHER	WESTERN	AYURVEDIC	UNSP
603	540	4	59	565	29	9
%	89.6	0.7	9.8	93.7	4.8	1.5

T A B L E - 10

FERTILITY FOR MARRIED WOMEN ONLY BY AGE AT MARRIAGE

AGE AT MARRIAGE & AGE GROUP (YEARS)	MARRIED FEMALES	NUMBER OF LIVE BIRTHS	NUMBER OF LIVING CHILDREN	NUMBER OF CHILDREN BORN IN LAST YEAR
(1) 10 - 14	7	38	27	-
(2) 15 - 19	147	772	653	23
(3) 20 - 24	168	775	677	32
(4) 25 - 29	46	197	166	4
(5) 30 - 34	15	58	45	6
(6) 35 - 39	2	12	9	-
(7) 40 - 44	-	-	-	-
(8) 45 - 49	-	-	-	-
(9) 50 & OVER	-	-	-	-
TOTAL	385	1852	1577	65

T A B L E - 11

SOME SPECIAL OCCUPATIONAL SKILLS OF EMPLOYED BY NUMBERS

CARPENTRY	MASONRY	MAT WEAVING	BATIK	SPINNING & WEAVING	OTHER	TOTAL
2	1	2	1	7	6	19

EMPLOYED POPULATION CLASSIFIED BY AGE GROUP

SEX AND OCCUPATION

AGE GROUP (YEARS)	OCCUPATION	SEX	
		Males	Females
5 - 18	Domestic Servant	3	3
	Farmer-Cult.-Paddy	5	-
	" " -Vegetables	2	-
	" " -Other Crops	2	-
	" " -Coconut	2	-
	Agricultural Labourer	3	-
	Textile Weaving	-	1
	Labourer(Other)	7	3
		24	7
19 - 49	Ayurvedic Physicians	1	-
	Teachers	4	7
	Managers	1	-
	Grama Sevaka/Village Headman	1	-
	Bus Conductor	3	-
	Govt. Clerk	-	1
	Mercantile Clerk	1	-
	Other Clerk	1	3
	Salesman	1	-
	Domestic Servant	1	2
	Dhoby	-	1
	P.C.	1	-
	Watcher	1	-
	Farmer-Cultivator-Paddy	109	4
	" " -Vegetables	11	-
	" " -Other Crops	62	2
	" " -Coconut	46	3
	Other Cultivators	5	-
	Agricultural Labourers	36	8
	Other Agri-Workers	-	1
	Textile Weaving	-	4
	Tailors	1	-

T A B L E - 12

TYPE OF ACTIVITY, STUDENT POPULATION & UNEMPLOYED POPULATION BY AGE GROUP AND SEX

(Population over 5 years of age)

AGE GROUP (YEARS)	Employed		Unemployed		Engaged in Household Work		Students		Retired Old Disabled		Too young to work		Other		Total	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
5 - 18	24	7	40	9	47	57	212	211	4	2	44	41	18	13	389	340
19 - 49	317	58	33	38	59	325	24	22	8	5	-	-	1	1	442	449
50 & Over	91	27	-	-	1	47	-	-	29	26	-	-	-	-	121	100
Total	432	92	73	47	107	429	236	233	41	33	44	41	19	14	952	889
Total of Both Sexes	524		120		536		469		74		85		33		1841	
%	28.46		6.52		29.11		25.48		4.02		4.62		1.79		100	

TABLE 13 (Contd.)

EMPLOYED POPULATION CLASSIFIED BY AGE GROUP

SEX AND OCCUPATION

AGE GROUP (YEARS)	OCCUPATION	SEX	
		Males	Females
19 - 49 (Contd.)	Motor Mechanics	1	-
	Brick Makers	1	-
	Carpenters	2	-
	Masons	1	-
	Bus/Lorry Drivers	1	-
	Other Vehicle Drivers	3	-
	Carters	1	-
	Labourers	18	21
	Occ. Not adequately described	3	1
		317	58
50 and Over	Ayurvedic Physicians	1	-
	Grama Sevaka	1	-
	Launderers	-	1
	Farmer-Cultivator-Paddy	53	1
	" " -Vegetables	2	2
	" " -Other Crops	12	4
	" " -Coconuts	17	-
	Other Cultivators	-	1
	Agricultural Labourers	4	7
	Other Agri. Workers	-	1
	Labourers (Other)	1	10
		91	27

T A B L E - 14

EMPLOYMENT STATUS BY SEX AND AGE GROUP

(POPULATION OVER 5 YEARS OF AGE)

AGE GROUP (YEARS)	EMPLOYER		EMPLOYEE		OWN ACCOUNT AND UNPAID FAMILY WORKER		T O T A L	
	M	F	M	F	M	F	M	F
5 - 18	-	-	11	10	13	-	24	10
19 - 49	21	4	82	74	216	6	319	84
50 & OVER	7	-	18	31	86	11	111	42
TOTAL	28	4	111	115	315	17	454	136
TOTAL OF BOTH SEXES	32		226		332		590	
%	5.4		38.3		56.3		100	

Note:- The total of the employment status category as shown in this table includes some part time workers who were engaged in household work and in study, and thus exceeds the total shown as employed in the earlier table number 12.

T A B L E - 15

UNEMPLOYED POPULATION CLASSIFIED BY AGE GROUP AND SEX

AGE GROUP (YEARS)	MALES	FEMALES	TOTAL
5 - 18	40	9	49
19 - 50	33	38	71
50 & Over	-	-	-
TOTAL	73	47	120

T A B L E - 16

AVERAGE MONTHLY HOUSEHOLD INCOME AND PER CAPITA INCOME

INCOME GROUP	NUMBER OF HOUSEHOLDS	%	NUMBER OF INCOME RECEIVERS	TOTAL MONTHLY INCOME Rs.	AVERAGE MONTHLY INCOME Rs. cts	AVERAGE INCOME PER INCOME RECEIVER Rs. cts
INCOME BELOW 100	28	7.9	32	2371	84.68	74.09
100-199	69	19.4	84	10107	146.48	120.32
200-299	116	32.0	160	26378	231.39	164.86
300-399	61	17.1	97	20025	328.28	206.44
400-499	35	9.8	73	14775	422.14	202.40
500 & Over	47	13.2	93	40885	869.89	432.62
TOTAL	356	100	539	114,541	321.74	212.51

T A B L E - 17

INCOME RECEIVERS CLASSIFIED BY MAJOR INDUSTRIAL GROUPS

AGE GROUP	AGRICULTURE		TOTAL	INDUSTRY		TOTAL	TRADE		TOTAL	SERVICES		TOTAL	OTHER		TOTAL	TOTAL		TOTAL
	M	F		M	F		M	F		M	F		M	F		M	F	
5 - 18	14	-	14	-	1	1	-	-	-	3	3	6	7	3	10	24	7	31
19 - 49	269	18	287	6	4	10	2	-	2	19	7	26	21	22	43	317	51	368
50 & OVER	88	16	104	-	-	-	-	-	-	2	1	3	1	10	11	91	27	118
TOTAL	371	34	405	6	5	11	2	-	2	24	11	35	29	35	64	432	85	517
%			78.3			2.1			0.4			6.8			12.4			100

T A B L E 18

TOTAL MONTHLY HOUSEHOLD EXPENDITURE BY INCOME GROUP

INCOME GROUP	NO. OF H.H.	FOOD	HOUSING	FUEL & LIGHT	CLOTHING	HOUSE-HOLD OPERA-TIONS	HOUSE-HOLD SER-VICES	HEALTH	TRANS-PORT	RECREA-TION	OTHER	TOTAL
BELOW 100	30	3998.20	60.00	140.55	140.00	48.07	6.50	99.93	71.55	9.55	2.00	4,576.35
100-199	69	15835.70	82.00	575.70	975.40	329.29	45.25	499.57	291.10	269.10	331.60	19,234.71
200-299	114	34984.80	78.93	1278.10	3787.25	511.42	140.[illegible]5	1337.50	544.85	1140.30	830.20	44,633.60
300-399	61	23380.70	1130.54	782.70	2810.05	419.50	95.75	555.90	426.20	1295.95	1248.30	32,235.59
400-499	35	17147.30	180.33	624.00	1980.25	245.43	72.65	680.15	711.00	631.10	137.90	22,410.11
500 & OVER	47	29490.40	1391.29	981.90	3841.55	40.16	317.75	869.75	1066.30	1439.55	663.50	40,102.15
TOTAL	356	124837.10	2923.09	4472.95	13534.50	1593.37	678.15	4042.80	3111.00	4785.55	3213.50	163,192.51
%		76.50	1.79	2.74	8.29	0.98	0.42	2.48	1.91	2.93	1.97	100

TABLE - 19

PARTICULARS OF HOUSE BY NUMBERS

TYPE OF HOUSE			
SINGLE	ATTACHED	ANNEX	TOTAL
345	8	3	356
96.9	2.3	0.8	100

TABLE - 20

CONDITION OF HOUSE

PERMANENT	TEMPORARY	IMPROVED STRUCTURE	TOTAL
233	12	141	356
57.0	3.4	39.6	100

T A B L E - 21

HOUSING - TYPE OF ROOF

	TILES	ASBESTOS SHEETS	CADJAN	OTHER	TOTAL
Number	79	7	270	-	356
%	22.2	2.0	75.8	-	100

T A B L E - 22

HOUSING - FLOOR AREA BY SQ. FEET

	BELOW 100	100 - 199	200 - 499	500 & OVER	TOTAL
Number	9	54	207	86	356
%	2.5	15.2	58.1	24.2	100

T A B L E - 23

HOUSING - NUMBER OF ROOMS

No. of Rooms	1 - 2	3 - 5	6 - 9	10 & OVER	NO ROOMS
Number of Houses	225	125	3	1	2

T A B L E - 24

HOUSING - TENURE OF ACCOMMODATION

Type of Tenure	OWNED OCCUPIED	RENTED	FREE OF RENT	OTHER	TOTAL
Number of Houses	336	3	14	3	356

T A B L E - 25

HOUSING - TYPE OF ROOF OF DWELLING AND NO. OF OCCUPANTS

TILES		SHEETS ASBESTOS		CADJAN		OTHER		T O T A L	
Number of House-holds.	Number of Occupants	Number of House-holds.	Number of Occupants	Number of House-holds.	Number of Occupants	Number of House-holds.	Number of Occupants	Number of House-holds.	Number of occupants
79	539	7	49	270	1514	-	-	356	2102
22.2	2.0			75.8				100	

T A B L E - 26

HOUSING - TOILET FACILITIES

Kind of Facility	WATER SEAL	CESSPIT	NONE	TOTAL
No. of Houses	13	208	135	356
%	3.65	58.43	37.92	100

T A B L E - 27

HOUSING - SOURCE OF WATER

	PIPE BORNE	WELL	TANK	RIVER/STREAM	TOTAL
DRINKING (No. of Households)	-	346	10	-	356
%	-	97.2	2.8	-	100
COOKING (No. of Households)	-	339	17	-	356
%	-	95.2	4.8	-	100
BATHING (No. of Households)	-	69	277	10	356
%	-	19.4	77.8	2.8	100

T A B L E - 28

HOUSING - SOURCE OF ENERGY

	KEROSENE	FIREWOOD	OTHER	TOTAL
COOKING (No. of Households)	1	354	1	356
%	0.3	99.4	0.3	100
LIGHTING (No. of Households)	349	2	5	356
%	98.0	0.6	1.4	100

TABLE - 29

HOUSEHOLD EQUIPMENT BY THE NO. OF HOUSEHOLDS

	HOUSEHOLD EQUIPMENT											
	COOKER	SEWING MACHINE	RADIO	petromax type lamp	BICYCLE	TRACTOR & TRAILER	HAND TRACTOR	CAR	LORRY OR VAN	BULLOCK CARTS	SPRAYERS (AGRICULTURAL)	FIRE-ARMS
NUMBER OF HOUSEHOLDS	2	89	121	92	93	1	4	3	1	56	9	4
%	0.6	25.0	34.0	25.8	26.1	0.3	1.1	0.8	0.3	15.7	2.5	1.1

T A B L E - 30

NO. OF HOUSEHOLDS CLASSIFIED BY OWNERSHIP OF PADDY LAND

ACREAGE	OWN	LEASE OR ANDE	OTHER
Below 1 Acre	32	19	7
1 - 4 Acres	24	67	11
5 - 9 Acres	2	11	-
10 - 19 Acres	2	1	-
20 & Over	-	-	-
Total	60	98	18

T A B L E - 31

OWNERSHIP OF PADDY LANDS BY ACREAGE

OWN			LEASE OR ANDE			OTHER		
A.	R.	P.	A.	R.	P.	A.	R.	P.
97	1	38	227	1	12	16	1	20

T A B L E - 32

NO. OF HOUSEHOLDS CLASSIFIED BY OWNERSHIP OF HIGHLAN"

ACREAGE	OWN	LEASE OR MORTGAGED	OTHER
Below 1 Acre	41	1	13
1 - 4 Acres	136	166	145
5 - 9 Acres	12	10	16
10 - 19 Acres	6	4	6
20 & Over	2	-	1
Total	197	181	181

T A B L E - 33

LAND UTILIZATION CLASSIFIED BY ACREAGES

	ACREAGES		
	A	R	P
COCONUT	552	1	03
CHENA CULTIVATION	432	2	20
CITRONELLA	127	3	22
UNCULTIVATED	141	0	00
OTHER	89	0	00
TOTAL	1342	3	05

T A B L E - 34

PADDY ACREAGE CLASSIFIED BY CULTIVATION SEASONS

BOTH SEASONS			ONE SEASON			UNCULTIVATED		
A	R	P	A	R	P	A	R	P
08	2	00	319	3	10	07	3	20

T A B L E - 35

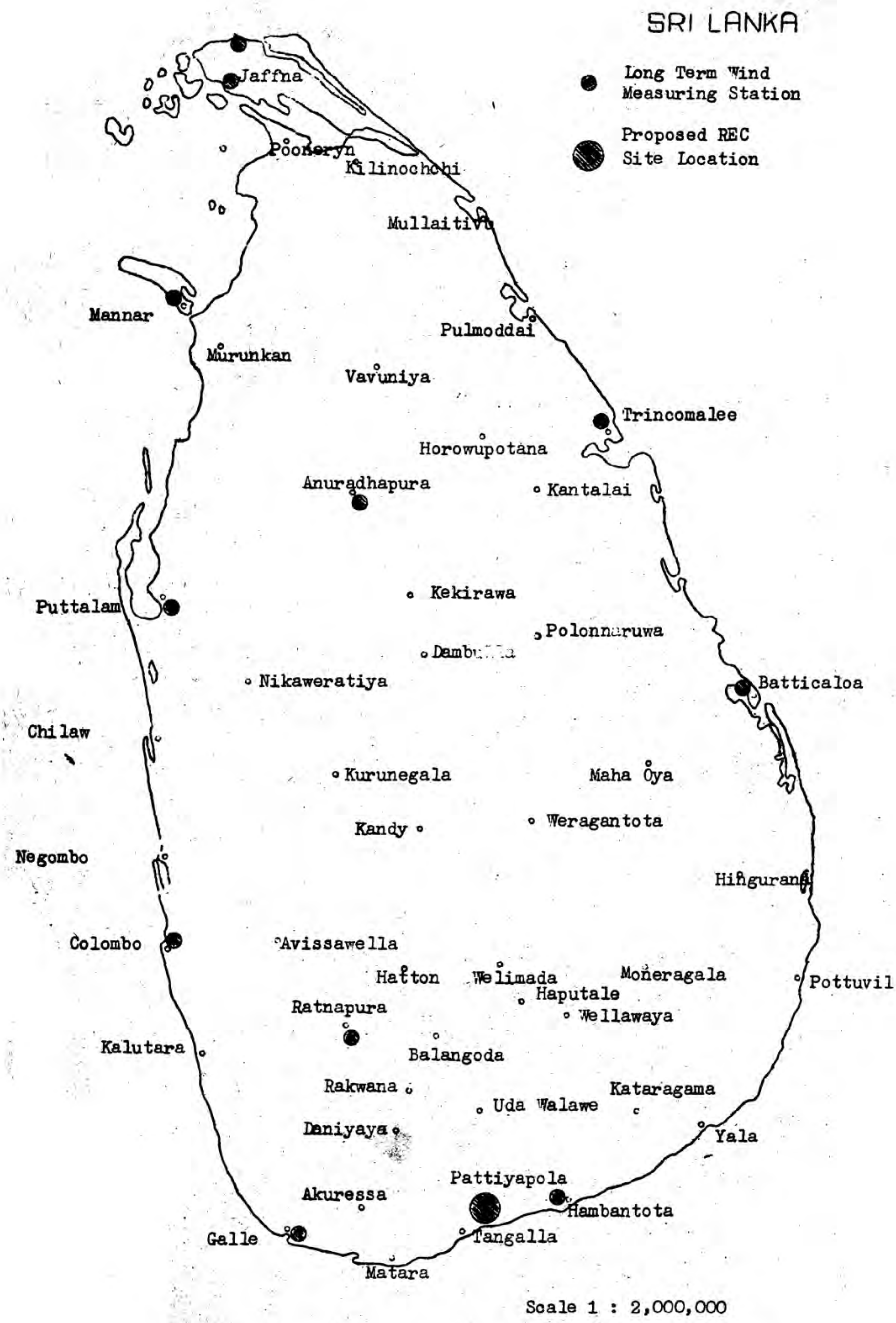
TOTAL NO. OF LIVESTOCK

CATTLE	BUFFALOES	GOATS	BIRDS
654	142	04	159

T A B L E - 36

OWNERSHIP OF LIVESTOCK

LIVESTOCK	NO. OF HOUSEHOLDS WITH													
	1	2	3	4	5	6	7	8	9	10-19	20-29	30-39	40-49	50 & Over
CATTLE	10	14	10	5	5	4	2	2	-	18	4	-	-	1
BUFFALOES	2	1	-	1	-	1	-	-	-	4	1	-	-	1
GOATS	-	-	-	1	-	-	-	-	-	-	-	-	-	-
BIRDS	6	6	4	5	6	4	-	2	-	-	-	-	-	-



Map Showing Location of Proposed Site for UNEP Energy Centre

APPENDIX 4(b)(ii)

RURAL ENERGY CENTRE - PATTIYAPOLA

Project Background

The Governing Council of the United Nations Environment Programme in May 1975 issued a directive concentrating its attention on the improvement of the human environment in remote village of the developing world. This directive while observing that millions of people living in rural areas are far removed from the main stream development also focussed its attention on the fact that an input of energy on a comparatively a small scale could provide the basic energy needs for cooking, pumping of drinking and irrigation water and lighting of households. Such energy inputs the decision noted could lead to an enhancement of the standard and quality of life of the people living in rural areas resulting in an overall improvement of the social environment.

Conventional energy delivery systems such as the extension of existing electricity grids through rural electrification schemes or resorting to autogeneration or diesel generation, could no longer provide the energy needs of the rural areas of the developing world, in view of high capital investments needed for rural electrification and due to the rapid rise in the cost of fossil fuels coupled with its finite availability.

Further the Governing Council of the UNEP recognised that most of the rural areas in the developing countries have no fossil fuel resources but possess in varying degrees renewable energy resources such as solar, wind, and Biogas obtainable from agricultural and animal wastes and wood fuels from quick growing trees, which could be harnessed using existing appropriate technologies to provide the energy needs of those rural areas.

As a result of this decision by the Governing Council of the UNEP, the executive Director accorded high priority to the setting up of a few demonstration centres to harness either individually or in combination locally available renewable resources such as solar, wind, biogas etc. in some typical rural areas in the Asian, African and Latin American regions of the world. Sri Lanka was chosen as the venue for the setting up the Asian Demonstration Centre.

The Oklahoma State University - USA was chosen by the UNEP as the Consultant to the Sri Lanka Project. Dr. H. Jack Allison of the Oklahoma State University (OSU) who headed the OSU-UNEP team that visited Sri Lanka around December 1975 carried out the necessary investigations of the Pattiyapola village selected by the Government Agent Hambantota, representing Sri Lanka Government in accordance with the guiding criteria given by UNEP. A feasibility report was prepared by OSU in June 1976 which was studied by UNEP and Sri Lanka Government Officials. A UNEP Mission visited Sri Lanka in September 1976 to discuss various issues and to consider steps for the implementation of an experimental project. A project Document was prepared on the basis of agreements reached between the UNEP Mission and representatives of the Sri Lanka Government, outlining the scope and responsibilities etc. of the REC Project. Ceylon Electricity Board was endowed with the task of implementing the Project.

Objectives

The immediate objective of the Project as set out in Sri Lanka is to study on an experimental basis, the possibility of harnessing locally available renewable resources of energy and their socio-economic impact on rural populations. The sources of energy (solar wind and biogas) harnessed in an integrated manner, will produce electricity (AC) to meet the needs mainly lighting and pumping of drinking water of a small rural community.

Description of the Project

The Rural Energy Centre constructed in the Pattiyapola village attempts to use a number of renewable energy resources, energy storage mechanisms and energy conversion schemes to provide reliable energy to as many families in the village as possible. It is an experimental project to test whether such provision is technically possible and at what cost. In electrical terms the system has a rating of at least 50 Kilowatts, and it has been designed to operate at that capacity for three to six hours per day. When fully operational the REC will provide sufficient energy to satisfy the basic energy needs (excluding cooking) in a manner which will require little if any adjustment to the social structure of the village.

As indicated in the annex A (REC basic shemetic) inputs to the system include solar radiation, wind energy, firewood water and organic wastes. Four wind mills each with a rated capacity of 2 kW (at 25 mph. wind regime) with convert wind energy into electrical energy which can satisfy a variety of functions including battery charging and water pumping. In addition to the variety of services which can be provided from such windmills, a flexibility of location for the wind mills is provided which cannot be obtained from competitive units which provide mechanical energy for water pumping.

Photo voltaic panels (2 KW peak) and solar concentrating collectors are used for convertion of solar energy into electrical or mechanical energy. The Photovoltaic panels converting solar energy to electricity D.C. can be used for battery charging, water pumping or for any other use needing D.C. electricity. The solar collectors convert solar energy into thermal energy which is converted to mechanical energy in a Ranking Engine. This form can use directly or converted to electricity (7.5 kVA) to feed the village distribution network or charge batteries by conversion to DC electricity. The Rankine Unit could also be operated using firewood, biogas or organic wastes. The cooking water used in the Rankin Unit can be exhausted into the fields and used for irrigation purposes.

Organic wastes primarily cowdung mixed with water is used in feeding the biogas digester (3000 cu.ft. capacity per day) to produce biogas which can be used directly for cooking used in a boiler to feed the Rankine enginer or injected into a spark ignition Engine for conversion into mechanical energy and electrity (37.5 kVA AC). The fertilizer displaced from the biogas facility could be used in the fields where crops are grown.

A protected source of water is considered essential every village and for this reason a water purification system is also incorporated.

A small meteorological station to monitor data on the solar radiation, wind regime and rainfall etc. was also considered essential to optimise the operation of the REC.

The implementation stage of the project commenced in early 1977 with Mr. Subasinghe, Additional General Manager (Operation & Maintenance) CEB functiong as the Project Manager and Mr.B.P. Sepalage, Electrical Engineer, CEB functioning as the Project Engineer.

As required by the UNEP a survey of the socio-economic conditions of the village was carried out, in July 1977 and the report of the Socio-economic survey is given in annex B. Site operations of the Project was officially inaugurated in October 1977 by the Hon. Minister for Power and Highways.