Ministry of Science, Technology & Human Resources Development

Consultative Meeting
on

Renewable and Alternate Energy Sources and Applications Relevant to Sri Lanka

Report

of the meeting held on
Friday, 19 May 1995
at the
Auditorium, NARESA

Organized by
the Division of Alternate Sources of Energy
of the
Ministry of Science, Technology and Human Resources Development
and
the Steering Committee on Energy
of the
Natural Resources, Energy and Science Authority of Sri Lanka
(NARESA)

List of Contents

Consultative Meeting on
Renewable and Alternate Energy Sources and Applications
Relevant to Sri Lanka

Introduction

The necessity and the purpose of having the Consultative Meeting on Renewable and Alternate Energy Sources and Applications Relevant to Sri Lanka was identified by Honourable Bernanrd Soysa, Minister of Science, Technology and Human Resources Development (M/ST&HRD) in early May 1995. Thus, the meeting was organized with support from the Ministry of Science, Technology and Human Resources Development (MST&HRD) and the Natural Resources, Energy and Science Authority of Sri Lanka (NARESA) along with its Steering Committee on Energy, with the co-operation of the Honourable Anuruddha Ratwatte, Minister of Irrigation, Power and Energy (M/IP&E) and Deputy Minister of Defense (DyM/D), the Ministry of Irrigation, Power and Energy (MIP&E) and other ministries, government and private sector organizations, and NGOs. The list of participants is given at Annex VII.

The inaugural session of the meeting was chaired by Honourable Bernard Soysa, M/ST&HRD. The Chief Guest was Honourable Anuruddha Ratwatte, M/IP&E and DyM/D. Following the welcome address by Vidya Jyothi Professor K. K. Y. W. Perera, Honourable Bernard Soysa, Honourable Anuruddha Ratwatte and Vidya Jyothi Dr. Arthur C. Clarke addressed the meeting. Honourable Bernard Soysa in his address mentioned that 68% of the people in Sri Lanka still have no access to electricity. Alternate energy sources may be suitable for some of these people if such energy could be given at affordable prices. This is one of the aims of trying to find out which alternate technologies can be immediately implemented in Sri Lanka. Honourable Bernard Soysa further thanked for the co-operative manner in which Honourable Anuruddha Ratwatte had allowed him to handle "kilowatts" while "megawatts" are retained for the MIP&E.

Honourable Anuruddha Ratwatte mentioned in his address that fuel wood still remains the main energy source of Sri Lanka. He further stated that rural electrification is very useful and is being persued. Alternate energies will save the use of conventional energies and help the environment. He further stated that he would work together with the Hon. M/ST&HRD for national benefit. The full text of the address by Honourable Anuruddha Ratwatte is given at Annex III.

Dr. Arthur C. Clarke mentioned that there is no shortage of energy which is abundant in nature. He mentioned that it is the lack of knowledge to harness that was a problem. Dr. Clarke spoke of a pump made in Georgia, which appeared to have more than 200% efficiency. Probably this was due to high temperature (10^8 C) reached at collapsing bubbles, associated with an energy generation.

The first working session commenced at approximately 10.00 a.m. with Professor Priyani E. Soysa, Director General of NARESA as the chairperson. Subjects discussed were biomass, dendro thermal, biogas, bio-conversion, gasification, small / micro hydro, solar thermal, solar photo-voltaic, wind, water pumping, battery charging, eneregy services and delivery projects. The list of resource persons is given at Annex VI.

The working session II was commenced approximately at 12.00 noon with Professor K. K. Y. W. Perera as the chairperson. During this session the participants grouped themselves into four sub committees in the main subject areas of bio-mass, small hydro, solar and wind energy. After delibration in the sub groups the plenary met at 1.00 p.m. and projects were presented by group leaders. These projects are given in Annex V. Discussions followed and the projects were in general accepted; however, it transpired that the projects need elaboration. Nevertheless, the projects were considered as important from the point of view of a short and medium term energy scenario.

The closing remarks were given by Professor K. K. Y. W. Perera where he thanked Honourable Bernard Soysa, Honourable Anuruddha Ratwatte, Vidya Jyothi Dr. Arthur C. Clarke, Mr. H. A. Wimalagunawardene, Secretary/MST&HRD, Dr. Tissa Vitharana, Adviser/MST&HRD, Professor Priyani E. Soysa, Director General of NARESA, the NARESA Energy Committee, resource persons and participants. He also thanked the staff belonging to NARESA and other organizations who worked to make the Consultative Meeting a succeess. The meeting adjourned at 2.00 p.m.

20 May 1995

KK/gk

Consultative Meeting on
Renewable and Alternate Energy Sources and
Applications Relevant to Sri Lanka

Friday 19 May 1995 - 0830 hrs - NARESA Auditorium

Purpose and objectives of the meeting
by
Vidya Jyothi Professor K.K.Y.W. Perera

As the title indicates the consultative meeting is on renewable and alternate energy sources and applications relevant to Sri Lanka.

Energy Options

There are many renewable and alternate energy possibilities, which include:

- Wind energy
- Solarenergy (inclusive of photo-voltaics and solar heating)
- Ocean thermal energy conversion
- Tidal energy
- Bio-mass, inclusive of fuelwood, biogas and biomass gasification
- Small hydro plants (inclusive of mini and micro hydro)
- Solar Pond etc.

Short Term Options for Sri Lanka

Of these possibilities, we are concerned in the Consultative Meeting on proven Renewable and Alternate Energy Sources and applications relevant to Sri Lanka. The Energy Division of the Ministry of Science, Technology and Human Resources Development and the Steering Committee on Energy of the Natural Resources Energy and Science Authority of Sri Lanka, have narrowed on four areas which are considered to have mature technologies ready for use and application in Sri Lanka, at least to some extent. The four areas are :

- bio mass which includes fuel wood, bio gas etc.
- small hydro including mini and micro
- solar including photo-voltaic, solar heating and drying etc.,
- Wind for water pumping, electricity generation etc.

Concept and Organization

The necessity for this Consultative Meeting was identified by Honourable Bernard Soysa, Minister of Science, Technology and Human Resources Development. Thus the meeting has been arranged on the direction of the Ministry of Science, Technology and Human Resources Development, with the co-operation of the Ministry of Irrigation, Power and Energy and other relevant organizations and individuals. The Natural Resources, Energy and Science Authority along with its Steering Committee on Energy supported the meeting.

Objectives

The main objective of the meeting is to arrive at a consensus on practical applications of proven Alternate and Renewable Energy technologies which are relevant to Sri Lanka.

Present at the meeting were those who have carried out considerable research and development; those who have manufactured or constructed or implemented devices, sources, or applications; entrepreneurs and financiers as well as government organizations and NGOs who would need or support such alternate and renewable resources of energy. Thus a second objective is the direct interaction of these several categories to enable promotion and implementation of identified projects.

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Alternate and Renewable Energy Sources and Applications Relevant to Sri Lanka

Working Paper by Mr Sunith Fernando - Director - AED - MST&HRD

1.0 Background

Energy plays a vital role in the socio-economic development of a nation. Industry, transport, commerce, agriculture and households, all consume energy of different types and in varying intensities to obtain energy services required by the users. The choice of an energy source for a particular energy service is primarily determined by its appropriateness for the given application, cost of the energy service, reliability of supply as well as the convenience of use.

During the last two decades there has been a growing worldwide interest concerning the harnessing of nature's renewable sources of energy to supplement what are called conventional energy sources -- mainly, oil, natural gas, coal and hydro power. This interest was initially driven by the rising oil prices in mid seventies, but was later reinforced by global environmental concerns - mainly, the global warming phenomenon due to accumulation of carbon dioxide in the atmosphere.

Potential renewable energy options are many, but only few of them have emerged as technically mature technologies. Some are already being used on a commercial scale, but still their contribution to the global energy supply remains insignificant. Only exception in this regards is biomass which has always been the dominant source of energy for three quarter of the world's population -- those living in developing countries.

Main objective of this paper is to present the background setting to the consultative meeting. It attempts to highlight issues which deserve consideration when examining the scope for application of alternate and renewable energy sources in the Sri Lankan context. The paper confines itself to small scale applications as this is the area where renewable energy sources are most likely to make a contribution.

2.0 An Overview of Renewable Energy Technologies

The technology of harnessing renewable sources of energy depends on the end-use. Basic principles concerning the harnessing of renewable energy sources are generally well known, but status of the energy conversion technologies themselves varies from laboratory scale models to off-the-shelf systems available in the market. Following is a brief description of the status of renewable energy technologies.

BIOFUELS

Biogas

Technologies used for the conversion of organic material into biogas have been in existence for many years in both developing and industrialised countries. The gas is being used for cooking and lighting and also to power internal combustion engines delivering electrical or motive power.

In addition to the gas produced, the fermentation of these materials reduces them to a slurry containing high concentration of nutrients making them effective and valuable as fertilisers. A further by-product of the process is its positive effect on public health. Bacteria harnessed in reducing the organic material to slurry and biogas kill pathogens usually found in high concentrations in organic waste materials and which pose a severe threat to the human well-being.

Large numbers of biogas plants have been installed in China (7-8 million), India (100,000) and South Korea (29,000). In most other countries the number of installed biogas plants may be below 1000 [Kristoferson and Bokalders, 1986]. Although research on biogas is still progressing the technology could be considered mature enough for small scale applications.

Biomass fuelled electricity generation

The technology essentially consists of a conventional fuel wood fired boiler supplying steam to a steam turbine coupled to an alternator. It could also be operated as a *co-generation* systems where the steam coming out of the turbine is used as process steam in situations where such a demand exists.

Biomass fuelled electricity generation plants are being used on a sufficiently large scale to rate it a mature technology. Currently operating plants are operating on wood wastes and/or agriculture residues. The term *Dendrothermal* plants is used to define an integrated biomass power production system encompassing growing, managing, harvesting and supply of biomass on a sustainable basis to fuel a biomass electricity generating plant. Dendrothermal power generation has been attempted in the Philippines in early eighties.

A future technology for dendrothermal power is the integrated system of biomass gasification - steam injected gas turbine on combined cycle (BIG-STIG). The system is more efficient than the conventional steam turbine - overall efficiency including that of the gasifier has been reported as 35% [NOVEM 1992]. As the gas turbine cost is relatively insensitive to scale (unlike the boiler-steam turbine system), the BIG-STIG system is considered a better option for smaller power plants [Williams, 1989]. Though the aeroderivative turbine proposed for the system is a well developed technology the total system is still being developed.

Major issues confronting dendrothermal power plants are more related to the fuel growing and supply side than to the generation technology.

GEOTHERMAL ENERGY

Geothermal energy is derived from heat contained in the earth's crust. It is not strictly renewable as underground heat sources can theoretically be exhausted. In practice, however, the global resource is so vast as to be considered renewable.

The resource exists in two principal forms -- aquifers and hot dry rocks. In the case of aquifers, hot ground water is extracted via a borehole and used for directly for heating purposes or where the temperature is sufficiently high, thermal energy is used for electricity generation. By 1984 the worldwide use of geothermal energy has been 6000 MW_{th} for heating purposes and 3842 MW for electricity generation, mainly in the USA, Philippines, Italy and Mexico.

HYDRO POWER

Hydro-electric power

Hydro electric power is one of the most developed renewable energy technologies which is being used worldwide. In the context of current interest in renewable energy development, what is being promoted is the revival of small scale hydro power generation. Plants of this scale are considered environmentally more benign and could also be used for localised power needs.

With the improvement of the industrial base and local R&D capabilities in developing countries, there is widening scope for local manufacture of small hydro equipment at costs lower than those in industrialised countries. Small hydro equipment manufacture is already well established in India and China. Manufacture of hydro equipment is also being carried out in many other countries, including Sri Lanka, on a non-industrial scale.

Hydro power for water pumping

Conventional centrifugal or axial water pumps driven by a hydro-turbine is widely used in China for lift irrigation purposes. In the Fujian Province alone about 100,000 *turbine pumps* have been installed during the last two decades [Kristoferson and Bokalders, 1986].

Hydraulic ram is another very old water pumping technology, which was developed by Montgolfier in 1796, and used extensively in Europe and the USA in the first quarter of this century. The pump uses the water hammer effect to transform potential energy due to head of water into kinetic energy to pump a part of the incoming water to a higher elevation. As with small hydro equipment, hydraulic ram pumps too could be manufactured in most developing countries.

OCEAN ENERGY

Ocean thermal energy conversion (OTEC)

OTEC system makes use of the temperature difference between the warm ocean surface and the cooler bottom water to operate a heat engine. For OTEC to be feasible a temperature range of at least 15° C is required. Sites having temperature differences ranging from 15° C to 22° C are found in some parts of the Tropics.

As the plant efficiency is extremely low, around 2% - 3% the system requires structures which could accommodate very large water flow rates. The technology is still at the early stage of development.

Tidal energy

Tidal power plants make use of the rise and fall of the ocean surface to create a head of water for subsequent use in a low-head hydraulic turbine. Tidal range could vary between 0.5m to 10m in some parts of the world. Technology involved is the hydraulic turbine system which is well developed. The best known large scale electricity generating plant is the 240MW La Rance system at an estuary into the Gulf of St. Malo in Brittany, France [Twidell and Weir, 1986]. Other countries using tidal power plants are China - 100 MW since 1987 and Canada - 20MW since 1984.

Wave power

Wave power technology harnesses the energy in waves offshore using either floating or seabed systems or inshore. Most development is now focused on inshore-based devices where an oscillating water column in an enclosed space is used to force air through an air turbine. Research on wave power is in progress in Japan, Britain and Scandinavia [Twidell and weir, 1986].

Research is also being carried out in India by the Indian Institute of Technology (Madras), under the sponsorship of the Department of Ocean Development. A prototype of 150kW is currently field tested under this programme [Brochure of the Indian Wave Energy Programme].

SOLAR ENERGY

Solar photovoltaic (PV) is a technology which enables the direct conversion of solar energy into DC electricity by means of a solar cell containing a silica-based semiconductor. Individual cells are arranged in modules of about 20-50 W peak capacity which can be linked to form an array of the desired capacity. The technology is mature enough for commercial application to meet small power requirements.

Solar energy could also be used for thermal applications, such as, water heating and air heating. Solar water heaters are now being commercially produced in a number of countries.

Some advanced solar technologies are Solar Electricity Generation Systems using parabolic mirrors to concentrate energy on a heat exchanger. A plant of 30MW is reported to be operating in California. Another solar technology which aims at large scale power generation is the Solar Pond. Much research is being carried on solar ponds in Israel and Australia.

WIND ENERGY

Use of wind energy for water pumping is an old technology that has survived to date though its application has dwindled in numbers since early this century. The technology is well known and commercially produced. Current research aims at the cost reduction of wind pumps primarily through the use of lighter wind rotors and improved pump performance. It is still premature to rate most new designs as fully mature for large scale industrial production.

Another small scale application of wind energy is battery charging for which mature technology already exists. As in the case of wind pumps, research is now being directed, mostly in developing countries, towards cost reduction.

Wind electricity generation has made considerable advances during the last two decades. Total installed capacity of large wind power plants is over 2000 MW most of which is the State of california in the USA. In Asia, commercial scale application of wind electricity generation is seen in India - over 100 MW and China.

3.0 Application of Renewable Energy in Sri Lanka - issues to be addressed

Based on the preceding overview of renewable energy technologies and considering the resource availability in Sri Lanka, it could be concluded that energy sources relevant to Sri Lanka for immediate application are:

(a) Biomass
(b) Small hydro
(c) Solar
(d) Wind

The scope for application of renewable energy sources in Sri Lanka has to be examined in a wider context. Major issues which need to be addressed in such an assessment are:

- o technology maturity,
- o potential end uses,
- o social acceptance,
- o financial viability

Technology maturity

A mature technology has several features: (a) it has been designed with careful consideration of the operational requirements at the user level, and (b) satisfactory performance of the device has been tested under real field conditions.

Commercialisation of an energy technology which has not achieved the desired level of maturity often results in the consumer rejection of not only the particular device but also the concept of harnessing such an energy source. The need of an objective evaluation of the maturity of renewable energy technologies cannot, therefore, be over-emphasised.

Potential end-uses

It is a well known fact that renewable energy sources are characterised by site specific conditions and also exhibit seasonal pattern. Similar characteristics can be observed in relation to the energy demand at the end-use level, eg. need for water pumping in irrigation. Therefore, potential end-uses of a renewable energy source have to be examined with a clear understanding of the energy demand profile and resource availability.

Social acceptance

Social acceptance or the "marketability" of renewable energy technologies has been a long standing issue in many countries. This may be partly due to the *technology driven* approach adopted by most renewable energy projects with little or no consideration given to dialogue with the potential beneficiaries.

It is often tempting to consider socio-economic aspects as being peripheral to the technology development efforts. But, in reality, it is this dialogue which will provide valuable feed-back information to engineers as to the nature of the technology which will most suit their needs.

Financial viability

Appliçation of renewable energy technologies faces the dilemma of being capital intensive on one hand while it is targeted at the economically marginalised population. In essence what this means is that even though a given technology may be financially viable on the long term, the potential user is unable to cope with the high capital outlay. The problem arises basically from the high interest rates prevailing in the country -- a common feature of most developing country economies.

Summary of Papers *

Section	Title	Author
Biomass	Trees for Energy and Industrial Raw Materials Sri Lanka's Most Sustainable Resource	Vidya Jyothi Dr Ray Wijewardene, Mr P G Joseph and Dr Nalin Walpita
	Bio-gas Technology - Current Status and Potential	Mr G K Upawansa
	Bio Conversion	Mr M D A Athula Jayamanne
	Wood Gasifiers for Thermal and Shaft Power	Mr Victor Mendis
Small / Micro Hydro	Decentralized Micro Hydropower Systems : A Rural Energy Option	Mr Lahiru Perera and Sharni Jayawardene
Solar	What is Needed for the Solar Photovoltaic Industry in Sri Lanka to Develop	Mr Lalith Gunaratne
	Solar Photovoltaics - Cost Comparison Against Financial Incentives for Conventional and Larger Power Plants	Mr Priyantha Wijesinghe
Wind	Wind Energy for Battery Charging	Mr T A Wickramasinghe
Financing	Energy Services Delivery Project (Global Energy Fund / World Bank)	Mr D G D C Wijeratne

* Summaries to be extracted. Full papers at Annex IV.

Summary of Projects *

Section	Project Title	Proposer
Biomass	Fuel Wood Based Tea Factory Dual Power Generation Project	Dr Nalin Walpita and Mr P S P S Saram
Small Hydro	Hydro Power for Battery Charging	NERD Centre
	Five Village Micro Hydro Projects Chosen for Implementation	Mr Lahiru Perera
Solar	Manufacture of Solar Therm Solar Water Heaters in Sri Lanka	Solar Therm Co
Wind	Wind Power for Rural and Domestic Irrigation Systems	Star Engineers (Mr M T M Wimalasena - Proprietor)
	Wind Energy for Battery Charging	NERD Centre

* Summaries to be extracted. Full project proposals at Annex V.

Summary of Follow-up Action

1. Bio-mass from Trees -

   Dendro thermal project approved by the Government in 1993 - to proceed with this. For this, a suitable consultant or consultancy firm with experience in the subject area to be engaged.

2. In relation to the fuel-wood combined use power project at Poonagala, it was suggested that the project could be made viable if a 15% grant component is made available. Such a grant component could be justifiable from Government sources such as the Energy Fund, because of the fact that this is a pioneering project. A substantial amount of data and results could be collected; it would be useful for optimization and for further development. If a grant could not be made, equity funds from the Government (on which they will get a return as other shareholders) will also be another method to get the project off the ground. The amount involved is in the region of Rs.8 million.

   A duty waiver on this project (as in the case of diesel projects) is also justifiable.

3. There was a general request to have low interests or concessional funds for alternate energy development and expansion. The idea that was mooted was to tax the polluting energies more and to divert such tax to fund an Alternate Energy Fund. The alternate energy fund could provide concessional funding to suitable Alternate and Renewable energy projects.

4. Matching Alternate Sources and Demand -

   To study Alternate Energy Supply and Demand patterns in different regions and areas of Sri Lanka with a view to matching.

5. It was pointed out that imported diesel generating plants at the moment enjoy duty waiver. Similar duty consessions to be made available for raw materials, equipment and devices for alternate energies (for eg: photo-voltaics, solar thermal, wind and micro hydro).

6. Awareness programmes for alternate energy applications and resources which may be applicable at certain locations and groups of people. Such awareness programmes, training programmes and publicity could be funded by the Government, in addition to eforts by NGOs and others.

7. Dr. Nalin Walpita mentioned that for mini / micro hydro projects above Rs.2.5 million investments, BOI status has been given. It would be logical to extend the similar status to all alternate energy projects in the 4 areas.

   (a) Biomass
   (b) Small / micro hydro
   (c) Solar
   (d) Wind

[It is perhaps not necessary to extend other perks such as duty free vehicle; (only the reduced customs). Only the investments on imported duties and tax concessions may be adequate.]

8. It is suggested that for alternate energy sources, that the BOI approval limit be reduced to projects of US$1 million and above. For special cases even lower amounts may be entertained on the recommendation of MST&HRD.

9. It was noted that training in the construction and maintenance of bio-gas plants is necessary. Such training efforts may be funded by the Government, as it is not a direct subsidy to the product. This remark will apply to many other alternate energy sources.

10. For types of applications using wood waste, paddy husk etc., adequate awareness and training programmes are necessary prior to popularization.

11. Wind -

    It is suggested one of the NIVA 3000 wind plants locally manufactured by Star Engineers (proprietor Mr. N. T. M. A. Wimalasena) be bought by NERD Centre and fully tested.

12. To encourage labelling of efficiencies and parameters of photo-voltatics and other alternate energy supplies and devices.

13. Micro Hydro -

    NERD Centre brought to the notice a small cross-flow float turbine coupled to a generator of 100 W capacity, cost approximately Rs.20,000/- inclusive of the alternator. This unit is conveniently usable for battery charging purposes. A head of water of 20 to 30 ft and a 2" pipe are the basic requirements. This needs popularization.

20 May 1995
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Consultative meeting on

RENEWABLE AND ALTERNATE ENERGY SOURCES AND APPLICATIONS

relevant to Sri Lanka

19th May 1995 at the Natural Resources, Energy and Science Authority of Sri Lanka (NARESA)

A G E N D A

0830-0845	Registration of participants
0900-0910	Welcome Address and objectives of the Meeting by Prof. K.K.Y.W. Perera
0910-0920	Opening remarks by Hon. Bernard Soysa, Minister of Science, Technology and Human Resources Development
0920-0930	Address by the Chief Guest Hon. Anuruddha Ratwatte, Minister of Irrigation, Power and Energy
0930-0940	Energy: Futuristic vision - Dr Arthur C. Clarke

WORKING SESSION I - Chairperson : Prof. Priyani Soysa, DG, NARESA

0940-0950 Presentation of Working Paper on "Alternate and renewable sources of energy: resources, technologies and their applications in the Sri Lankan context"

0950-1130 Mature technologies and their applications: Case studies highlighting field level experience, issues, constraints, expansion of application

(a) Biomass
- i. Dendro thermal - Dr Ray Wijewardena, Dr Nalin Walpita
- ii. Biogas - Mr G.K. Upawansa
- Bio-conversion - Mr Athula Jayamanne
- iii. Gasification - Mr Victor Mendis

(b) Small/micro hydro - Mr Lahiru Perera

1030-1045 Break for refreshments

(c) Solar
- i. Solar thermal - Ms Lakshman Jayasuriya & N M Jayalath
- ii. Solar PV - Mr Lalith Gunaratne, Mr Priyantha Wijesooriya

(d) Wind
- i. Water pumping -
- ii. Battery charging - Mr T.A. Wickremasinghe

(e) Energy Services Delivery Project - Mr D.C. Wijeratna

WORKING SESSION II - Chairperson : Prof. K.K.Y.W. Perera

1130-1200	**Group work towards preliminary identification of alternate and renewable energy projects, partners, responsibilities and follow-up action**
1200-1245	**Presentation of the outline of identified projects and necessary follow-up action - by group leaders**
1245-1310	Discussion
1310-1315	Closing remarks
1315-1415	**Lunch**

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දිනය / திகதி / Date } 05 th May 1995

Dear Prof/~~Dr~~/~~Mr~~/~~Ms~~ *Perera,*

Consultative meeting on

RENEWABLE AND ALTERNATE ENERGY SOURCES AND APPLICATIONS

relevant to Sri Lanka.

8.30 A.M. on May 19, 1995 at the NARESA Auditorium

Hon. Minister of Science, Technology and Human Resources Development has directed that a consultative meeting be held with the main objective of arriving at a consensus on practical applications of proven alternate and renewable energy technologies which are relevant to Sri Lanka.

Development of renewable and alternate energy technologies has been in progress for a number of years in Sri Lanka. Nevertheless, their application to meet specific energy needs of the population has been lagging though technology has advanced.

Hon. Minister has kindly agreed to inaugurate the meeting and to be present during the consultative meeting.

You are invited to participate at this meeting and to contribute towards identification of specific opportunities for alternate and renewable energy. Draft agenda of the meeting is annexed.

Thanking you,

Yours sincerely,

H A Wimalagunawardene,
SECRETARY.

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Consultative meeting on

RENEWABLE AND ALTERNATE ENERGY SOURCES AND APPLICATIONS

relevant to Sri Lanka

19th May 1995 at the Natural Resources, Energy and Science Authority of Sri Lanka (NARESA)

TENTATIVE AGENDA

0830-0845 Registration of participants.

0900-0910 Welcome Address and objectives of the Meeting. by Prof. K.K.Y.W. Perera

0910-0920 Opening remarks by Hon.Bernard Soysa, Minister of Science, Technology and Human Resources Development.

0920-0930 Address by the Chief Guest Hon. Anuruddha Ratwatte, Minister of Irrigation, Power and Energy.

0930-0950 Presentation of Working Paper on "Alternate and renewable sources of energy: resources, technologies and their applications in the Sri Lankan context".

0950-1130 Mature technologies and their applications: Case studies highlighting field level experience, issues and constraints.

(a) Biomass:

i.	Dendro thermal	- Dr.Ray Wijewardena - Dr.Nalin Walpita
ii.	Biogas Bio-conversion	- Mr.G.K.Upawansa - Mr.Athula Jayamanne
iii.	Gasification	- Mr.Victor Mendis - Mr.Adikarinayake

(b) Small/micro hydro - Mr.Lahiru Perera

<u>1030-1045 Break for refreshments</u>

(c) Solar

i.	Solar thermal	- Alfa Engineers
ii.	Solar PV	- Mr.Lalith Gunaratne - Mr.Priyantha Wijesooriya

(d) Wind

i. Water pumping
ii. Battery charging - Mr.Wickremasinghe

(e) Financing arrangements - Mr.D.C.Wijeratna

1130-1200 Discussion

1200-1230 Group work towards preliminary identification of alternate and renewable energy projects, partners, responsibilities and follow-up action.

1230-1315 Presentation of the outline of identified projects and necessary follow-up action - by group leaders.

1315-1415 LUNCH

CONSULTATIVE MEETING ON RENEWABLE AND ALTERNATE ENERGY AND APPLICATIONS

Address by Hon. Anuruddha Ratwatte, Minister of Irrigation, Power & Energy

I consider it a great pleasure and a privilege to be associated with you today to address you at this important event which is focussing on applications of Renewable and Alternate Energy Sources.

Energy is the life blood sustaining the development efforts. It keeps the wheels of industry turning and supplies basic energy needs and comforts of citizens. In the coming decades, Sri Lanka will need more energy resources to maintain and accelerate economic growth. The Government is committed to doing everything possible to sustain the momentum of national development, improve the quality of life of our people, and meet their aspirations.

I consider this seminar important and significant in the sense that it is timely, appropriate and relevant in the context of the present rural energy situation. Particularly, utilisation of alternate energy resources has a potential for the devleopment of rural energy systems towards which the contributions from conventional and centralised energy systems have so far been minimal.

Fuel wood constitutes the main energy source in Sri Lanka. This is now a dwindling resource and the magnitude of the problem of matching supply with demand has to be assessed in definite terms. The solution has to be found, as the use of high grade expensive energy sources for activities such as domestic cooking would be beyond the means of the average rural citizens. From the national point of view, supply of such refined forms of energy for cooking purposes on an extended scale would impose an extra burden on the already heavy capital and recurrent energy budget. The strategies which may include further improvement of the efficiency of usage, development of alternate agro residual resources, methods to provide continued and sustained fuelwood supplies, have to be developed. Identification of productive activities based on wood energy technologies will add a new dimension to economic development potential in the rural areas.

The other pressing demand in the rural areas is for electricity. The advent of electricity to a rural area signals the beginning of a new era. My Ministry places a high priority in extending the benefits of electrification to more and more rural areas. The main use of electricity in rural areas is for lighting. This may seem to be a usage with low economic returns, but it fulfils a vital need of the rural population.

Studies have shown in the past, that rural electrification has not encouraged the growth of rural industry to a very great and anticipated extent. Rural industrial entrepreneurship is now being encouraged and supported. Medium scale export oriented industries which formally clustered around Colombo and other urban centres are spreading on to the rural areas bringing with them enhanced employment opportunities to rural youth and a consequent improvement in the living standards of the rural masses. All these activities rely on the availability of electricity.

Exploitation of non-conventional energy resources, especially wind, mini hydro, solar and bio-gas as substitutes and supplements to conventional sources of energy is an aspect which results in a saving of conventional energy sources. The fact that such sources are environmentally benign, makes them attractive to an increasingly environment conscious world.

Solar power could to some extent meet the demand for home lighting in remote rural areas where extension of the grid would be uneconomical and where due to the wide scatter of farm and colony houses, some extent of subsidy would be necessary to bring this technology within the reach of the rural citizens who may ultimately fix his ability to pay on the basis of the cost of kerosene which he presently uses for home lighting. The improved quality and other benefits may add an enhancement to the rental.

It is my belief that an integrated approach to the formulation of plans and development of energy supplies to the various consuming sectors is essential due to the multi-sectoral interactions needed for the entire process. Interministerial co-operation is required for prioritization of energy inputs and the activities would involve the co-operative and co-ordinated efforts of several governmental organizations which come under several Ministries. Non Governmental Organizations too can play a supportive role in the entire process. The provincial organizations are also intimately involved, mainly as a matter of immediate concern to the areas coming under their purview.

I am certain that these matters will receive due attention during this consultation and that you will develop action plans which will ultimately meet the aspirations of the people in Sri Lanka and will fulfil the national objectives. I notice that representatives from a large number of these involved organizations are present here today and experts on the various fields are due to address. From the programme I have seen that a lecture presentation is to be followed by group discussions which I think is most important. I look forward to receiving the final report resulting from this consultation, and will consider it to be very valuable guideline in formulating government policies and strategies for providing energy to the people in Sri Lanka. The Hon. Bernard Soyza and I will work together to achieve the national objectives.

I also extend my thanks to Hon. Bernard Soyza, Minister of Science and Technology and the officers of the Ministry for organizing this consultation. Noting the calibre of experts and members participating in this consultation, I am confident that a positive contribution will emerge for effective implementation, for which I pledge my support. I conclude wishing you all success.

Thank you.

TREES FOR ENERGY

and industrial raw materials

Sri Lankas most sustainable resource

by

Ray Wijewardene, P.G. Joseph, and Nalin Walpita.

1. Introduction

Although the economy of Sri Lanka has long been supported by the produce of it's tree crops - tea, rubber and coconuts, it is rarely appreciated that the most valuable source of raw materials available to any humid-tropical coutry is it's TREES..... and invariably the most neglected! Although one of the major sources of energy in a country which lacks fossil (coal or petroleum) energy, tropical trees provide the raw materials for a wide range of industries.

Food & Beverage	Tea, Cocoa, Coffee, Coconuts, Vanillin
Industrial	Plastics (rubber), Timber, Gums, Oils.
Fibres and Textiles	Rayon, Viscose, Pulp, Paper, Cotton, Cellulose
Chemicals	Lignin, Xylose, Poly-isoprenes.
Drugs	Allopathic as well as Ayurvedic.
Fuel Wood	For industrial heating and electrical power
....	to name just a few!

2. Energy Sources

Where energy is concerned, trees already provide over 70% of the total fuel consumed in this country .... the break-down by source of energy usage being:

a. Locally-sourced
 1. Trees (biomass) for industry 12 %)
 2. Trees (biomass for domestic fuel 59 %) 71 %
 3. Hydropower................................ 10 %

b. Imported (petroleum & coal)
 1. for transport .... 12 %
 2. for electricity .... 1 %
 3. for industry (mostly for heating).... 4 % See Figure 1.
 4. for lighting (e.g.kerosene).......... 2 %

Note: It is significant that although wood has provided by far the greatest quantum of fuel in this country, it has hitherto received the least attention.

3. Fuel Wood

Exploring the fuel-wood situation further, the distribution of land in Sri Lanka is as follows:

Total land area	6,560,000 ha.	100 %
Natural forest	1,750,000 ha.	28 %
Forest plantations	75,000 ha.	1 %
Industrial plantations .... (tea, rubber, coconut etc,)	1,000,000 ha.	15 %
Paddy lands	500,000 ha.	8 %
Scrub lands	600,000 to 625,000 ha.	10 % (*)
Chena lands	(over) 1,000,000 ha.	15 %
Remaining - non-agro-foresty ..... (rock, domestic, roads, lakes, rivers shores etc.)	1,610,000 ha.	23 %

The forestry sector master plan has identified over 600,000 hectares as 'scrub land'(*). This land urgently needs some form of 'cover' to prevent further degradation. It could ideally be covered with energy plantations.

While, under favourable conditions, one hectare of energy plantation would yield over 20 tonnes of dry matter per year on a continuous basis a more conservative yield figure should be taken as 13 tonnes/ha/yr. This would be on a 4 to 10 year harvesting cycle.

The 600,000 ha. of 'scrub land' (*) could conservatively produce 7.8 million tonnes of wood annually, equivalent to 2 million tonnes of oil, (- twice our annual consumption!) This quantity of wood, if utilised to produce electricity, would generate 5,000 GWh of energy annually (- more than our annual consumption from hydro-power). [Giga=10]

3. Pricing

Energy-efficiency-wise, 1 tonne of oil is approximately equivalent to 4 tonnes of wood; therefor at the present oil price of Rs.6,000 per tonne, the energy equivalent price of wood would be about Rs.1,500 per tonne. As the price for imported oil continues to escalate, the price for wood-fuel becomes increasingly more attractive. Further, wood-fuel costs about 65% the price for coal - for an equivalent amount of energy.

The industrial sector in Sri Lanka annually consumes around 1-million tonnes of fuel-wood (for tea drying, brick kilns; ceramic kilns, baking, etc). Most of this comes from either the natural forests or from rubber plantations. The demand for rubber wood, for other more remunerative purposes as furniture and wooden toys is happily increasing. However, continuing extraction of fuel-wood from natural forests will further deplete the exisitng forest cover. Hence there is an immediate need to produce that 1-million tonnes of fuel-wood needed annually by the industrial sector, and this could be produced from about 80,000 hectares of energy plantation.

The industrial sector also consumes about 0.25 million tonnes of imported oil annually, - most of it to generate heat in boilers and furnaces. This could be substituted by 1-million tonnes of fuel-wood produced from a further 80,000 hectares, thus saving about Rs.1,500-million in foreign exchange

The remaining 440,000 hectares (of scrub land) could provide a further 5.72-million tonnes of fuel-wood annually. This could be used to generate 3,000-GWh of electrical energy annually, and would be equivalent to a 500-MW power plant operating at about 70% power-factor. This, itself, would be the equivalent of 75% of our present annual power consumption, (the present hydro-power generating capacity being 4,000-GWH,) and approximately equivalent to 50% of the total identified hydro-power potential of Sri Lanka. Incidentally, the (controversial but now necessary) coal-fired plant is proposed initially to produce 300-MW, and increasing eventually to 1,000 MW.... based totally on imported fuel!

4. Local Employment

Considering an extent of 3 hectares of land given to a family, fuel-wood grown on this land as a sole-culture would conservatively produce 39 tonnes of fuel-wood annually on a continuing cycle. At Rs.1,000 per tonne (farm-gate price) this would represent an annual income of Rs.39,000. If, however, the farmer inter-crops his land with vegetables or fruits his income could well be increased by at least 30% to over Rs.4,000 a month.

The 600,000-hectares of scrub land could thus be expected to provide productive employment for 200,000 families while producing over 7.8-million tonnes of fuel-wood; the equivalent of 2-million tonnes of oil.

4. Plantation Management

Sri Lanka possesses unique talents in the area of plantation management; presently still limited to the conventional plantation crops of the colonial era, tea, rubber and coconut. These skills can ideally be extended to the management of energy plantations on, for example, the 'nucleus-plantation' system whereby a centrally managed plantation of, say, 100 hectares would have 'stewardship' responsibility for, say, a further 1,500 hectares of satellite 'small-holder' plantations around it for supply of seedlings and for plantation management guidance. It would also provide the very necessary organisation of the harvesting and collection of trees reaching maturity and of their transport. Such systems are well established in India for forestry production as well as - now in Sri Lanka, too - for the production from satellite sugar-cane fields surrounding sugar-cane processing factories.

5. Fuel-wood energy conversion

Well proven technologies are available, world-wide, for coverting fuel-wood to electricity ... as also into the wide range of industrial raw-materials.

(It is somewhat little known that Rayon and Viscose yarns for textiles are made from wood pulp unlike the Nylons which are made from petroleum. Our nearest neighbour has several such

Rayon factories being fed from local wood plantations, and distinct from their vast cotton growing and milling resources.)

The three best known wood-to-electricity conversion systems are generally selected according to the size of the operation.

a. Gasification and external combustion

This process is suitable for converting existing oil-fired boilers and furnaces to wood-fuel, and Sri-Lanka's NERD centre has considerable experience in this technology.

b. Gasification for internal combustion engines (usually under 2-MW)

This technology is well developed for the generation of electricity from carbonised biomass fuels; the charcoal is gasified, cleaned, cooled and used to fuel 'internal-combustion' engines.

c. Steam turbines for power-generation (usually above 2 MW)

This is the system usually adopted the world over to generate electricity from oil or coal, and is also used for wood-fuel in a very great number of countries, as also at sugar-cane factories for generating electricity from bagasse the biomass waste after sugar extraction.

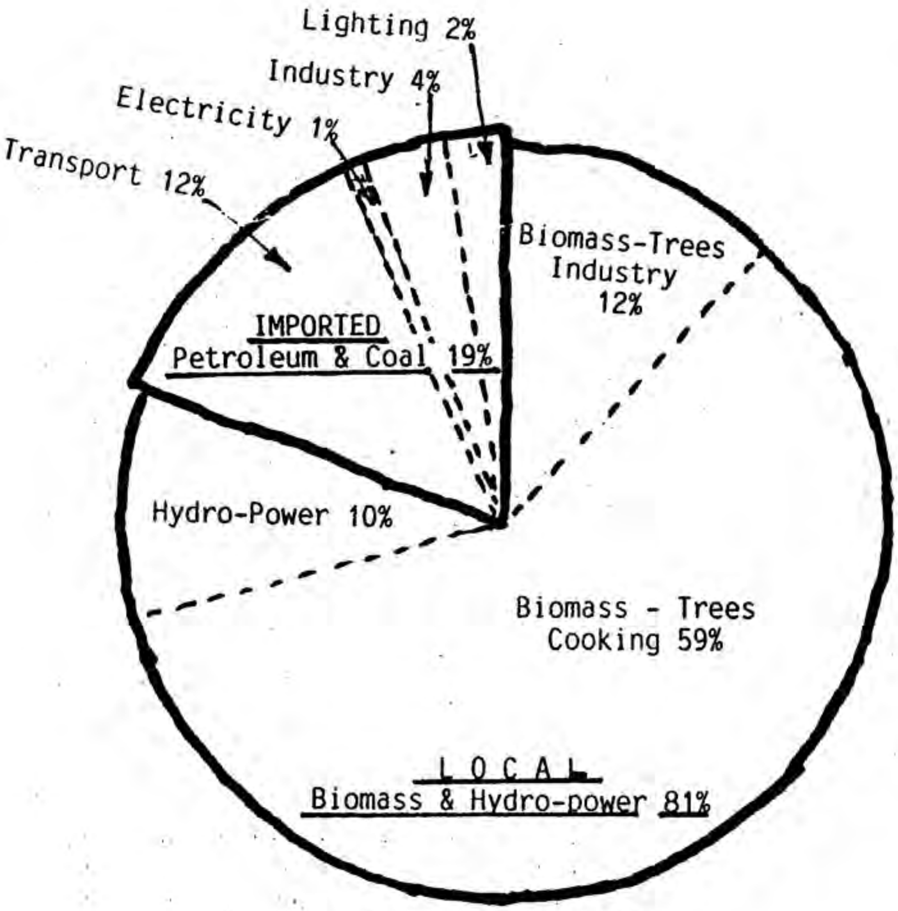
The technology for generating electricity from biomass is thus well established.

6. Benefits

a. The gainful employment of over 200,000 rural families on even just the 600,000 hectares of scrub-land available throughout the country. Extended to the (over) 1,000,000 hectares of presently marginal and chena'd lands the rural employment potential exceeds half-a-million families.... each with a sustainable income of at least Rs.36,000 annually, and producing a major part of this country's needs of fuel... presently relying heavily on imports.

b. The 'greening' once again of Sri Lanka. Our forest cover, now down to less than 25% of the land area, could thus realistically be increased to over 65% of its area covered with forests and tree-plantations.

c. The saving of around Rs.10-billion in foreign exchange now spent on imported fuels, from just the 600,000 ha of scrub lands converted to fuel-wood production... and increasing to savings of over Rs.25-billion annually when extended to include the chena'd lands, too. [billion = 1000-million = 10]



A L L   E N E R G Y

Local - Bio-mass & Hydro-power 81%

Imported - Petroleum & Coal 19%

Figure 1

Appendix

TREES AS A SOURCE OF ENERGY & INDUSTRIAL RAW MATERIALS
Current status of the Project Proposal to the Cabinet

In April '93 the Cabinet of Ministers approved such a comprehensive proposal submitted by the Institute of Fundamental Studies, and endorsed by an expert panel comprising senior representatives from the Ministries concerned with Power, Energy, Electricity, Lands, Forests, Plantations, Science and Technology and also from the private sector.

While making certain specific recommendations to the Ministries concerned with Finance, Lands, Plantations, Industry, Power and Energy, towards the generation of incentives for private sector participation in commercial forestry and fuel-wood production, the (then) Ministry of Power & Energy was required to invite appropriate consulting/funding organisations (e.g. FAO, GTZ, ODA etc) with experience in this area to prepare:

A. a detailed and comprehensive study for Sri Lanka into all aspects of private sector commercial foresty including electricity generation, timber production, and the production of tree-based industrial raw-materials.... the study to include a program for progressively encouraging the use of such dedicated fuel-wood production:
   a. by industries currently consumiung fuel-wood from indiscriminate (usually government-owned) sources.
   b. by industries presently using imported fuel oils.
   c. for dendro-thermal-power systems to generate electricity to meet part of the growing demand of the national grid.

B. a detailed recommendation and analysis for establishing in a suitable location a pilot dendro-thermal electricity generating facility (perhaps of about 500 KW capacity) with corresponding plantation and connection to the national grid ,in order to provide local proving experience into the feasibility, in Sri Lanka, of dendro-thermal electricity generation. It is expected that the consultants might also be able to recommend appropriate funding arrangements for such a facility.

Note

When making this recommendation the expert panel was aware that the erection of so small (about 500 KW) a dendro-thermal generating facility could result in an operating efficiency of only around 15% versus about the 18 to 20% efficiency for a larger (several megawatt-sized) facility, However, proving experience would also be needed and acquired locally, of the technology for the commercial growing for systematic, rotational harvesting (and their subsequent coppicing or regeneration) of fuel-wood trees, together with the necessary road-ways and logistic arrangements for conveying the wood on a continuous basis from field to the generating facility. Such technologies have already been developed in several tropical countries abroad and will need to be learned through such an experience as is proposed.

The initial 500 KW generating facility - together with convenient connection to the national grid - would require a dedicated plantation of about 320 hectares, (about 1.78 km by 1.78 km - or about 1 mile by 1 mile) in size. However, until the plantation comes into regular harvesting - in about 4 to 7 years - the necessary fuel wood, in the order of about 25 cubic metres (or five tractor-loads per day at Rs.500 per cu.m.) will need to be purchased and transported to the site. This might be followed by a 2 MW facility with about 1300 hectares of plantation (3.5 km by 3.5 km) on which some 400 families might be engaged.

Subsequently, dendro-thermal generating facilities each of around 10 MW are envisaged together with an accompanying plantation of about 6,400 ha (or about 8 km by 8 km, each serviced by about 2,000 families) Five such 10MW facilities could then be installed each year to provide an annual increase in generating capacity of 50 MW. (as required to match the anticipated increase in demand for electricity in Sri Lanka) .... and annual increases in employment for 20,000 rural families .... an operation near matching that of the Mahaweli Authority!

The general establishment and operating costs for each such facility would roughly be :

Commissioning costs
----

10 MW generating facility (@ $1250 per KW = $12.5M).....	Rs. 625M.
6,400 ha plantation (@ Rs.60,000 / ha - over six years)...	Rs. 384M
Total (about).....	Rs.1,000M

Annual operating costs

Gross income from sale of electricity at Rs.3/= per KWh. (@ 10,000 x 8760 x 0,85 x 3/=)		Rs. 223M
Less:		
Operating and maintenance (@ 3% on Rs.625M.)	Rs. 19M	
Fuel-wood, harvesting and transport costs (148,000 cu.m./yr @ Rs.500/cu.m.)	Rs. 83M	

Total costs	Rs. 102M	
Nett income		Rs. 121M

Note: A pay-back period of about 1,000/121 = 7 years.

BIOGAS TECHNOLOGY

Current Status and Potential

G. K. Upawansa, Hyneford, Nawalapitiya

There are about 5,000 biogas units varying from 6 cu.m. volume to 100 cu.m. scattered in all parts of Shri Lanka including the North. A biogas unit is helpful in:

i. Providing a clean, safe and versatile fuel which can be used in cooking, lighting, refrigeration, and running diesel, kerosene or gas engines.

ii. It produces the best manure known to farmers. The biogas manure is the answer for nitrogen deficiency of tropical farm lands and also looks after the entire nutrient requirement of crops, while accelerating growth due to crop-growth hormones.

iii. The ecological impact of this technology is also important. 20 working biogas units in an area will save an acre of forest for a year. It will be much better to erect biogas units instead of planting trees. Enhancing vegetative growth, enriching soil with it's full range of micro-organisms are other ecological factors of importance.

The three major types of biogas units installed and operating in the country are as follows:

1. Continuous flow type for animal sheds.

2. U.A.S.B. units for toilets. (Upflow-Aanerobic-Sludge-Bed)

3. i. Dry-batch type with flexible cover on top.
   ii. Dry-batch type with fixed dome for farms and cities. (this is not yet operating)

Present costs range from Rs.1,500 to Rs.2,000 per cu.m. volume inclusive of gas appliances. The appliances developed include:

a. Gas lamp with adjustments for varying gas pressure.

b. Stoves for low and high gas pressures.

c. Simple low-cost conversion tube to operate engines.

Adoption rate is slow but steady. Expansion of the technology is mainly due to functioning of units in-spite of no propaganda. Lack of sufficient number of trained technicians is the major retarding factor. The cost of appliances such as lamps, stoves, are high due to the small numbers manufactured. There is no agency that can help an owner if and when some problem is faced. These are the present constraints.

Proposals

i. Awareness programmes must be conducted in cities to construct U.A.S.B. units instead of septic tanks. U.A.S.B.s are low cost, more efficient, versatile (change according to the sites situation) and self-cleaning, besides giving a fuel.

ii. Construction of 100 demonstration units at a cost one-million rupees among beginner organic farmers. This will enable to convert more farmers for biogas usage as well as for ecological farming. If this proposal is materialised, at least six more technicians can be trained in construction.

iii. If a fixed-dome dry-batch type proves successful an accelerated extension program has to be undertaken to convert city digestible garbage to biogas fuel and valuable biogas manure. For example, if Colombo city market garbage only is converted to biogas, it will be sufficient to supply cooking gas for about 5,000 families, and would provide manure for 1,000 acres of organic farms, saving over eight-million rupees in foreign exchange, annually.

BIO CONVERSION

Abstract

The National Engineering Research & Development (NERD) Centre of Sri Lanka launched a research programme about 10 years ago to develop an alternative to the traditional Indian & Chinese Biogas Systems. The main objectives were to overcome several disadvantages that are present in the traditional systems, viz. (a) need of a farm environment and the use of animal wastes as primary ingredients, (b) need for continuous maintenance of these systems and (c) the resulting fertiliser being in a wet condition which is difficult to handle.

The NERD Centre has successfully developed a batch type digester for biogas generation which overcomes all these problems. The basic raw-material is straw or any other similar material. The digestion of straw has a six months cycle which fits in well to the two seasons of paddy cultivation. In addition to providing biogas to the farmer, the resulting digested material is found to be a complete organic fertiliser suitable for paddy cultivation.

The system is more than a mere biogas generator; it is an extremely environment-friendly, organic, fertiliser factory. Properly harnessed and popularised it will be a tremendous boon to farmers of developing countries.

The drybatch system is ideal for digesting market garbage also. About 2 years back, the Centre launched a research programme on garbage digestion. Considerable research work has been carried out in this field and results are good. Two and half tonnes market garbage can be put into a normal domestic drybatch type biogas digester and it generates average 1.3 Cu.M of biogas per day. Digestion period is about 4 months.

According to the request made by Mayor of Colombo Municipal Council, NERD Centre has launched a large scale research programme to develop methods of disposing garbage by biogas technology in commercially viable manner. After conducting variable levels of research programmes, Centre has identified profitable garbage disposing methods specially for market garbage which create serious problems to the Colombo Municipal Council currently.

Project No.1:-

Digesting market garbage/agricultural residue to obtain Biogas & Bio fertilizer.

Anticipated Benefits

1. Controlling environmental hazards due to non usage of market garbage/agricultural residue.

2. Can gain considerable profits as there is a demand for Bio fertilizer

3. Promoting bio farming by utilizing Bio fertilizer to touch the international demand for Bio Fruits, Bio Vegetables etc.

4. Emitting Biogas from this process can be used for thermal applications.

5. National benefits like foreign exchange saving on importing chemical fertilizer & maintaining natural richness of the soil.

Proposed Implementing Mechanism

1. Encouraging small farmers by conducting awareness programmes/workshops & Transferring Technology to have their own Bio fertilizer plants, as well to do bio farming.

2. Introducing the market garbage digesting system for bio fertilizer manufacturing, to municipalities & private Enterpreneurs.

3. Encouraging private sector to invest on bio fertilizer manufacturing & bio farming.

4. Introducing subsidy for family biogas units, as that subsidy can recover through national benefits from this units.

5. Even poor people can start cottage level bio fertilizer manufacturing & packaging for home gardening & flower beds in urban areas.

Current Practice (Case Studies):-

At NERD Centre we had No. of Biogas digesters for straw & market garbage digesting. The Bio fertilizer comes out at the end of digesting process & is packed as 2kg Bio fertilizer packets. (Each Rs.15/-). Employers of NERD Centre now utilizing this fertilizer packets for their home gardening & flower beds and is in demand now.

In the aspect of fertilizer, NERD Centre had developed a extremely cost effective digesting method suitable for farmers with polythene cover for heap of straw. The Biogas emitted from such a system can be collected at negative pressure and Centre has developed a mechanism to utilize that biogas after increasing the pressure. Ultimate fertiliser can handle easily as it is above the ground.

Project No.2 :- Converting offal to animal feeds

Anticipated Benefits

1. Controlling environmental hazards due to non usage of offal.

2. Can gain considerable profits as the current prices of animal feeds are high.

Proposed Implementing Mechanism

1. Encouraging small piggery owners, by conducting awareness programmes / Workshops & Transferring Technology to use boiled offal as a piggery feed.

2. Developing a large scale animal feed plant which can use fresh offal as a row material (small scale research works has been carried-out at NERD Centre).

3. Developing a low cost system to convert poultry feathers to digestible feed (Currently practised in developed coutries), as large amount of feathers available with chicken offal.

Current Practice (Case Studies)

Even now considerable amounts of farmers are using boiled offal as a good feed for their piggeries & poultries and it is possible to improve this system with developed technology.

In medium size farms it is possible to do cooking offal from their slaughter house by using biogas from their piggery-biogas units. This method is currently practicing in some small farms.

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/BIOGAS

Solar Thermal Applications

1. Solar Hot Box Cooker.

The **Model One**, is shown in Fig 1. A blackened aluminium tray, (lining the inside of the box), absorbs the incident solar energy coming through the 610mm x 610mm double-glass cover. The 'green house effect' prevents the insolent energy from escaping back through the glass cover. Glass Wool Insulation around the metal tray prevents heat losses through the walls. The casing is of light aluminium gauge. The adjustable mirror helps to reflect additional solar energy to the hot box.

Maximum temperatures of 130°C-145°C were obtained inside the box.

Items to be cooked are placed in metal saucepans (blakened outside), and covered with metal lids (blackened on top). The saucepans are put into the cooker through a side door. A meal consisting of 250g Rice, 500g Meat/Fish, 200g Vegetables, in three saucepans, can be cooked in approximately 2 1/2 hours on a Sunny Day, within the period 10.00AM to 2.00PM. This cooker can also bake a 500g butter-cake in 3 - 3 1/2 hours.

The cost of the cooker was Rs 2000/-; it was found to be too high for the consumer. The periodic adjustment of the mirror was also inconvenient. Also, house wives may not like to keep the food out side the house, in hot box, for a couple of hours to be cooked.

Model Two, shown in Fig 2, was developed to reduce cost and improve performance.

Using the sun-path diagram, for the Sri Lankan latitude, the metal tray was designed to prevent shadowing. It was found that a single 3mm thick glass cover was adequate for cooking purposes. The glass cover was tilted at 7° (which is the latitude angle of Sri Lanka) to get better transmittance. The unit was kept facing south so that insolent energy always fell on the absorber tray. Hence a mirror was not required. Using expanded-polystyrene and coir fibre for insulation, and using a concrete box cover the cost of the unit was further reduced. The cost of the unit was brought down to Rs 1000/-.

The Unit is now being sold for Rs 1200/- as material costs have escalated.

2. Flat Plate Solar Water Heater

This was developed and **licensed to Alpha Therm**, and they manufacture it under the trade mark **"Solar Therm"**; it is widely accepted in the local market. A 15 gallon Unit costs Rs 30,000/- The managing director of the firm, Mr. Lakshman Jayasuriya would

elaborate on this matter.
The unit is shown in Fig 4.

3. Integrated Solar Water Heater.

This model, has the solar collector (a blackened metal plate directly above the elliptical water tank in contact with the water. A glass cover traps the absorbed heat by 'green house effect'. The collector is designed to prevent shadowing. A wooden frame holds the Copper Tank of 15 gallon volume,and the absorber plate is of copper, corrugated, with plane copper bordere to prevent shadowing. It has a 3mm glass sheet cover, the insulation is of expanded-polystyrene and coir fibre, a thin sheet metal casing is used. The unit is installed on a south facing roof.

The cost of the unit is around Rs 10,000/-, which is half the price of the Flat Plate Solar Collector. It gives good performance during the day, but has the disadvantage that it loses heat in the night due to radiation of heat into the atmosphere.

The unit is shown in Fig. 7.

4. Direct Gain Solar Drier.

A simple Solar Dryer is shown in Fig. 3.

The collector is made of several trays of corrugated steel, blackened to absorb incident solar energy. The two sides of the drier are concrete beams, to reduce the cost, and enable it to be assembled on a roof-top. The drier is kept slanted with the apertures at the top end and bottom end providing the the pathway for air flow occuring due to buoyancy effects.

Scraped coconut, chillies, grains, fish, vegetables, jack fruit, etc were successfully dried in this unit.

The Cost of the unit is around Rs. 5000/-.

5. Cabinet type Copra Dryer.

A Cabinet type Copra dryer, for the small holder, was designed and tested. Tests results were good. Copra can be dried in 3 days. The cost of the unit is Rs 2000/-.
Further improvements are being done.

6. Solar Still.

A low cost Solar Still is shown in Fig 6.
A Blackened corrugated tray absorbs the solar energy coming

through the glass cover. The glass cover in kept at 7° inclination to the horizontal and facing south. The Frame is of Reinforced Concrete in two halves. The brackish water fed through the inlet fills the troughs in the corrugated absorber plate, evaporates due to insolent solar energy, condenses on the underside of the glass cover, and slowly moves along the underside of the glass to the collection groove at the bottom end, and is collected through the outlet.

The cost of the unit is around Rs. 3250/-.

7. Parabolic Solar Concentrator

The Parabolic Solar Concentrator, a well known apparatus, has the disadvantage that it has to be adjusted frequently so that the sunlight falls parallel to the axis. A very high temperature can be obtained at the focus depending on the size of the parabolic reflector.

A parabolic reflector of Dia 1 metre has been success fully used for cooking using both an ordinary pan as well as a pressure cooker.

If an automatic tracking mechanism (or a manual method of tracking)is used, very high temperatures can be obtained, and a Stirling Engine (which is generally of large size and low efficiency) can be effectively run to generate electricity. Ventilation fans can be easily run using a Stirling Engine and small parabolic reflectors.

8. Solar Refrigeration.

Using the Absorption Refrigeration Cycle, and using a Flat Plate Solar Collector (with a hot water radiator tube) to supply heat input to the refrigeration cycle an effective Solar Refrigeration unit can be designed. This is useful for rural dispensaries. R&D is still being carried out.

9. Indoor Solar Cooker.

Heating oil in a Flat Plate Collector and circulating the oil in the space between a saucepan and an outer sheath, an effective Indoor Solar Cooker can be made. We have achieved temperatures in the oil of upto 130°C, and in the pan of upto 100°C. Further improvements are being done.
The cost of the unit would be around Rs 25,000/-.

SUMMARY

The **Solar Hot Box** cooker, although *simple and inexpensive*, has the *disadvantage that the housewife has to leave the food outside the house for a couple of hours to cook*. Also stirring of the food and addition of condiments mid-way in the cooking is not feasible. These disadvantages have been overcome in the **Indoor Solar Cooker**, although it is *more expensive*.

The **Flat Plate Solar Water Heater**, is succesfully marketed by a licensee Alpha Therm, under the brand name **Solar Therm**; It is *half the price of the imported product* and is widely accepted. The **Integrated Solar Water Heater**, a different design, at a *cheaper price*, although with a few drawbacks, is now licensed and has good market potential.

Solar Refrigeration using the **Absorption Refrigeration Cycle**, still under R&D, is suitable for *rural dispensaries* and schools etc.

Vegetable drying using **Solar Vegetable Dryer** is suitable to *reduce wastage of vegetables & fruit at producer end*, thereby increasing the small farmers income. **Cabinet Dryer for Copra** is suitable for small scale producer.

Solar Still is useful for obtaining *distilled water*; and for extracting *potable water* in arid areas.

Parabolic Solar Concentrator can be effectively used for *cooking with a pan*, or pressure cooker *at the focus*. It can also be used for *power generation with a Stirling Engine* (the drawback being the low efficiency); The Parabolic Concentrator also needs a tracking system to function effectively.

RECOMMENDATIONS

Promote **wider usage of Solar Thermal Energy**:

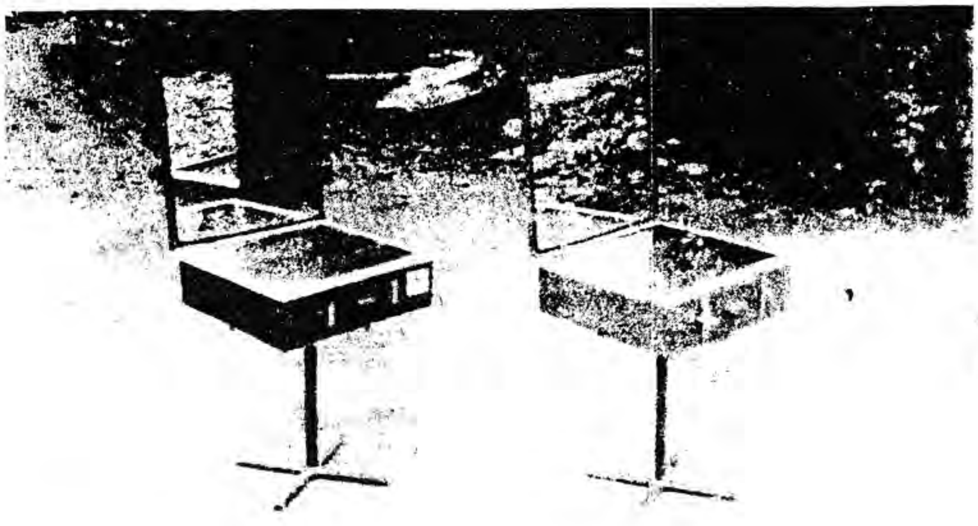
1) In *rural areas* for
   - -drying of vegetables and fruit;
   - -Copra drying;
   - -obtaining potable water & distilled water;
   - -refrigeration for dispensaries;
   - -cooking;

2) In *urban areas* for
   - -Hot Water for Domestic & Hotel sectors;

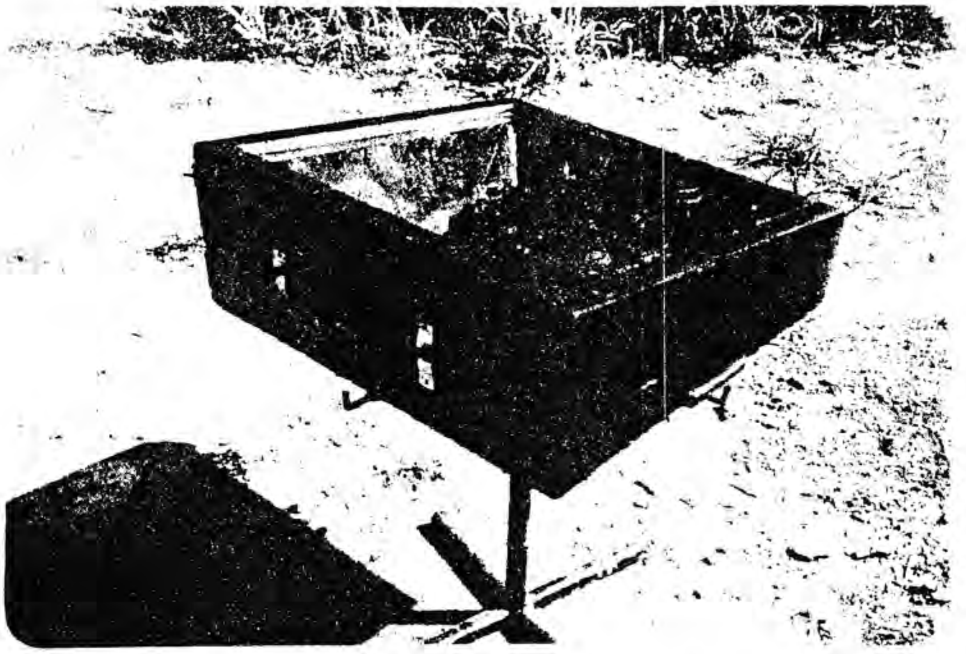
3) Parabolic Concentrator with *Stirling Engine* could be used:
   - -for mechanical power for ventillation fans;
   - -and for *electricity generation* (upto 5 kW or so), if an economically feasible unit is locally made.

N.M. Jayalath.

(1) Solar Thermal Energy Technology

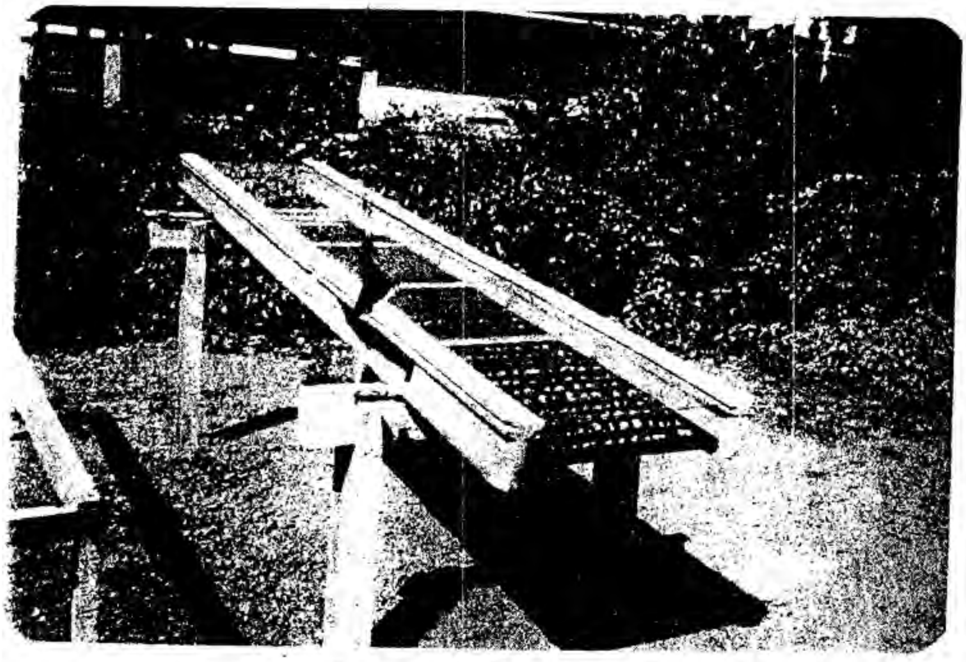


Solar hot box cookers with mirror FIG 1

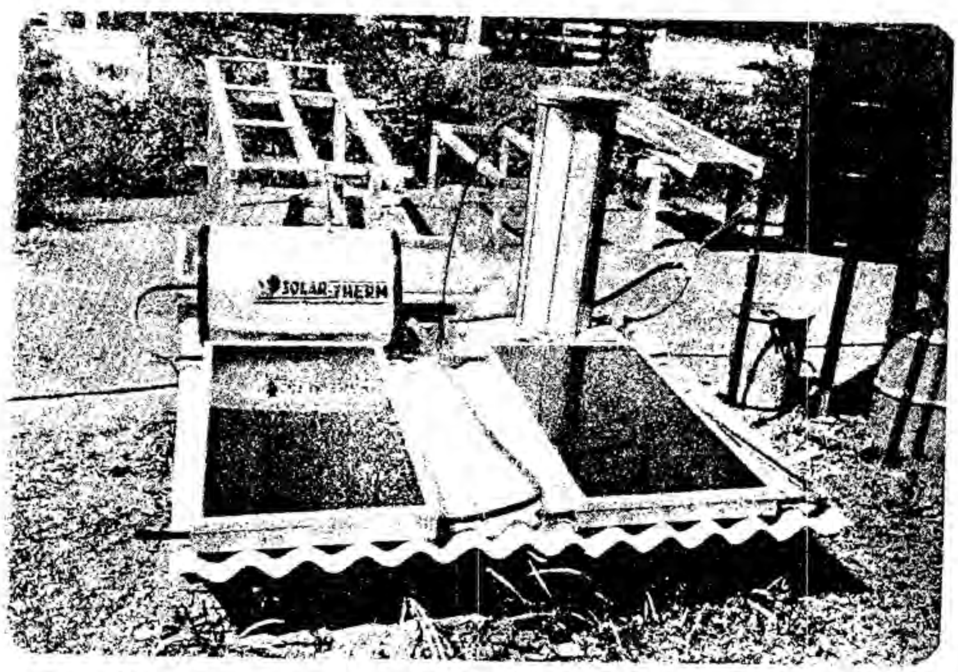


Improved mirrorless solar hot box cooker FIG 2

(1) Solar Thermal Energy Technology

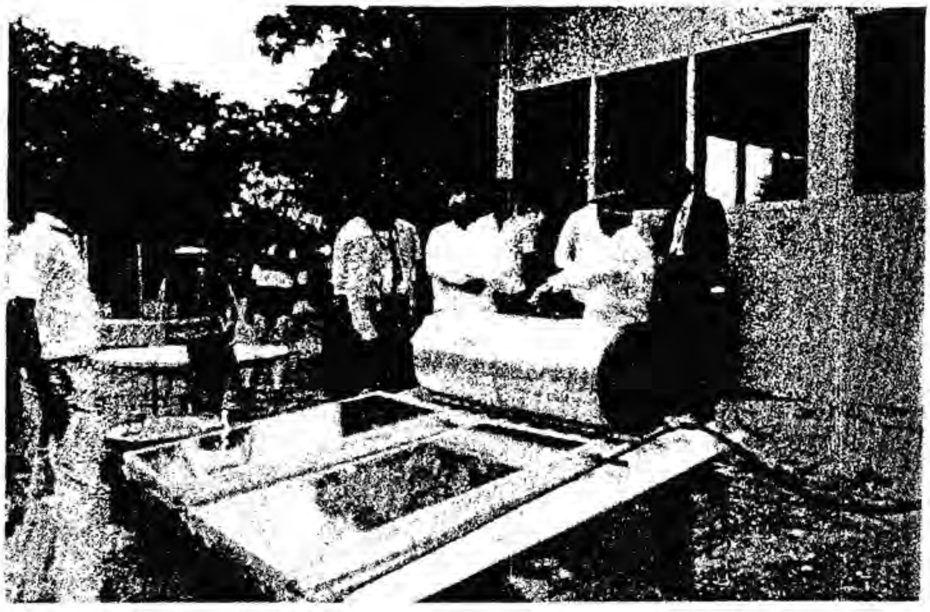


Direct gain Solar dryer



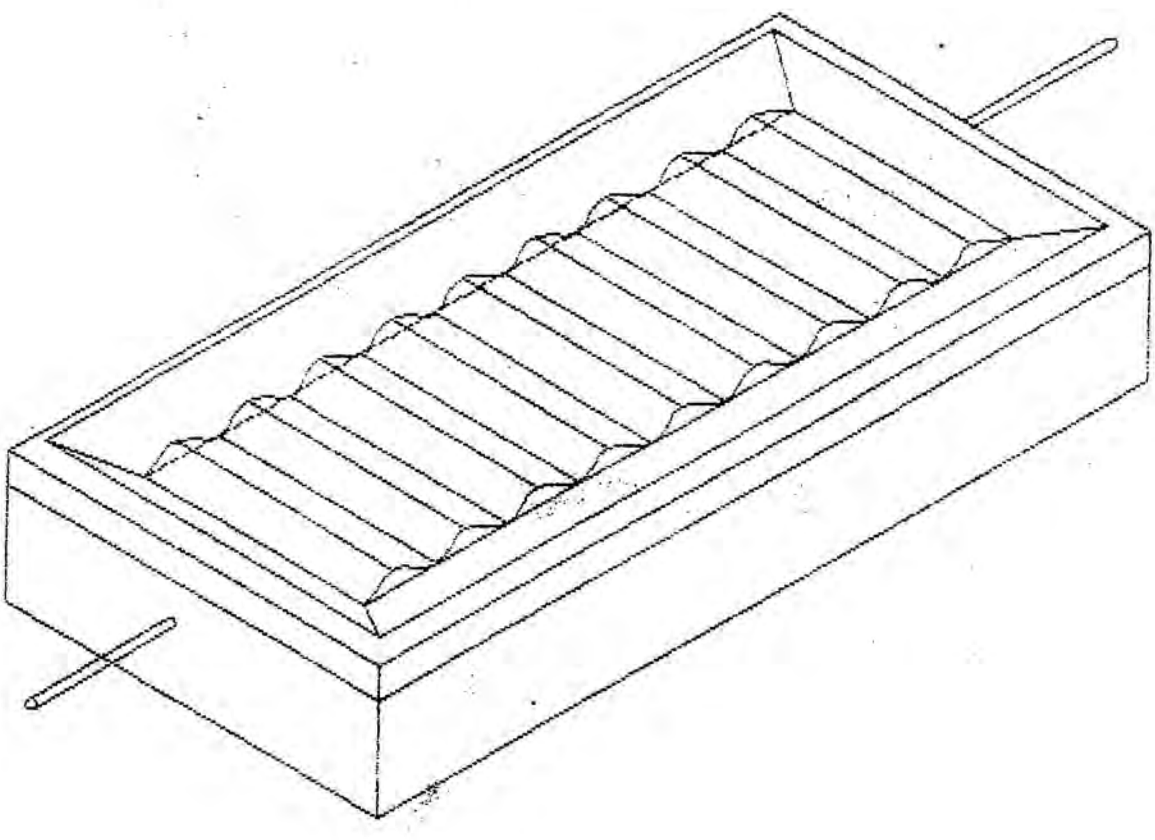
Solar water heaters with horizontal and vertical tanks

(1) Solar Thermal Energy Technology



Solar water heater with 30 gallon horizontal tank FIG 5

Solar Still FIG 6



DESIGNED	NATIONAL ENGINEERING RESEARCH & DEVELOPMENT CENTRE OF SRI LANKA
DRAWN	
CHECKED	
SCALE NOT TO SCALE	INTEGRATED SOLAR WATER HEATER
DATE 03/03/92	DRG.NO TE/ISWH/92/A01

FIG 7.

WOOD GASIFIERS FOR THERMAL AND SHAFT POWER

by - Victor Mendis, Chairman, NERD Centre

1 INTRODUCTION

Fuel wood is one of the major sources of energy in Sri Lanka like other developing countries especially in the South Asian Region. When considering the total commercial energy requirements in the country a major share of about 72% is occupied by fuel wood for small as well as medium industries.

The steady increases in fuel wood prices and the shortage of supplies, make it necessary to find efficient ways of utilizing fuel wood. Instead of direct combustion, the gasification of firewood is found to be more efficient and an effective process of energy conversion in most thermal applications. The National Engineering Research and Development Centre of Sri Lanka launched several R & D programs since 1982 to develop suitable gasifiers for in various applications. During the last nine years, the NERD Centre has successfully developed and commercialized series of gasifiers for thermal as well as shaft power applications.

2 WOOD GASIFICATION

2.1 History of gasification

Gasification of coal and bio mass can be considered as a century old technology. The oldest way of gas production from carbonaceous matters is called pyrolysis or distillation process in which bio mass is broken down by heat in the absence of Oxygen. Gasifiers that converts such fuel into a combustible gas have been in use since the early 19th century.

During the second world war in the early 1940's, when petroleum supplies for civilian use was heavily curtailed in Europe, Asia and Australia, producer gas was used in trucks, buses, taxis, tractors and even on boats. In 1938 Europe operated about 9,000 producer gas buses and trucks but there were almost none on any other continents. By 1941, however, about 450,000 vehicles were in operation in all parts of the world, and by 1942, the number had grown to approximately 920,000 with Japan operating a 100,000 vehicles. However, later, due to the abundance, convenience and cheapness of fossil fuel, oil became the prime source of energy. This led to a reduced interest in the gasification process, however the present time because of the energy crises there is a renewed interest in gasification.

2.2 Gasification process

Gasification is a process in which solid fuels are broken down by the use of heat to produce a combustible gas. Fuels that can be gasified include wood, charcoal, coal, and a variety of other dry organic materials.

The gasification process takes place in a gasifier which consists of a container, usually upright, into which the fuels are fed from the top. A controlled quantity of air is drawn into the lower part of the unit, allowing some fuel to burn as in a normal stove or furnace in the hearth zone. The essential feature is that the supply of air is restricted so that combustion does not spread to the whole fuel load. Depending on the application, the necessary air draft may be created by the suction of an engine or by a fan. By burning a part of the fuel, enough heat is released to cause the chemical breakdown and gasification. It is a very complex process of association and dissociation that takes place.

The main combustible components of producer gas are hydrogen and carbon monoxide with small amounts of methane. The calorific value producer gas is relatively low when compared to that of natural gas.

2.3 Chemistry of producer gas

Four distinct processes take place in a gasifier: drying of the fuel, pyrolysis, combustion, and reduction. Although there is considerable overlap, each can be considered as occupying a separate zone in which fundamentally different chemical and thermal reactions take place.
The basic chemical reaction taking place in the combustion zone is the combination of oxygen in the

air with carbon from the fuel to produce carbon dioxide which is an incombustible gas. This is an exothermic (heat releasing) reaction, and the temperature in the combustion zone consequently rise until the rate of heat-loss balances the rate of heat-gain from the combustion. Normally the combustion zone reaches a temperature of between 900 and 1300 degrees centigrade. If any hydrogen is present in the combustion zone, it also reacts with oxygen. Again, this is an exothermic reaction and water vapor is formed as the product. The principle chemical reactions taking place in the combustion chamber and reduction zone are as follows:

$C + O_2 \rightarrow CO_2 + 393800$ KJ/Kg mole
(Combustion reaction)
$C + H_2O \rightarrow CO + H_2 - 131400$ KJ/Kg mole
(Boudouard reaction)
$CO + H_2O \rightarrow CO_2 + H_2 + 41200$ KJ/Kg mole
(Water gas reaction)
$C + CO_2 \rightarrow 2CO - 172600$ KJ/Kg mole
(Water gas shift reaction)
$C + 2H2 \rightarrow CH4 + 75000$ KJ/Kg mole
(Methane forming reaction)
$CO_2 + H_2 \rightarrow CO + H_2O + 41200$ KJ/Kg mole
$CO_2 + C \rightarrow 2CO - 172600$ KJ/Kg mole

Producer gas generated from wood by an air blown gasifier, typically contains following components.

Combustible components:

Carbon Monoxide	- CO	- 20 - 22%
Hydrogen	- H_2	- 12 - 15%
Hydro-carbon gases such as Methane	- CH_4	- 2 - 3.5%

Inert components:

Nitrogen	- N_2	- 50 - 54%
Carbon dioxide	- CO_2	- 0 - 10%
Oxygen	- O_2	- 0.5 - 1.5%

The uncleaned gas may contain some tarry matter, moisture, ash, dust and volatile substances.

However, in practice, tarry liquid matter and ashes carried with producer gas, have to be removed before gas is to be used. If the raw producer gas is not cleaned sufficiently well, the equipment where the gas is finally used for burning, will have clogging and malfunctioning problems, caused by accumulations of tar, moisture and ashes. Heating value of the producer gas is around 4-6 MJ/Nm^3. The typical thermal efficiency of the gasification process ranges from 75 to 85% when using dry wood as the feed stock.

3 Gasifier types

Many varieties of gasifiers have been developed over the years. Depending on the mode of gasification and on the method of contacting between the gas and solids, gasifiers are classified as fixed bed, fluidised bed and entrained bed gasifiers.

In a fixed bed gasifier fuel is supplied in a lump form in size ranging from 6mm to 50 mm. The air flow can be counter current, co-current or cross-current. The ash is removed from the bottom of the gasifier through a grate. On the basis of removing combustible gas from the gasifier, they are classified again as updraft, downdraft and crossdraft gasifiers.
In a fluidised bed gasifier, the fuel is supplied as small particles, less than 10 mm,like paddy husk or saw dust. which is then maintained in a suspended state. Thorough mixing of fuel and gas causes rapid heat transfer that results in a more uniform composition and temperature compared to fixed bed gasifiers.

3.1 Downdraft gasifiers

The most common type of gasifier is the downdraft or co-current moving bed gasifier. Fuel is fed in at the top and flow of air is downwards through the combustion and reduction zones.

A characteristic feature of downdraft gasifier is that the tar and heavy hydrocarbons driven from the pyrolysis zone passes through the combustion zone and are cracked to smaller hydrocarbons. One significant feature of the downdraft gasifier is the reduced cross-section at the combustion zone often called throat. The aim of the throat is to ensure that adequate temperature is reached across the whole diameter of the combustion zone, to crack any tar that passes through. Because of the high temperature attained in this area, throats should be cooled and made replaceable. Because the producer gas leaves directly from the reduction zone, it tends to contain significant quantities of ash particles and soot. The exit temperature also tends to be higher with downdraft design. These gasifiers have the advantage that they produce a relatively tar-free gas when they are working properly.

The specifications of the NERD gasifiers are given below.

Model	Max. burning rate kg/hr	Heat output MJ/hr
AF60	14	205
AF100	30	441
AF125	45	661
AF150	67	985
AF200	110	1617
AF250	150	2205
AF300	170	2499

5 Applications

The NERD Centre downdraft wood gasifiers have been successfully used in various industries for thermal as well as shaft power applications.

5.1 Thermal application

Several industries which require thermal energy, use firewood, and heat is obtained by direct burning since the prices of other sources of energy like electricity, fossil oil etc. are high. Buy gasification of firewood the thermal efficiency of most thermal applications can be improved.

5.1.1 Tea drying

The tea industry is one of the main pillars of the Sri Lanka economy, and it is also the largest fuelwood consumer in the country. Sri Lanka produces 200 million kg of made tea utilizing 400 million kg of fuelwood per year on an average basis. Therefore, the reduction of the firewood consumption in tea industry remains an important issue from a national point of view.

In the tea manufacturing process, energy is required as an input in two stages. Firstly, withering requires approximately 2.8 MJ/kg of made tea.Secondly drying needs approximately 11.4 MJ/kg of made tea. At present, heat is generally produced by combustion of firewood or fuel oil.

Due to the high cost of fuel oil, almost all the driers are being operated on fuelwood except in the hill country. The hot air required for tea processing is obtained from a heat exchanger which is heated externally. Fuelwood is burnt inside a furnace containing tubes, through which atmospheric air is blown.

a) Moisture Removal in Tea Processing

The moisture content of green leaf is reduced to 55% from 80% in the withering process using conditioned air. The temperature of the air is about 25-40°C, which is only to maintain a hygrometric difference of 4°C.

The moisture content of made tea is reduced from 55% to 2.5% in the drying process, using hot air from the heat exchanger. The optimum drying temperature should be between 85-90 C; therefore hot air just entering the drier should be about 93-96 C. The optimum drier exhaust temperature is 50-55 C. the residence time of tea in the drier varies according to the drying temperature. For a drying air temperature of 85-90 C, the residence time would about 18-24 minutes.

b) Fuel wood in tea processing

To whither 1 kg. of made tea 0.7 kg firewood is required and to dry 1 kg of made tea it requires 2 to 2.5 kg of firewood. Therefore approximately 3 kg. of firewood is required to produce 1 kg of made tea. These values may be considered as average figures and the true value generally depends upon the efficiency of the furnace/heat exchanger/drier combination.

In 1986 Sri Lanka produced 211.3 million kg of made tea and consuming an estimated 377.4 million kg of firewood. This is really a large amount of firewood and if this consumption pattern is allowed to continue the effect on the environment and the ecology will be disastrous.

The reduction of firewood consumption could be accomplished by improving the combustion efficiency, enhancing the heat transfer efficiency and increasing the drier efficiency. An improved combustion efficiency can be achieved by first converting the firewood to producer gas and then burning it to generate heat energy at a higher temperature.

c) Salient features of the design

In order to cater to the manufacturing requirements, the gasifiers have to operate for 16 to 18 hours continuously. This is achieved by introducing a tapered hopper having a capacity sufficient for 12 hours operation of the gasifier. Because of the tapered configuration fuel bridging problems are avoided.

To achieve a high flame temperature, a certain amount of secondary combustion air is used. It is possible to obtain a flame temperature of about 1100°C. The temperature of the drying hot air can be controlled, by manipulating the primary air flow into the gasifier for gasification reactions; and the secondary air supply for the combustion of producer gas.

Following safety devices and control equipment are installed.

1.Interlock device, which prevents the possibility of starting the air blower of the gasifier before starting the ID fan of the furnace.

2.Flame monitor,which indicates audibly and visually the absence of the flame.

3.Once the flame goes off, an electronic signal immediately switches off the air blower of the gasifier. This arrangement prevents the accumulation of fuel gases inside the furnace.

4.Temperature controlling device, which controls the temperature of the hot air and maintain the hot air temperature between 110°C and 90°C.

5.1.2 Foundry application

Sri Lanka has had a traditional technology for non ferrous foundry production for a long time. These foundries have been manufacturing brass and aluminum fittings such as hinges, tower bolts, door and windows lock etc. for the building industry. During recent years this industry has been facing the problem of rising cost of liquid fuel which has been used practically by every small scale foundry.

This situation has created considerable difficulties for the small-scale non-ferrous foundry industry with the result that the cost of the products have increased considerably and some foundries have had to close down. An alternative fuel for this purpose, has been coconut shell charcoal. But now coconut shell charcoal is used for producing activated carbon, for which high prices are available in the world market. The cost of this fuel also has now increased to the level of the liquid fuels. In this scenario

NERD Centre undertook research to solve the problem of reducing the fuel cost in non-ferrous foundries.

The knowledge and experience gained in producer gas R & D led to its use as the alternative fuel in the foundry industry. Since producer gas is a low calorific value gaseous fuel, a suitable burner was developed to achieve very high furnace temperatures which are sufficient to melt aluminum and brass scrap.

The traditional practice of firing the crucible from the bottom results in rapid deterioration of the crucible due to very high temperature gradient that exists across the crucible wall. It has been found that while an imported crucible has a life time of 20-30 melts, the locally manufactured crucible which is available at a fraction of the cost of the imported one could only have a life time of 3-5 melts with traditional firing practices.

A new method of firing the charge was devised in order to increase the life time of the crucible and to achieve high fuel efficiency by avoiding the high temperature gradient across the crucible wall. This is accomplished by firing the crucible with the charge from the top of the crucible where the flame impinges directly on the charge. Essential features of this arrangement are shown in Figure 6.

In this manner a considerable amount of fuel could be saved with the reduction of melting time, in addition to extending the life of the locally manufactured crucibles from about 5 melts to about 25 melts.

The machinability, hardness and tensile strength of the castings which are cast using these methods are found to be within acceptable limits.

The same principle may be utilized for melting Zinc, Aluminum and brass and bronzes too. The NERD Centre has developed galvanizing plants in which firewood based producer gas is used as the fuel. The burner was developed further by introducing little amount of high carbon oil to the flame to increase flame temperature of 1200 C in order to cast metal with high melting temperature.
But firing the crucible from the top it was possible to melt 1Kg. of brass using 1.6 kg. of firewood.

5.1.3 Cooking

Fuel wood is extensively used as the major cooling fuel still in Sri Lanka. But, nowadays firewood fuel is replaced by LPG and electricity in urban areas, because of the convenience in their use. A few years back, kerosine oil widely used as the cooking fuel in urban areas, but because of its high price, kerosine oil usage for cooling purposes has become much less.

Electricity and LPG prices are also increasing gradually and soon, their prices will become unaffordable for lower and middle classes. On the other hand, utilization of super grade energy sources such as electricity and LPG for cooking purposes is not so advisable as far as energy conservation is concerned.

The tests indicate that the use of producer gas for cooking with a 900°C of flame temperature and 35% -40% efficiency and 4.5 times cheaper than using LP gas.

5.2 Shaft power applications

Producer gas must be free of dust, tar, moisture and volatile materials for IC engine applications. unless these impurities removed, there would be serious damage to internal parts of the engine components. Therefore, auxiliary equipment such as cyclone separators, filters, gas scrubbers and gas coolers are required for removal of impurities and conditioning producer gas, for IC engine applications. Cooling is essential in order to increase the volumetric efficiency of the engine.

Both diesel and petrol engines could be modified to be fueled with producer gas. However in the case of diesel engines only up to 80% of diesel can be replaced with producer gas since some diesel is needed to produce self ignition.

Petrol engines can be converted to run on producer gas very easily by installing a new system. Two butterfly valves are installed, one in the producer gas line and the other in the air line, to facilitate the proper regulation of the air/gas mixture which will be admitted to the engine. Here the distance between the inlet manifold and the original carburetor should be minimized.Since the combustion limits of the producer gas and air mixture life within a very narrow range, adjustment of the two butterfly valves has to be done very carefully. Since producer gas has a low calorific value, there will be a 40% to 50% reduction in power

In the case of diesel engines, the air intake arrangement is removed from the inlet manifold and instead a gas-air mixer is incorporated. The reduction of the diesel flow rate to the engine is expected after the conversion. But the reduction has to be done very carefully, after considering the lubricating arrangement of the fuel pump. Some fuel pumps are self lubricated and in such a situation careful regulation is required. 10%-15% power reduction is experienced with this type of conversion.

For IC engine applications, external blowers are not needed, once the engine is started, it sucks air continuously through the gasifier, generating producer gas. Throughput is regulated by accelerator control in the usual manner.

6 Conclusion

At the present rate of deforestation taking place in the country, there will be severe shortage of fuelwood which is one of the main fuel sources in the near future. With the prevailing situation regarding wood shortage, this valuable source has to be utilized in an efficient way for the sake of national interest.

In this regard, gasification is identified as one of the appropriate techniques which could be used especially in the field of heat generation. The main drawbacks of the system is the preparation of suitable wood logs for different gasifiers and also, wood feeding arrangement to the large gasifiers.

In order to overcome these problems, the NERD Centre has successfully developed a hammer mill and a wood conveyor.

Reference

1.Foley, G. and Barnard, G., **Biomass gasification in developing countries**, International Institute for Environment and Development, London, UK, 1983.

2.Ghoshray, A., **Design and performance evaluation of a corn cob gasifier for direct heat applications,** MEng thesis, Asian Institution of Technology, Bangkok, Thailand, 1986.

3.Kaupp, A. and Goss, R.G., **Small scale gas producer engine systes**, Federal Republic of Germany, 1984.

4.Kulasinghe, A.N.S. and Silva , H. H. de., **The development of producer gas cooking device,** National Engineering Research & Development Centre, Ekala, Sri Lanka, 1989.

5. Kulasinghe, A. N. S. , Silva, H. H. de, Perera, Leelarathne, M. W. and Thilakarathna, Y.R., **A south asian experience on appropriate research and development**, Presented at the workshop held by Regional Environmental and Natural Resources Information Centre,

5.Seng, L. H., **Effect of design parameters on the performance of a downdraft wood gasifier**, MEng thesis, Asian Institution of Technology, Bangkok, Thailand, 1984.

6.Navarathnam, S. **Mathematical modeling of a down draft wood gasifier**, MEng thesis, Asian Institution of Technology, Bangkok, Thailand. 1984.

7.**Producer gas information package,** Commonwealth Regional renewable Energy Resources information System, 1984.

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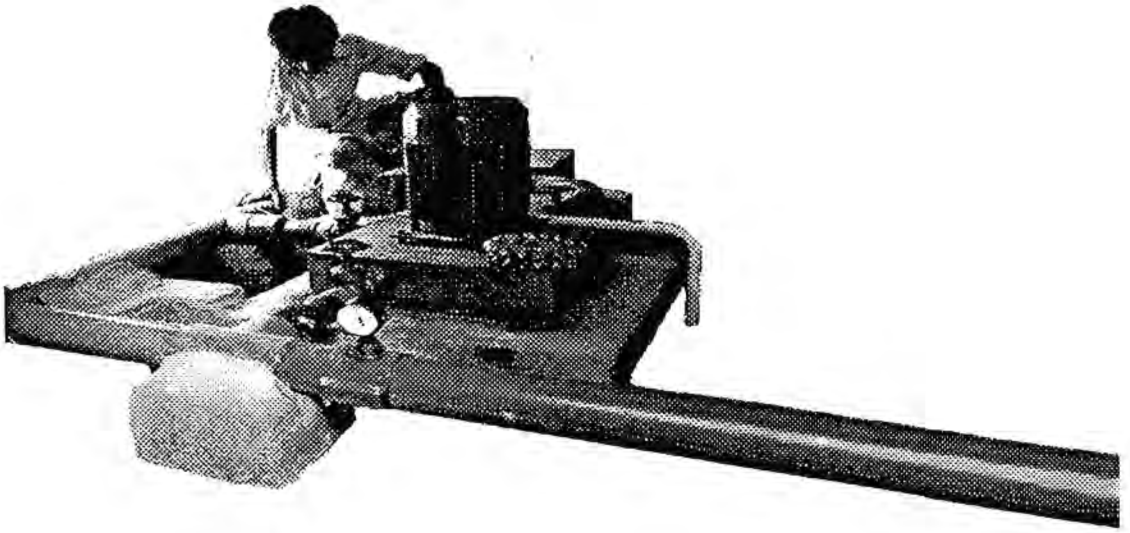
Decentralized Micro Hydropower Systems:
A Rural Energy Option

by
Lahiru Perera and Sharni Jayawardena



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Decentralized Micro Hydropower Systems: *A Rural Energy Option*

by Lahiru Perera and Sharni Jayawardena
Intermediate Technology Development Group

Resource use and conservation

- producing and conserving energy
- identifying energy potential and use
- conserving forests

Micro hydropower is a renewable source of energy, the development of which is not associated with adverse environmental consequences. It is especially suited for areas where large installations or grid extensions are not practicable i.e. too remote, too expensive, or too time-consuming. **Micro-hydro has been acknowledged as an appropriate way of providing power to a significant number of isolated communities.**

Micro-hydro can provide energy through direct mechanical power or by linking a turbine to a generator to produce electrical power. It can be used for domestic lighting or to power small, local industries. Expenses on kerosene are substantially cut, with the added benefit of reduced carbon dioxide emissions in households. Machines like saw mills, grain mills, and rice hullers can be more efficiently run by being mechanically powered by micro-hydro. Village level processing will enhance the incomes of communities by adding value to products within the community itself. Processing industries are usually located centrally and serve a number of villages, resulting in an outflow of income from these villages. **A processing unit within the village will reduce transport costs and save time for villagers, particularly for women. In remote communities with poor road networks and transport facilities, a battery charging unit can be one of the most useful ways of sharing micro hydropower.**

There is considerable micro hydropower potential in the country - in hilly regions with a high annual rainfall like certain areas of Matara, Galle, Ratnapura, Kandy, Kegalle and Nuwara Eliya districts. Recent developments - at both village and government policy levels - have created widespread interest among communities and private entrepreneurs.

ITDG is presently developing a technical support base for micro-hydro development in Sri Lanka. This will include an inventory of small hydro sites; a reliable hydrology model for stream flow prediction in small catchments; and guidelines for project development.

At the village level, nineteen micro-hydro schemes (annexure) are in operation and approximately 150 individuals or groups have indicated their interest to set up their own. It is significant that in most villages where micro-hydro units were built, there has been increased environmental awareness with concomitant conservation methods being adopted by communities - tree planting to prevent siltage and erosion in catchment areas, and the control of illicit timber felling. The Forest Department, and environmentally conscious NGOs like the International Irrigation Management Institute (IMMI) have initiated micro-hydro projects because of their positive environmental consequences.

The Ministry of Power and Energy has promoted the implementation of micro-hydro systems especially in relation to grid connections. The Ministry of Energy Conservation has supported micro-hydro generation at commuity level. The more recent interest in renewable energy applications by the Ministry of Science, Technology and Human Resources Development is encouraging. This indicates the recognition, by the Ministry, of the important link between rural energy supply and rural productivity.

Local capabilities

- evaluating power potential
- manufacturing equipment
- building civil works
- making connections (wiring)
- operating and managing
- maintaining and repairing

The Ceylon Electricity Board (CEB), in 1993, encouraged the private generation of micro and mini hydropower by undertaking to buy power from producers. The CEB also offered to carry out free feasibilities. This policy decision has implications mainly for the larger producers - like the estate management companies - who want to reduce production costs and increase profits by rehabilitating disused units or installing new ones. However, by stimulating local capabilities in micro hydropower generation, rural communities with substantially less capital will be able to benefit as well.

The capacity to design, install, operate, and maintain micro-hydro units is clearly established in the country. A half dozen local workshops are producing and adapting equipment from existing designs, and foundries are fabricating turbines and components with locally available raw materials. Skilled indigenous casting is being revitalised in the manufacture of pelton wheels.

To facilitate and simplify machinery production and to save costs, the use of a motor transformed into a generator is promoted. Engineers have been trained in the manufacture of induction generator controllers which are presently installed in a majority of the units.

A database of technical and institutional expertise in micro hydropower generation has been set up. The micro-hydro training and demonstration unit at Sarasavigama - an appropriate technology farm run by Satyodaya - is open to manufacturers of small turbines for testing their machinery.

Capabilities for evaluating power potential within communities is not yet adequate. Two people from Akuressa and Ingiriya - now being referred to as *catalysts* - are able to carry out initial feasibilities for prospective implementors. Catalysts are innovators and enthusiasts with a fair degree of technical and organisational skills and links with local manufacturers and technicians. An important aspect of carrying forward work in village hydro has been identified as the development of local catalysts.

Information materials have been produced to help (and caution) people who want to invest in and/or generate micro hydropower. The leaflet - "Is Micro Hydropower Right for Your Village?" (annexure) - includes pointers on how to make basic feasibility measurements of power potential.

It has been generally observed that rural communities have the capacity to construct the civil works. Experience also indicates that there is usually an electrician or mechanic in the village who is able to help the community carry out part of the work connected with installation, wiring, maintenance and repairs.

Safety aspects of micro hydropower have been discussed with electricity consumers, and people with some technical skills trained in operation and maintenance aspects and battery charging. Supplementary information materials have been developed.

Affordability / Financing

- contributing community resources
- accessing subsidies/credit
- enhancing end uses

The current interest rate in the development finance sector is 20%, with a five year repayment period. Micro-hydro is financially viable for villagers only if the initial capital cost is subsidised up to 50%. Micro hydropower generation usually costs around US $ 2,000 per kW for smaller schemes.

To make micro-hydro affordable, people need to have access to credit and subsidies initially. The financial viability of projects would depend, to some extent, on whether a hydro unit can be used to earn a revenue in addition to domestic power supplies for lighting, and radio and television. To make village hydro more productive and affordable, end use machinery - particularly for operation during the day time - is encouraged.

A tariff structure has been developed as a method for assessing the economic viability, welfare aspects, end use products and sizing and design of schemes. The equation is deliberately designed to include parameters such as "number of houses" because this helps make social-benefit decisions. For example, it will be possible to choose between one design approach which links more houses to the hydro, and another which links fewer houses but offers a day-time employment opportunity to some of the poorer villagers. The equation gives a monthly tariff figure, because this is the parameter of most direct interest to the villagers.

In most villages, the cost of the civil works can be carried out and related costs borne by the community. Full or part funding for the village micro-hydro units already installed were made by the Matara Integrated Rural Development Project, the Rotary Club of Colombo West, the Ministry of Energy Conservation and the Janasaviya Trust Fund.

It is recommended that low-interest development loans be extended to individuals or groups through regional offices of development banks. The People's Bank recently provided loans to help people carry out wiring for a recently set up micro hydro scheme in Nakiyadeniya. This is the first time that a formal credit institution has extended credit to an electricity consumer society.

Links with local authorities

- making contact
- obtaining approval
- recognizing ownership

Local authorities, including the Forest Department, should facilitate authorization procedures which might be needed for village hydro. A formal system for authorization needs to be adopted. The projects sponsored by the Ministry of Energy Conservation have been vested with the Regional Secretariat which has been given a supervisory function. It is important that this does not discount or undermine the responsible role the Electricity Consumer Societies play.

The Government Agent's Office and Integrated Rural Development Projects could assist communities strengthen their organisational and management capabilities.

Institutional building

- setting up electricity consumer societies
- drawing up a constitution
- developing a tariff structure
- regulating power use
- monitoring technology/equipment
- sharing information

Village power supplies are managed by Electricity Consumer Societies. The Societies draw up their own constitution and develop a tariff structure, which includes a fine for default or 'illegal' use. These 'laws' are unique to each village.

ITDG has, with community participation, developed guidelines on institutional and tariff structures. It is necessary to have a strong and trusted leadership, clear rules implemented at the outset by the Society, clearly worked out distribution costs and benefits, and the democratic participation of members and beneficiaries throughout the process. Electricity Consumer Societies have devised systems to keep record of breakdowns, repairs and maintenance work and the costs involved.

It is clear that social issues within communities have definite implications on the implementation and sustainability of projects. Therefore, **it is important to be sensitive to, and understand, the interplay between resources, hardware, skills, processes and relationships of energy production.**

The ability of village hydro to meet the needs of people depends on the technical generating capacity of the particular scheme and the way in which societies choose to share benefits and costs. Limited capacity means it is unlikely to provide light to all villagers and higher costs mean it is unlikely to meet the needs of the poorest. Some Electricity Consumer Societies give free or subsidised connections to disadvantaged households.

One of the most encouraging consequences of the projects is increased environmental awareness and commitment. When both production and consumption of electricity take place locally, people have a vested - and more immediate - interest in protecting their environment. In Akuressa, the Education Department has recommended that all schools in the district visit the project in Kalugaldeniya as part of their science curriculum. Each visitor is charged a fee of a plant.

Electricity Consumer Societies in the Matara and Ratnapura districts have set up a regional network which will work towards developing their units and assisting communities who want to set up new ones. The network has asked Divisional Secretariats in the districts to reserve extents of forest land in the area which are being indiscriminately cut down.

Research and development

- increasing efficiency
- reducing costs
- increasing capacity
- making innovations

Feasibility studies are being carried out on appropriate end uses, and the development of suitable machinery. **Village hydro has clearly identified the need to study the use of energy efficient lamps.**

Costs involved in increasing the capacity of small hydro projects is generally high due to limitations in the technology available at present. The capability for manufacturing turbines for low and medium head sites is limited in Sri Lanka although low-head hydro resources in the range of 5 to 30 ft head are found in significant numbers. Research and development work has begun on the development of a cross-flow turbine for low-head sites which could even be incorporated in the irrigation channels of the dry zone.

Technologies which can lower the capital cost of micro-hydro installations are being developed. For instance, costs will drop considerably if motors are turned into generators and water pumps into turbines. In many countries - like Nepal and Sri Lanka - which have significant micro hydropower potential, electric motors, water pumps and pvc pipes - which are relatively inexpensive - are freely available. Capacitors are all that are needed to convert motors into generators. The cost of induction generators is simply the standard price of the motor with around 20% added for capacitors.

The generation equipment of a typical micro-hydro scheme accounts for 35% - 45% of the operation, maintenance and capital costs. It has been estimated that an induction generator system can save up to 20% for small schemes. In addition, significant savings are made on operational and maintenance costs due to the higher reliability of induction generators.

Regulations

- harnessing water
- transmitting power
- setting standards

In the past two decades, there have been dramatic developments in the energy sector related to both production and consumption. There is now greater awareness and concern in the government and the private sector about energy production, management, distribution and efficiency. This sensitivity is being extended to related social and environmental issues.

Government policy towards privatisation and the encouragement of private investment through Build, Own and Operate and Build Own and Transfer projects represents micro hydropower generation as a good investment. But **existing policies, standards and methods do not encourage the development of a useful strategy for the wider generation and use of micro hydro in the country. Regulations governing power transmission, wiring and the harnessing of water should be reviewed and appropriate standards implemented. The Government could also review import subsidies on equipment to encourage local manufacture.**

In relation to the setting of appropriate standards, the government could adopt the procedure carried out by the National Housing Development Authority in their settlements upgrading programme. The conventional approach to building standards has been to allow the public health and planning officials to decide on and impose their codes. In the Community Building Guidelines and Rules Approach, standards are decided at a partnership workshop where representatives of community interest groups and health and technical professionals work together to make building codes for each settlement.

Legally speaking, community building guidelines are made possible under a special provision of the Urban Development Authority Act. A low-income project area can be specifically designated and exempted from "normal" planning regulations and building codes. The community is then allowed to establish its own regulations and guidelines under liberalized standards.

If Building Guidelines and Rules are to be observed, they need to have the general acceptance of the majority of the interest groups of low-income settlements. This principle of general acceptance by the majority of interest groups allows any issues and conflicts to be dealt with by the enforcement of public responsibilities through combined community pressure and, sometimes, action by the Authorities.

An integrated approach

- identifying present limitations
- looking for alternatives

One of the restrictions of scope of remote, stand-alone micro hydropower production has been its inability to provide an entire village with power, due to limited capacity. A more basic limitation is the lack of the necessary natural resources - micro hydro potential existing in some areas only. **It is clear that an integrated approach including other energy options needs to be explored.**

The government should adopt a national policy for decentralised power supply which would includes a subsidy for alternative energy sources in the same way it subsidises rural development, grid electricity and kerosene.

The government could adjust import tariff structures to encourage the local manufacture of equipment up to 150 kW.

There is still limited understanding of the energy needs and concerns of rural communities, including the implications of power provision for productivity. It is vital to bring village energy issues to the forefront of development thinking and action.

IT Sri Lanka
May, 1995.
file: NAREWP60

VILLAGE MICRO HYDRO ELECTRIFICATION PROJECTS ASSISTED BY THE ITDG

	NAME OF THE PROJECT	LOCATION(KM)	DISTANCE TO THE GRID(KM)	PRODUCTIVE/COMMERCIAL LOADS	KW RATING	NO.OF HOUSES CONNECTED	COST Rs.'000
1	Kohugoda	1.8 - Ihala Maliduwa	3.0	Battery charging	0.9	1	40
2	Ihala Maliduwa	12 - Akuressa	2.4	Battery charging	3.0	31	250
3	Puhulahena	0.7 - Imaduwa	3.0	-	1.2	10	200
4	Pathavita	10 - Deniyaya	2.0	Ironing centre	3.5	66	400
5	Dolagodawatte	1.5 - Ihala Maliduwa	3.0	-	1.0	10	131
6	Udagedera	1.5 - Ihala Maliduwa	3.0	-	1.0	9	117
7	Dolapalledola	1.8 - Ihala Maliduwa	3.0	-	2.0	20	216
8	Isnawathadola	1.5 - Ihala Maliduwa	2.0	Battery charging	2.25	18 + Temple	303
9	Umangedera	4 - Ellagawa	4.0	Plaining machine	1.5	17	144
10	Sarasavigama Training Unit	20 - Peradeniya	1.5	Brooder	1.0	-	300
11	Eramudugoda (Jayatissa)	8 - Akuressa	4.0	-	0.5	1	Private
12	Suriyakande (Sirisena)	1 - Suriyakande	2.0	-	0.5	2	Private
13	Yagirala	10 - Elkaduwa	3.0	Battery charging	1.8	15 + Temple	265
14	Nakiyadeniya	2 - Nakiyadeniya	4.0	-	3.0	22	154
15	Sinharaja Aranya	2 - Suriyakande	3.0	Battery charging	3.5	Temple	159
16	Kudagala	3 - Karagoda	3.0	-	0.75	1	Private
17	Pothupitiya Aranya	10 - Kalawana	2.0	Battery charging	1.5	Temple	206
18	Niriellawatte	15 - Ratnapura	0.5	-	5	19	367
19	Illukpitiya	2 - Morawaka	2	-	5	50	412

WHAT IS NEEDED FOR THE SOLAR PHOTOVOLTAIC INDUSTRY IN SRI LANKA TO DEVELOP

Lalith Gunaratne
Solar Power & Light Company Limited.

18th May 1995

What is Needed for the Solar Photovoltaic Industry in Sri Lanka to Develop:

Lalith Gunaratne,
Solar Power & Light Company Limited

Solar Photovoltaics has been used in Sri Lanka from the early 1980s, especially, for lighting applications. The CEB, through its Alternative Energy Unit, introduced it with Vidya Silpa being the first commercial company to import modules to sell in Sri Lanka.

Both Vidya Silpa and the CEB Energy Unit were selling systems from Colombo.

In 1987, after doing an extensive Market and Feasibility study, Power & Sun (now Solar Power & Light Company) established a solar PV module assembly facility in Sri Lanka and commenced marketing of lighting systems for rural homes through a decentralized network around the country.

About the same time, Sunpower Systems Limited, a Maharajah Organization company also commenced operations and focused more on larger institutional systems for telecommunications, water pumping and government projects such as the Pansiyagama and the Uva Infrastructure Development Project for Mahiyangana.

In 1990, a new community based method of dissemination of solar PV systems were introduced by a newly formed non-governmental organisation called SoLanka Associates and already established Sarvodaya Shramadana Society.

Therefore, Sri Lanka has now seen the private sector, government (top down) and the NGO (bottom up/community based) methodologies to disseminate solar PV systems to rural areas. These have given the promoters an opportunity to learn valuable lessons on how to promote solar PV effectively.

The Technology, Cost and the Private Sector Role:

The lessons that were learned are that the technology is now proven beyond doubt and the dissemination must involve the community in the process of selling, financing, installing and maintaining systems.

From a private sector point of view, the real barrier for its dissemination on a commercial basis is the relative high cost of the systems in relation to the market that is targeted.

A typical rural household will have to pay about Rs. 20,000 to purchase a 30 Watt system to operate 4 lights, a television and a radio on a daily basis.

....continued

Bringing the relative high cost of solar modules down has been a goal of the promoters worldwide for many years. Only mass use of solar PV will see significant reductions in cost in the coming years. This is now happening at an international level with US and European governments taking decisive political action to encourage the use of solar PV in those countries with the future preservation of the earth in mind.

The Immediate Need for Sri Lanka:

Yet in the interim for Sri Lanka, with government and policy support, solar PV can become a more favourable option for a certain percentage of households in villages without CEB grid power.

(A market study done for the National Development Bank by Kenneth Abeywickrama and Associates in 1991 showed that 350,000 households existed in Sri Lanka that could afford a typical system at current prices).

Following is a short list of areas that need to be addressed at the government level;

- reducing tariffs on imported raw material for solar modules and other balance of system items.

- reducing tariffs on solar modules.

- facilitating the creation of public awareness of solar PV as an effective alternative for grid power in rural areas.

- facilitating needs based research programmes for the development of new applications for solar PV.

- creation of mechanisms for effective financing for the purchase of systems at the village level.

For instance, the reduction of tariffs should be studied in the context of import substitution for kerosene, not to mention the high social costs that are implicated with the use of kerosene for lighting.

In conclusion, the above points need to be dwelt on an individual basis. The author hopes that the role of the newly created Alternative Energy Unit will be to address these types of issues which will result in the Sri Lankan solar power industry being able to develop to a position where the benefits will be passed on to the end user at the village level.

Providing electricity with "least cost" options both in terms of monetory and environmental value to the couple of million households in rural Sri Lanka is essential. Otherwise, we are leaving a significant portion of our population in darkness - an unacceptable situation at the dawn of the 21st century.

Using Solar Photovoltaics for Domestic Rural Electrification: What Has Been Done and What Remains to be Done In Sri Lanka

By

Viren Perera & Lalith Gunaratne
Joint Managing Directors
Power & Sun (Pvt) Ltd

Introduction

This paper, which is not technical in nature, is a description of what we have done in Sri Lanka over the past five years in our efforts to establish an effective, practical and viable solar photovoltaic (PV) industry in Sri Lanka. Please excuse the paucity of reference materials and a bibliography, and treat the appendix as part and parcel of this paper.

Why Decentralized, Alternative Energy Sources Are Needed

The demographics of a typical developing country, where 65% to 80% of the population live in relatively thinly populated rural areas, makes the supply of electricity using centrally generated conventional power frequently unliable. Furthermore, even if it was viable, the adverse impact on the global environment of using conventional 'dirty' power sources to meet this need would be serious enough to question the justification of following such an approach.

At this moment, the vast majority of this world's population - almost all of them in rural areas of the developing world - live without the benefits afforded by the basic modern amenity of electricity. No one will argue against the position that everything that can be done should be done to give these people power. However, since we know that using centrally generated power to supply electricity to decentrally located populations is frequently unviable for obvious reasons, it leads to the logical conclusion that decentralized power sources with minimum negative environmental impacts must be used for this purpose. Furthermore, these energy sources should be capable of generating even small amounts of power relatively economically - an important consideration because almost all first time electricity users require very modest amounts of power (in Sri Lanka, the Ceylon Electricity Board reports that the average rural house uses five light points, a radio and a small television set; usage that generates a monthly electricity bill of just US$ 0.80 to US$ 1.25 per month).

There are a few energy sources' which fit the necessary requirements: wind, mini/micro hydro, bio-gas and solar PV. Of these, we believe that solar PV is the best one to develop and promote (please note that this does not imply that we believe the others should not be promoted where appropriate). The reasons being that:

- In relation to wind power, it is:
  - easier to maintain
  - more dependable
  - is decreasing in real cost over time

- in relation to mini.micro hydro power, it is:
  - easier and quicker to instal
  - does not have as many potential environmental impacts
  - is decreasing in real cost over time

- In relation to bio-gas, it is:
  - more convenient to use
  - is appropriate and viable by a greater proportion of the population
  - is decreasing in real cost over time

Therefore, what we have done in Sri Lanka is to establish a manufacturing facility and a distribution and marketing network to effectively promote the use of solar PV for domestic rural applications. Please refer to Appendix I, titled "Sri Lanka: The Rural Electrification Problem", for an insight into why solar PV must play a role in the country's rural electrification program. This document was prepared for the Ministers of Power & Energy and Housing & Construction and the Secretary to the Ministry of Finance in March 1991. Appendix II, titled "Photovoltaics, Entrepreneurship and the Developing World: An Insight into the Establishment of a Solar Energy Industry in Sri Lanka"' for a description of the background of our company, Power & Sun (Pvt) Limited. This paper was initially presented in June 1988, in Ottawa, Canada, at the Solar Energy Society of Canada's annual conference and was subsequently updated in October 1990.

The Barriers Encountered to the Use and Popularization of Solar PV

Appendix III, titled, "Excerpts from the Market Study Commissioned by The National Development Bank and Executed by Kenneth Abeywickrama Associates, January 1991", will give the reader an objective description of what Power & Sun has achieved during the past 3 years, since it launched its "Suntec" brand solar electric systems. It further goes into the details of why solar PV is valid for Sri Lanka, describes who has been purchasing solar PV and provides an overview of the marketing problems faced by the solar PV industry.

The barriers to making solar PV a significant contributor to Sri Lanka's energy mix can be listed as follows:

1) Lack of a Clear Electrification Policy: The Ministry of Power and Energy has not clearly demarcated areas which will and will not get electricity from the national grid. The result is that politicians and the general population believe that, in the foreseeable future, the entire country will be connected to the grid. Naturally, this is a serious hindrance to the acceptance of solar PV. Many have been the occasions we have gone into areas which have no reasonable chance of ever getting electricity to have all our work undone by politicians promising electricity at election times. Needless to say, the electricity never comes and the people are without solar - which they would have bought in the absence of the politician's promise - and without grid power.

2) Lack of Awareness of Why Decentralized Power Sources Are Needed: While we have made great strides in raising the general public's awareness of solar PV, we still have some way to go before we can say the same about government officials. As long as they believe electricity means grid power - and that it can be extended any and everywhere - they will not actively promote solar PV. Though we have started to get the message across that as much as 40% to 50% of the country's households can never get electricity from the grid (according to Prof. K.K.Y.W. Perera, May 1989, then-Secretary to the Ministry of Power & Energy and then-Chairman of the Ceylon Electricity Board), the message is best conveyed by a party other than ourselves. Electricity supply from the grid is a potent political promise which is rarely fulfilled and effectively blocks the acceptance of an alternative like solar PV. Our goal is to point out to officials and politicians that their promises can be kept - provided solar PV is used.

3) Lack of Effective Government and Institutional Support for the Use of an Alternative Source of Power Such as Solar PV: This, of course, is a direct result of the two points raised above. The solving of these should effectively remove this impediment.

4) Lack of Effective Consumer Finance Schemes: An effective user finance scheme is sorely lacking. Such a finance scheme will go a long way towards facilitating the development of solar PV because:
   :: It will make solar PV more affordable to a greater proportion of the population
   :: It will help minimize the financial risk as perceived by the use of investing in a new approach to obtaining electricity.

Though we have lobbied for and have successfully seen the establishment of many finance schemes (please refer to Appendix IV for details of three of them) none have proved to be effective. The main reasons for this have been apathy and lack of support at the branch-level within the financial institutions, and lack of clear government support.

5) Lack of Development Funds to Finance Companies Involved In Promoting Solar PV: Our company has incurred substantial development-related costs. These have had to be borne by the company, though it has been under pressure from the start to operate as a commercially viable business. While we have little doubt that providing solar PV to a country with 2.5 million unelectrified houses will prove to be a lucrative business soon enough, concessionary funding that recognizes the value of developing alternative energy industries should be available during the development period. Having had to shoulder all its development costs has placed a severe strain on our company's resources, to the point that Power & Sun's effectiveness has sometimes been impaired.

How the Above Barriers Can Be Removed

Firstly, the government must formulate a clear electrification policy which, in recognizing that not all villages and rural homes can be electrified using grid power, clearly demarcates areas which will not be supplied with electricity through grid extension. To serve these areas, the policy should specifically state the role solar PV is to play. International funding agencies can assist by providing the funds required for the studies necessary to formulate policy.

Secondly, a focussed education campaign is required to enlighten officials and politicians that decentralized power sources, such as solar PV, are the only effective and viable means of supplying electricity to rural areas - particularly for domestic applications.

Thirdly, the government must actively support and encourage the use of specific alternative power sources. It is a fact that, no matter how many unkept promises have been made, the government remains the most credible voice in the area of electricity supply. Tax incentives could also prove to be an effective way to encourage the use of solar PV.

Fourthly, an effective consumer finance scheme must be established. It has been our experience that using existing financial institutions to implement such loan schemes have not been effective. Hence our recommendation is to establish a financial institution or co-operative dedicated to the specific activity of financing solar PV users. Ideally, the interest rates should be as low as possible and the pay back period at least seven years.

Finally, a fund should be established to finance the development costs of companies engaged in establishing alternative energy industries. Not only will this attract more companies into this sphere of activity, but it will also lower the cost of energy to the end user.

Conclusion

Though a lot has been done in Sri Lanka to ensure the development of solar PV as an important contributor to the country's energy mix, more needs to be done. International funding bodies, such as the World Bank, USAID and the ADB, can play an important role in eliminating the remaining barriers by:

1) Funding studies to determine a clear and specific energy policy that recognizes explicitly the role alternative energies can play.

2) Provide funds for an educational/promotional series of seminars and workshops to communicate to all relevant government officials and politicians:
   * the importance of alternative energies
   * which of these power sources are available for use immediately
   * how they can encourage and support the use of such energy sources.

3) Provide funding for, and help establish, a dedicated financial institution or co-operation to fund the purchase of alternative energy systems by potential users.

4) Making monies available to private enterprise to fund the development costs associated with entering and developing alternative energy industries.

What is important to note is that all of the above should be done as a comprehensive approach to successfully encouraging the use of alternative energies. Anything less, we feel, would seriously impair the overall effectiveness of the end result. It is encouraging to see the World Bank and other important funding institutions taking such a serious look at alternative energies for the developing world. We can now look forward hopefully to the removal of the last barriers to the successful acceptance of alternative energies into the mainstream.

By Priyantha Wijesooriya
SOLANKA ASSOC.

SOLAR PHOTOVOLTAICS

COST COMPARISON AGAINST FINANCIAL INCENTIVES FOR CONVENTIONAL & LARGER POWER PLANTS.

CONVENTIONAL POWER SOURCES	SOLAR PV
DIRECT STATE INVOLVEMENT IN POWER PLANT CONSTRUCTION FOR HYDRO POWER, COAL POWER PLANTS.	SUCH INVOLVEMENT REMAINS TO BE SEEN
POWER PLANT COSTS (LINE OF CREDIT) NEGOTIATED AT SOFT LOAN LEVELS USUALLY BETWEEN ABOUT 4%	SOLAR MARKET IS FORCED TO OPERATE AT MARKET RATES AT ABOUT 21%
REPAYMENT PERIODS FOR HYDRO & OTHER MACRO-SCALE PROJECTS VERY FLEXIBLE, PERHAPS ABOUT 30 YEARS TO REPAYMENT TERMS	SOLAR MARKET IS FORCED TO OPERATE UNDER MARKET TERMS AND TIME PERIODS. (MAXIMUM PERIOD 5 YEARS).
COST OF LINE EXTENSION USUALLY BORNE BY CEB, HENCE ON FUNDING AGENCY FOR RURAL ELECTRIFICATION AT $ 10,000/KM (REF:WORLD BANK)	CAPITAL COSTS ARE A PRIMARY CONCERN TO THE END USER WITH NO SUCH PARALLEL SUBSIDY

By Priyantha Wijesooriya
SOLANKA ASSOC.

SOLAR PHOTOVOLTAICS

COST COMPARISON AGAINST FINANCIAL INCENTIVES FOR CONVENTIONAL & LARGER POWER PLANTS.

CONVENTIONAL POWER SOURCES	SOLAR PV
FAR-REACHING BOI INCENTIVES OFFERED FOR INFRASTRUCTURE DEVELOPMENT THRU POWER PROJECTS OVER $ 25 MILLION IN VALUE	SMALLER & SOLAR PROJECTS YET TO BE OFFICIALLY RECOMMENDED FOR SUCH INCENTIVES (ALTHOUGH THIS ASPECT MAY BE CHANGING).
BANK FACILITIES ARE ARRANGED FOR CUSTOMERS TO GET EASY GRID-CONNECTION DUE TO STATE PATRONAGE AT 16% LENDING RATES ONWARDS.	BANKS ARE RELUCTANT TO FUND SOLAR PROGRAMS DUE TO LACK OF ENERGY POLICY RECOGNITION
FOR ALL IMPORTED GENERATING EQUIPMENT THERE IS USUALLY LITTLE CONCERN OF IMPORT DUTY, BY VIRTUE OF GOVERNMENT INVOLVEMENT	FOR SOLAR PANELS, DUTY IS 35% CIF, SOLAR CELLS 15% + TT
CONVENTIONAL POWER SOURCES ARE USUALLY EVALUATED AT LOW DISCOUNTING FACTORS WHICH HIDES THE REAL COSTS RELATED TO FUTURE, ENVIRONMENT, ETC.	SOLAR ECONOMY IS EVALUATED IN REAL COSTS BUT .THIS PLACES SOLAR AS A, NON-VIABLE OPTION

WIND ENERGY FOR BATTERY CHARGING

Introduction

Sri Lanka like most of the developing countries is facing an acute energy crisis. Sri lanka has a rural population of about 80%. In most of rural areas, agriculture is the principal source of income and employment. Animal & human muscle power are used mainly in agriculture & transportation activities & this could not sustain an adequate development in the rural sector to increase productivity.

Electricity is generated in Sri lanka mainly by using hydro power resourses (79%). But due to increasing demand in the future we need to find a suitable renewable energy to overcome this.

The most of rural villages are located away from the main transmission line & the supply of electricity to these areas involves a lot of capital investment. Therefore research and development activities need to be carried out to seek a suitable energy source & application of wind energy.

Activities Of NERD Centre

At present the activities in wind energy at NERD Centre concentrates on horizontal axis high speed types of wind turbines. Presently the centre operates a battery charging generator, driven by two bladed propeller type wind mills.

Due to non availability of accurate measuring instruments for wind data NERD Centre could not carry out proper wind speed measurements in Sri Lanka. However we carried out measurements of wind speed in Mahakandarava at Anuradapura district at 60ft above the ground level for few months before installation of wind generator, with the available mechanical wind chard recorder.

The wind generator installed at Mahakandarawa is working satisfactorily & charging four batteries per day as they have sufficient wind.

With the 60ft tower a wind generator of 100 watts costs Rs 45,000/= with stay supported tower, & with a 60ft tower a wind generator costs Rs 55,000/=. However the cost can be reduced for lower height of steel towers and with the use of concrete lamp posts or wooden poles.

100 WATTS WIND GENERATOR UNIT.

Specifications

Rotor :- 2.3 metre diameter, Horizontal Axis, with aerodynamically designed blades. The carved wooden blade is later fully covered with a fibre glass coating, the surface is smoothed with water sandpaper and painted to give weather protection.

Generator ;- Commercially available/NERD Centre manufactured 100 watts generator capable of charging two 12 volts, 45 amp batteries at a time.

The generator is a direct drive, permanent magnet, low speed, three phase generator. The rated power of the unit is 100 watts at rotor speed of 500 r.p.m. This generator develops a voltage of 12/24 volts for charging one or more batteries at a time. Battery charging starts at a very low speed as low as 150 rpm and charging current increases with the increase of wind speed. As the generator is very robust on its construction it needs very less maintenance. This generator unit is suitable for use in individual households or more houses for lighting purposes.

Cut-in wind speed :- 3 metre per second

Rated wind speed :- 6 metre per second

Control :- Counter weighted rotor with a tilting or turning mechanism which takes the rotor into a different plane and stall the wind mill at high winds speed. Stalling usually occurs at wind speeds above 10 metre per second.

Weight of the wind mill unit :- Turning Arrangement.

Approximately 85 Kgs. including 0.95 metre stub tower of 82 mm diameter G.I.pipe

Tilting arrangement.

Approximately 66 Kgs. including 0.95 metre stub tower of 82 mm G.I.pipe.

Tower :- It could be either a 10 metre standard concrete post or a steel fabrication for higher elevations. Depending on the wind speed the height of the steel tower can be varied. The stay supported steel tower is strenghened by guy wires which are fitted at 20,40 and 50 feet elevations of the tower. The guy wires are anchored to the ground at three locations 10.5 metre away from the tower. The tower is galvanised for prevention of corrosion.

Mode of operation :- Wind mill rotor is directly connected to the 100 watts generator, and the supply lines from the generator is connected to the battery via a control unit.

Advantages :- There is no fuel cost involved, maintenance cost is low and has reliable operation. One person trained on the system can look after it.

Experience in the field

NERD Centre itself has in operation two 100 watts wind generators at its premises. Field trials have been were carried-out for wind generators of 25 watts, 50 watts and 250 watts, up to now.

NERD Centre is having an experience of 10 years in the field of wind energy. Due to non avalibility of training facilities in countries which utilize the wind power on a large scale, we could not do much development of wind mills for higher capacities.

Wind Mill compressed air pump

NERD Centre developed a compressed air water pump to pump water to higher elevations. Wind mill rotor is directly connected to the reciprocating two cylinder 1 HP air compressor and the compressed air is piped to the well, where it is connected to the pneumatic pump unit via a sliding mechanism The pump unit mainly consists of a cylinder fabricated with sheet metal of gauge 20 epoxy coated or fibre glass, two foot valves and a two way sliding valve. This is operated using compressed air which replace water (pumping unit) in the immersed cylinder. Presently we are carrying out improvements of this unit before commercialization.

Presented by :-T.A.Wickramasinghe
Head/Department of Machine Development & Fabrication,
National Engineering Research & Development Centre of Sri Lanka,
Industrial Estate, Ekala, Ja-Ela.

ENERGY SERVICES DELIVERY PROJECT

D G D C Wijeratna
Additional General Manger (Planning)
Ceylon Electricity Board

(Notes for a short talk given at theConsultative Meeting on Renewable and Alternate Energy Sources and Applications relevant to Sri Lanka held at the Naresa Auditorium on May 19, 1995)

Background

Nature has not endowed Sri Lanka with fossil fuels or nuclear resources. However, it is blessed with a modest amount of hydro power, abundant sunshine, moderate winds and adequate biomass.

Rising international energy prices prompted CEB to investigate alternative energy sources. It set up the Alternative Energy Demonstration Centre in 1976 for this purpose.

Less than 40% of the country's households are provided with electricity. It was realized early this decade that extending the grid to the remaining 60% is not the least cost method of providing their energy needs. A decision was therefore taken to provide 20% of the households with renewable technologies. ESDP is the first project designed to achieve this above objective.

The project concept

Renewable based energy services delivery is a PRE-ELECTRIFICATION process and is a precursor to rural electrification.

Renewable energy costs are high and thus can only meet the high value energy service needs such as lighting and entertainment. However, a market niche exists for such needs.

The project should be commercially viable. In other words, no subsidies. However, credit will be given for environmental benefits.

Implementation will be by the private sector.

Funds will be provided to the private sector developers at reasonable costs.

Project Components

The project includes the following renewable components:

Solar home systems - off-grid
Pilot wind plant - grid-connected
Mini and micro hydro - grid-connected and off-grid
Biomass power plants - grid connected

Solar

Solar component is the provision of 10,000 solar home systems. These are stand-alone systems and not grid connected. It is expected that Energy Service companies (ESCOs) will deliver these systems, though direct sales to consumers are not precluded. CEB will offer its services to ESCOs as consultnats.

Hydro

Grid connected: Private developers will be able to obtain loans. CEB will carry out feasibility studies free of charge for MHPs of capacity less than 500 kW. CEB is preparing a power purchase agreement (PPA), a transparent tariff, and a grid connection standard. These will be completed in about three months time. These steps should help to create an enabling environment for private sector participation.

Off-grid: These are MHPs that will provide energy for basic needs of remote rural communities. Implementation will be by ESCOs. CEB will provide consultancy services.

Wind

Grid-connected: CEB studies indicate that the wind energy costs are still too high to be commercially viable. However, it is expected that the costs will come down to make the technology viable around the year 2000. CEB will therefore construct a pilot plant of capacity 3 MW at Bundala. However, funds will be available to any developer with a commercially viable project.

Off-grid: Off-grid applications have not been very successful in the past. Each proposal will be evaluated on its own merit.

Biomass

Grid-connected: So far there has been no proposals for a stand-alone woodfuel power plant. A feasibility study is underway on a cogeneration plant. Preliminary indications are satisfactory. If the project is viable, it will be eligible for funding. Tea and sugar-milling industries show most promise.

Project Cost

The estimated cost of the project is US$ 40 Million. It will be funded as follows:

US$ 30 Million - IDA Credit
US$ 10 Million - GEF Grant

Loans from the fund

The funds will be disbursed to the developers through a window in the proposed Private Sector Infrastructure Development Fund.

Private sector developers, Manufacturers of equipment, Energy Service companies (ESCOs) etc. will be eligible for loans.

Loans will be granted only to commercially viable projects. The developers will have to prepare comprehensive feasibility reports establishing not only the technical feasibility but also the financial viability of the project. The exact amount of the loan as a percentage of the project cost has not yet been decided, but expected to be not less than 50%. Environmental benefits will have to be clearly shown to qualify for the grant component; it will be about 20% of the loan amount.

FUEL WOOD BASED TEA FACTORY DUAL POWER GENERATION PROJECT

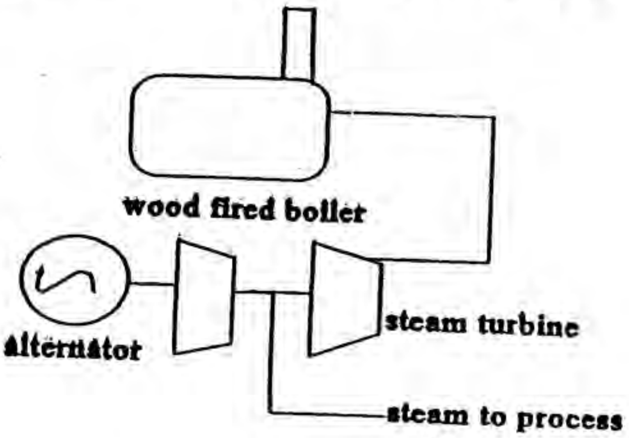
by

Nallin Walpita
P.S.P.S. de Saram

: PROJECT DESCRIPTION & JUSTIFICATION

Title of Project : FUELWOOD BASED COGENERATION PROJECT AT POONAGALLA

Poonagalla group (inclusive surrounding estates)	
Total availability of Eucalyptus	- 70,000 m3 over 7 years
Size of power plant envisaged	- 450 KW
Wood consumption per year	- 4000 Tonnes (approx 6600 m3)
Technology employed	- Wood chip fired power boiler with extraction condensing turbine.
Electric Power	- to factory and to grid
Steam	- to factory
Employment in plantation	- 100 labour full time per year
Employment in power station	- 20 unskilled labour per year



Special features of project: Commercial BOT ie handing over of plant to estate company after number of years.

Growing one extra tree for every five harvested/ coppiced, thereby achieving a nett increase in biomass stock.

OBJECTIVES OF THE PROJECT :

1. To prove the concept of a fuelwood based wood fired power generating station

2. Determine minimum land area required for generation of 500 KW, 1000 KW of power.

3. To determine actual labour absorption in growing, harvesting and utilising fuelwood in plantations for power generation and project the national impact.

4. To project national impact on electricity supply and employment of using plantations as platform for fuelwood based power generation.

5. To create an avenue for improving the economic viability of marginal and under utilised tea lands.

6. To create an avenue for diversification of income, especially in tea lands, with attendant benefits to both estate companies and workers.

7. To create added rural employment by possibly introducing a "nucleus - outgrower" system whereby smallholders supply fuelwood to central small power stations

8. To reduce Cost of Manufacture in tea factories

9. To determine sustainability, long term productivity and environmental impact of rotated fuelwood plantation immediately, without the need first to raise plantation

BENEFITS :

GROSS ANNUAL INCOME FROM ELECTRICITY SALES	-	Rs 10.7 million/year
GROSS ANNUAL INCOME IF FIREWOOD SOLD DIRECTLY	-	Rs 2.67 million/year

RATION CREATED VALUE DUE TO HIGHER VALUE PRODUCT 4:1

COSTS :

PLANT & EQUIPMENT COST : US $ 1260 per KW installed

= Rs 31 million

FUNDING :

TOTAL PROJECT COST	:	RS 31 MILLION
FUNDING ALREADY COMMITTED FROM LOCAL EQUITY INVESTORS	:	RS 10 MILLION
COMMERCIAL LOANS	:	RS 15 MILLION

ADDITIONAL FUNDING REQUIREMENT -

PREFERABLY GRANT MONEYS : RS 6 MILLION

PROJECT FORMAT

1. Project Title:-

   Hydro Power for Battery Charging

2. Proposed Location:-

   Micro hydro sites, Head range 10-40 ft flow range- 3.5-7 litres/sec, not within the reach of national grid.

3. **Project Description:-**

   Energy is extracted from water which flows through a penstock of a turbine to drive a three phase permanent magnet generator of 100 watts. The generator is directly coupled to the turbine. When the generator is in operation it produces alternating current which is converted to direct current for charging of automotive batteries. Depending on the avalability of head, two or more batteries can be charged per day. These batteries could be used for domestic lighting.
   Benificiaries:- Rural sector population
   Cost/Benifits:- Capital cost of the unit is Rs. 20000/=.
   There is no fuel cost involved. Maintenance cost is low. No envirnmental pollution and reliable operation of the unit.

4. **Status of the project:-**

   Lab testing of the unit is completed and the unit is now ready for field testing.

5. **Major issues confronted by the project:-**

   It is suggested to install few units in villages in rural areas as pilot plants and for that some funds are required.

6. Specific contributions/Assistance from the M/ST & HRD for project realization:-

Assistance is needed in popularization.

National Engineering Research & Development Centre of Sri Lanka,
2P/17B, Industrial Estate, Ekala,
Ja-Ela

Project Format

1. Project Title: Five Village Micro Hydro projects chosen for implementation
by - Lahiru Perera

2. Proposed locations:

1. Mugunamulla in Kotapola

A very active society had been formed to implement the project. A stream called *Kiriwana Ganaga* flows through the village which is suggested for harnessing. The society has already started necessary groundwork for the project. The society is planning to use the micro hydro power for processing dairy products, rice milling, etc. during day time. . Distance to the CEB grid from the village is four miles.

Expected electrical power output	24kW
Total project cost	Rs *2,324,500.00*

2. Panakaduwa in Pasgoda

An electricity consumers society exists in the village. Tea, paddy, cinnamon and few other cash crops are cultivated in the village and the majority of the villagers are tea small holders. A stream flows through the village which is a tributary of *Nilwala Ganga*. This can be used to generate micro hydro power which will be sufficient for the entire village. . CEB grid is four miles away from the village.

Expected electrical power output	25kW
Total project cost	Rs *3,088,000.00*

3. Meemure in Kandy district

The village is situated about 22 miles away from the Hunnasgiriya turn off. The village is a fairly isolated one and includes five *vassams*. One of the streams which flows through the village is *Heen Ganga*, a tributary of the *Mahaweli*, which suggested to be tapped.

Expected electrical power output	25kW
Total project cost (with local turbine)	Rs *3,342,680.00*

4. Matigahatanne in Passara

The village is situated very interior and is therefore fairly isolated. An electricity consumers society exists in the village. There are 100 households in the village and a battery charging centre for the non beneficiaries is proposed. A stream called *Agale Oya* flows through the village which is proposed to be harnessed to generate micro hydro power. Distance to the CEB grid is about two miles from the village.

Expected electrical power output	2kW
Total project cost	Rs *257,700.00*

5. Ambagahakumbura in Gilimale, Ratnapura

Majority of the villagers are tea small holders and farmers. CEB grid is about 1Km away from the village. It is also proposed to build a battery charging centre for the benefit of the non direct beneficiaries.

Expected electrical power output	1.5kW
Total project cost	Rs *167,210.00*

3. *Project Description:*

- Energy Source: Micro Hydro power
- Technology Used: Locally manufactured turbines and electro mechanical equipment
- Applications: Mainly domestic lighting
  Other end uses, Battery charging, Rice hulling, small scale cottage industries using micro hydro power
- Beneficiaries: 445 households expected to be electrified in total
- Cost/benefits: Total Project cost: ***Rs 9,180,090.00***
  Beneficiaries will save on kerosene
  Non beneficiaries will be benefited by the battery charging centres and other end user projects implemented with the schemes.

4. *Status of the project:*
Project feasibility studies are completed and are awaiting financial assistance

5. *Major issues/obstacles encountered in the implementation of the project:*
   - Government and other lending organisations not recognising the need to extend credit facilities to village societies/hydro developers for the implementation.
   - No proper process to obtain authorisation from local authorities for the utilisation of resources
   - Nonavailability of appropriate policies, standards, methods and regulations governing power transmission, wiring and the harnessing of water
   - Inappropriate import duties
   - Nonavailability of incentives to implement renewable energy projects in the same way that rural development, grid electricity and kerosene are subsidised
   - Non acceptance of decentralised power supplies
   - Price Regulations for Grid Connections.

6. *Assistance expected from the M/ST & HRD for project realisation:*
Financial assistance (part funding) required to implement the projects (detail project proposals could be submitted)

PROJECT TITLE : Manufacture of Solar Therm Solar water heaters in Sri Lanka.
by - Solar Therm Co

PROJECT LOCATION : Factory: Industrial Estate Ekala, Ja-Ela

OFFICE : 47 Church Road , Kandana.

SOURCE OF ENERGY: Solar Therm solar water heating systems use freely available sunlight as the source of energy for water heating purposes. Solar therm is ideally suited for a country blessed with bright sunshine throughout the year. Use of Solar technology which can be defined as one of the cleanest technologies can bring down the ever increasing energy bills spent for water heating purposes.

TECHNOLOGY:Solar therm solar heaters were initially developed by the National Engineering Research and development Centre (NERD) of Sri Lanka. We were selected as the sole licenced manufacturer based on our experience and interest on the product. We on our own were working on a solar water heater. Once we joined hands with Nerd Centre we had the access to the sophisticated test equipment, and the services of the solar energy dept, which helped us in a big way to manufacture and market a product which could compete with any of the Imported Solar water heaters in the market.
I spent 2 weeks at the Solar energy Dept of Korean institute of energy Resources which also helped us to upgrade the quality of this product We also had the services of consultants from the common wealth secretariat who gave us valuable advice based on their long experience in the industry. We also obtained the pioneering industry status from the Ministry of Industries

APPLICATIONS: Solar therm solar waters are available in a wide range capacities to suit various income groups and requirments. The market varies from sick and elderly people who need hot water as a basic need to Hotels Guest houses, hospitals and the industry where hot water is used as Preheated water for boilers . Hot water on tap which had been a luxury has become affordable to the average Sri Lankan household. We have sold over 1500 units in Sri lanka, and a few in the resorts in the Maldives Our 10 year old units are still functioning , and the recommendations given by them has helped us in a big way . most of our early customers have bought many more units for their children, and other projects where they are involved. For the first time after we started this project our contribution to the industry has been recognized, and we received a merit award at the Entrepeuner of the year 94 contest.

STATUS OF THE PROJECT: We are in the process of upgrading the manufacturing process. We wold like to request assistance in obtaining imported raw materials at concessional duty rate. We also will have to import some machinery to increase the production capacity for which also we request the same concessions. If this assistance is given we will be in a position to offer a solar heating system affordable to more people.

We also wish to bring to your notice of the facilities available in other countries to the users of solar water heaters and other energy saving equipment, such as loans to purchase these items at low interest rate sand offer them low electricity tarriff rates.

Project Format

1. *Project Title :* Rural and Domestic Irrigation System

2. *Proposed location : (if applicable)* Anuradhapura, Hambantota, Puttalam, Chilaw, Kurunegala

3. *Project description :* Please see page 88

   - *Energy source :*
   - *Technology used :*
   - *Applications :*
   - *Beneficiaries :*
   - *Cost/benefits :*

4. *Status of the project :*

5. *Major issues confronted by the project.*

   - *A description of obstacles encountered in the implementation of the project.*

6. *Specific contributions / assistance expected from the M/ST & HRD for project realisation.*

Wind Pump

Model	: Niva 3000
Rotor	: 3 MD
Height	: 7.5 m
Total Heal	: 25 + 10 up to 15
Capacity	: 10,000 ht to 15,000 al per day
Capability	: Multi crops 2 acres in the dry zone
Wind Mill Pipe	: Rs.35,000/=
	Export Quality - Rs.45,000/=
Guarantee	: Free service one year after sales service
Experience	: More than 12 years in the field

PROJECT FORMAT

1. Project Title:-

   Wind Energy for Battery Charging

2. Proposed Location:-

   Rural areas and coastal areas, where prolonged wind speeds of over 3 metre per second is available.

3. **Project Description:-**

   Energy is extracted from the wind to drive a three phase permanent magnet generator of 100 watts. The generator is directly coupled to the wind mill rotor and mounted on a tower, erected on suitable location. When the generator is in operation it produces alternating current and which is converted to direct current for charging of automotive batteries. Depending of availability of wind two or more batteries can be charged per day. These battries could be used for domestic lighting, operation of televisions and radios.

   Benificiaries:- Rural sector populaton

   Cost/benifits:- Capital cost of the unit is Rs. 45000/= for stay supported steel tower of 60 feet and Rs. 55000/= for self supported steel tower of same height. However the cost can be reduced for lower height of steel towers and with the use of concrete lamp posts or wooden poles.

   The advantages of the unit are, There is no fuel cost involved. Maintenance cost is low. No envirnmental pollution and reliable operation. One person trained on the system can look after it. Can provide employment for a few.

4. Status of the project:

Field trails were completed and technology available for commercialization.

The NERD Centre itself has two 100 watts wind generators and have been in successful operation for a period of over eight years. A wind generator of 100 watts erected at Mahakandarawa in Anuradhapura district also in suceessful opration for several years.

5. Major issues confronted by the project:-

Due to high capital investment, popularization of the wind generator is found to be difficult.

6. Specific contributions/Assistance from the M/ST & HRD for project realization

Assistance is needed for popularization in rural areas.

National Engineering Research & Development Centre of Sri Lanka,
ZP/17B, Industrial Estate,
Ekala, Ja- Ela

List of Resource Persons, Rapporteurs and Group Leaders

Resource Persons :

1.	Mr D C Wijeratne	Ceylon Electricity Board
2.	Mr Shavi Fernando	Ceylon Electricity Board
3.	Dr Nalin Walpita	
4.	Dr Ray Wijewardena	
5.	Mr Victor Mendis	NERD Center
6.	Mr Athula Jayamanne	- do -
7.	Mr Adikarinayake	- do -
8.	Mr Wickremasinghe	- do -
9.	Mr G K Upawansa	Hyneford, Nawalapitiya
10.	Mr Lalith Guneratne	Solar Power and Light Co Ltd
11.	Mr Priyantha Wijesooriya	
12.	Mr Lahiru Perera	Intermediate Technology Development Group

Rapporteurs :

1.	Mr Shavi Fernando	-	Wind Energy
2.	Dr Nalin Walpita	-	Biomass
3.	Dr Priyantha Wijetunga	-	Small Hydro Power
4.	Mr L Taldena	-	Solar Energy

Group Leaders :

1.	Mr Shavi Fernando	-	Wind Energy
2.	Dr Ray Wijewardene	-	Biomass
3.	Mr Lahiru Perera	-	Small Hydro Power
4.	Mr Lalith Guneratna	-	Solar Energy

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