Sri Lanka

Renewable Energy Report

Prepared for

APCTT

Asian and Pacific Centre for Transfer of Technology of the United Nations – Economic and Social Commission for Asia and the Pacific (ESCAP)

By

Gamini Senanayake

June 2009

Renewable Energy Cooperation-Network for the Asia Pacific

An Initiative of the
Asian and Pacific Center for Transfer of Technology (APCTT)

UNITED NATIONS ESCAP
Economic and Social Commission for Asia and the Pacific

Disclaimer

The views expressed in this report are those of the author and do not necessarily reflect the views of the Secretariat of the United Nations Economic and Social Commission for Asia and the Pacific. The report is currently being updated and revised. The information presented in this report has not been formally edited.

The description and classification of countries and territories used, and the arrangements of the material, do not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country, territory, city or area, of its authorities, concerning the delineation of its frontiers or boundaries, or regarding its economic system or degree of development. Designations such as ‘developed’, ‘industrialised’ and ‘developing’ are intended for convenience and do not necessarily express a judgement about the stage reached by a particular country or area in the development process. Mention of firm names, commercial products and/or technologies does not imply the endorsement of the United Nations Economic and Social Commission for Asia and the Pacific.

LIST OF ABBREVIATIONS

APCTT	-	Asia Pacific Centre for Technology Transfer
ARECOP	-	Asian Region Cookstove Programme
AU	-	Administrative Unit
AWDR	-	Average Weighted Deposit Rate
AWPLR	-	Average Weighted Prime Lending Rate
BEASL	-	Bio Energy Association of Sri Lanka
BOI	-	Board of Investment
CBC	-	Commercial Bank of Ceylon
CBO	-	Community Based Organization
CBSL	-	Central Bank of Sri Lanka
CDM	-	Clean Development Mechanism
CEA	-	Central Environmental Authority
CEB	-	Ceylon Electricity Board
CMA	-	Colombo Metropolitan Area
CP	-	Cleaner Production
DFCC	-	Development Finance Corporation of Ceylon
ECS	-	Electricity Consumer Society
E-FRIENDS	-	Environmentally Friendly Solutions Fund
ESC	-	Energy Supply Committee
ESCAP	-	Economic and Social Commission for Asia and the Pacific
ESCO	-	Energy Supply Company
ESD	-	Energy Service Delivery Project
FECS	-	Federation of Electrical Consumer Societies
FMO	-	The Netherlands Development Finance Company
GCMH	-	Grid-connected mini hydro
GDP	-	Gross Domestic Production
GEF	-	Global Environment Facility
GOs	-	Government Organizations
GOSL	-	Government of Sri Lanka
HNB	-	Hatton National Bank
IC	-	Internal Combustion
ICS	-	Improved Cook Stoves
IDA	-	International Development Association
IDB	-	Industrial Development Board
IDEA	-	Integrated Development Association
IFC	-	International Financial Corporation
IGC	-	Induction Generator Controller
INFORSE	-	International Network for Sustainable Energy
ITI	-	Industrial Technology Institute
JBIC	-	Japan Bank of International Cooperation
kTOE	-	Kilo Ton of Oil Equivalent
LECO	-	Lanka Electric Company
LGL	-	Lanka Gasifiers Pvt Ltd
LTGEP	-	Long Term Generation Expansion Plan
LTNCREP	-	Long-term Non-conventional Renewable Energy Plan
NARA	-	National Aquatic Resources Research & Development Agency
NCRE	-	Non-conventional Renewable Energy
NDB	-	National Development Bank
NERDC	-	National Engineering Research & Development Centre
NGOs	-	Non-governmental organizations
NREL	-	National Renewable Energy Laboratory
O&M	-	Operation & Maintenance

OGVH	-	Off-grid electrification infrastructure through village hydro
p.a.	-	Per annum
PCIs	-	Participating Credit Institutions
PEP	-	Promotion of Eco-efficient Productivity
PUCSL	-	Public Utilities Commission of Sri Lanka
RE	-	Renewable Energy
RERBEG	-	Renewable Resource Based Electricity Generation
RERED-AF	-	RERED Additional Finance
REREDP	-	Renewable Energy for Rural Economic Development Project
RESB	-	Renewable Energy Support Bond
RET	-	Renewable Energy Technology
SAEMS	-	South Asia Energy Management Systems Inc.
SARI	-	South Asian Regional Initiative for Energy
SEEDS	-	Sarvodaya Economic Enterprises Development Services
SHP		Small Hydro Power Projects
SHS	-	Solar Home Systems
SLBDC	-	Sri Lanka Business Development Centre
SLSEA	-	Sri Lanka Sustainable Energy Authority
SPP	-	Small Power Producers
SPPAs	-	Small Power Purchase Agreements
SRC	-	Short Rotation Coppice
TBill	-	Treasury Bill
TBond	-	Treasury Bond
TERI	-	The Energy and Resources Institute
UAFF	-	Up-flow Anaerobic Floating Filter
USAID	-	United State Agency for International Development
USD	-	United State Dollars
WCO	-	Waste Cooking Oil
Wp	-	Watt peak power

TABLE OF CONTENTS

PRELIMINARIES

Chapter 1
INTRODUCTION

Chapter 2
RENEWABLE ENERGY MARKET & INDUSTRIES

Chapter 3
LEADING R&D ORGANIZATONS IN RENEWABLE ENERGY

Chapter 4
INSTITUTIONAL INFRASTRUCTURE & INCENTIVES AVAILABLE

Chapter 5
POLICIES FOR THE PROMOTION, UTILIZATION & DEVELOPMENT OF RETs.

Chapter 6
FINANCIAL INSTITUTIONS SUPPORTING RE PROJECTS & THEIR CURRENT STATUS

Chapter 7
SCOPE FOR UTILIZING RENEWABLE ENERGY

Chapter 8
INDIGENOUSLY DEVELOPED RETs.

Chapter 9
CASE STUDIES ON DISSEMINATION, UTILIZATION & TRANSFER OF RETs

Chapter 10
BARRIERS FOR TRANSFERRING RETs

Chapter 11
STRATEGIES FOR FUTURE DEVELOPMENT OF RENEWABLE ENERGY

Chapter 12
CONCLUSION

ANNEXES

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENT

I wish to extend my profound gratitude to National Engineering Research & Development Centre (NERD Centre) of Sri Lanka and particularly its Chairman, Mr. D.B.J. Rantunga and Managing Director, Mr. M.W. Leelaratne for nominating me for this task. I also wish to express my sincere thanks to Dr. K. Ramanathan, Head of the Asian and Pacific Centre for Transfer of Technology (APCTT) and his assistant Ms. R. Saldanha for the trust and confidence placed in me by entrusting this task and thereafter for their very enthusiastic encouragement, assistance and excellent cooperation extended in performing this task. Last but not least, I express my sincere thanks to interviewees and all those who have readily provided me with information for the successful accomplishment of this task without which this would not have been a reality.

EXECUTIVE SUMMARY

Sri Lanka is a country blessed with sun, wind, rains and lush vegetation all year round and surrounded by the Indian Ocean. All these natural resources are testimony to the ample opportunities the country has to harness for energy needs.

Nearly 50% of the country's electricity generation is from renewable hydro resources, though its share is coming down as the large hydro power potential is being harnessed. The balance of the requirement is met by imported **fossil fuel** making Sri Lanka more vulnerable to external forces. The energy demand of Sri Lanka is on the increase for industrial and commercial uses as well as for rural electrification. It is undoubtedly a big challenge for every one, planners, policy makers and even the energy users. However, the share of electricity generation from non-conventional renewable energy resource is as low as 4%. The target is to achieve 10% by 2015.

It is estimated that more than 50 organizations with over 2,000 stakeholders are commercially involved in a rapidly growing renewable energy industry, which includes grid-connected, off-grid community and household based renewable energy systems.

Sri Lanka could boast of its profound success in promoting **SHS** for rural electrification which is quoted by many as unique. This is a typical case where public and private participation works very well. A conducive environment has been created with policy support, financing mechanisms, technological support, incentives, capacity building, etc. Sri Lanka could learn from this success and venture into more challenging but high potential renewable energy options such as Wind, Biomass and Solar to meet its growing energy needs.

Of the five main RE resources available in the country, the **market** for SHS could be treated as the most developed, next is Small Hydro Power followed by Biogas. The Wind market is the least developed. The Biomass market for power generation and thermal applications of industry and commercial sectors is also not developed despite its high potential.

Organizations engaged in **R&D** of RE could be broadly categorized into three sectors: State, Private and Non-government. NERD Centre in the State sector and Practical Action in the NGO sector are the most active players in this discipline. EnerFab and Lanka Gasifiers in the private sector are quite strong in demonstration of biomass technologies through their commercially oriented projects.

Institutions engaged in the sphere of RE in various capacities can be broadly categorized as "State" and "Non-state" based on their legal status. On the other hand, these organizations can be further categorized as "Regulators" having project approving powers, "Facilitators" having either facilitation and/or commercial interests and "Financiers" including credit providers and donors. Under this dual categorization, six types of organizations could be identified. **SLSEA** is positioned as the apex body with wider powers and has dual functions of both regulation and facilitation. All these organizations operate under a regulatory environment created by **PUCSL**. This multiplicity of organizations on one hand could be viewed as a blessing for the promotion and utilization of RE and on the other hand could be a hurdle especially at the time of project approvals due to bureaucratic hindrances.

Incentives for the promotion of RE can be broadly categorized as "Financial" and "Non-financial". Financial incentives are the outright grants, subsidies and loans available on concessionary terms. Provision of free services such as training and advisory services could be treated as non-financial incentives. All these forms of incentives are available or have been available for the promotion and utilization of RE options in Sri Lanka in varying degrees, at different times, in different regions for different target groups. In the early days, many NGOs such as **Practical Action** operating in this field offered grants for the developers as well as end users. Soft loans schemes such as **ESD**, **RERED** and even **E-FRIEND** consisted of grant components. Some **Provincials Councils** such as “Uva” and “Sabaragamuwa” offered financial incentives to offset the upfront cost of low-income end users of SHS and Village Hydro projects. Free services of State, NGO and even private sector are available mostly in the form of training and advisory services.

Sri Lanka now has a formal document on energy policy which came into effect in 2008. Though there is no specific policy yet on RE, Sri Lanka **National Energy Policy** has emphatically addressed the promotion, utilization and development of RE. Other policies such as Rural Electrification Policy, National Environmental Action Plan and Forestry Sector Master Plan have implications on policies applicable to RE in varying degrees. The latest addition is the introduction of “Net Metering” for electrical utilities in the country which allows customers who generate RE based electricity to get paid for it when it goes back into the grid.

A closer look at the Act of **SLSEA** reveals that much greater emphasis is placed on the promotion, utilization and development of RE with wide ranging powers for resource allocation, development, etc.

The **Funding** landscape of Sri Lanka in RE projects witnessed a dramatic change with the introduction of the ESD project which was operative from 1997 to 2002. With the tremendous success of ESD, the RERED project was launched in 2003 by broad basing the development objectives. At the end of the RERED project in 2007, an additional credit line was made available by the same funding organization for the extended phase of RERED project operative from 2008 to 2011. With the success of the above projects and with the valuable experience gained, the Commercial Bank of Ceylon has managed to tie up with IFC of World Bank for 50% risk sharing of RE projects. In addition to the above dedicated credit facilities, some RE projects (biomass based power generation) have benefited from other credit lines such as E-FRIENDS though it is not meant for the promotion of RE projects.

Based on Sri Lanka’s geographical positioning in terms of its tropical climate and natural terrain, Sri Lanka has a very high potential to draw on forms of RE sources. Endowed with a tropical climate, the potential for **Solar** energy is very high. The opportunities for producing localized **Hydropower** through pico, micro (village) and mini hydropower are also considerably high. In addition, the long coastal lines surrounding the island of Sri Lanka with several windy locations also provide tremendous scope for tapping **Wind** power.

A study carried out by DFCC Bank in 2007 under the RERED project, has estimated the potential from RETs in Sri Lanka by the year 2015 as follows; mini-hydro capacity will be increased up to 300 MW, biomass power generation up to 90 MW, wind capacity up to 50 MW and solar power generation up to 11.2 MW. Calculations on the national potential for **Dendro power** in Sri Lanka by BEASL have estimated this to be in excess of 4,000 MW annually generating over 24,000 GWh. Based on a very conservative assumption of 5 MW per Km^2 (including windy lagoons), Sri Lanka could accommodate around 24,000 MW capacity **Wind** power plants. Annual **Solar** resource in Sri Lanka ranges from 4.5 to 6.0 kWh/m2/day. A study on the potential of **Biogas** from biomass sources in Sri Lanka estimates a total power generation potential of 288 MW. **Biodiesel** is not yet produced on a commercial scale. The **Wave energy** potential of 1 meter off the southern coast of Sri Lanka is about 13 KW in January. It rises to 100 KW by May. The Ministry of Power and Energy estimates that stable electricity can be obtained at a plant factor of 67% using wave energy. With estimated currents of 3 m/s in the Palk Strait there may be opportunities to develop a **Tidal** stream.

Sri Lankan R&D organizations and some private companies have developed a number **RETs**. The majority of them are for the utilization of Biomass for domestic or rural applications.

Some private companies had successfully adopted gasifier technology for power generation and thermal applications to suit local conditions.

This report features 5 **case studies** of which 2 have been selected from the recently concluded PEP project. The **PEP** Project can claim the credit for encouraging and introducing **Dendro power** as a practically feasible alternative to the fossil fuel for the industry when financial institutions were reluctant to assist. The PEP Project was also directly responsible for introducing Dendro energy to the Sri Lankan **Ceramic Sector** which was placed in a back-to the-wall situation due the unprecedented escalation of fuel prices.

Often the result of **barriers** is to put RE at an economic, regulatory, or institutional disadvantage relative to other forms of energy supply. Many of these barriers could be considered “market distortions” that unfairly discriminate against RE, while others have the effect of increasing the costs of RE relative to the alternatives. All barriers could be broadly classified into 5 categories (Technical, Financial, Policy, Information and Institutional) and often they are not mutually exclusive.

Strategies have been suggested in this report to overcome the major barriers for the development and promotion of RE. Strategies suggested are of two types: (1) generic strategies that are valid for all renewable options (2) specific strategies applicable for a particular renewable option.

There are many shortcomings that ought to be overcome to get the best use of the abundance of RE resources. First and foremost is the technological base that needs to be consolidated. Technology has to be reliable and cost effective. Then the economics has got to be right for which there must be RE friendly credit facilities supplemented by prudent incentives. Capacity building at all levels is paramount to have a persistent and sustained effort. Above all what is crucial is the **national priority** assigned to the cause.

Chapter 1

INTRODUCTION

1.1 Introduction to the Report

This report provides an overview of the Renewable Energy (RE) sector of Sri Lanka as per the need of the Asian and Pacific Centre for Transfer of Technology (APCTT) to formulate a regional project for the development and promotion of Renewable Energy Technologies (RETs) through the sharing of member country experiences and collaborative projects.

Through this project, APCTT intends to develop an institutional cooperation mechanism to strengthen the capacity of countries in the Asia Pacific region to promote the adoption and utilization of RETs to meet their energy needs and foster sustainable development.

The methodology adopted in collection of information for the compilation of this report was mainly through the interviews of key organizations (Annex 2) involved in the promotion of RE and through secondary sources such as print and electronic publications (Annexes 1 and 3).

The report consists of 12 chapters and each chapter is devoted for one aspect. Some chapters are quite comprehensive while the rest needs further elaboration. The time factor was a constraint in achieving the desired comprehensiveness of all chapters.

At the beginning of each chapter, an overview of the aspect being dealt with is given followed by an elaboration depending on the information available.

1.2 Country Overview [53, 54]

Figure 1.1 – Map of Sri Lanka

Geography - Sri Lanka, an island in the Indian Ocean is located to the south of the Indian subcontinent, 880 km north of the equator. It lies between 5° 55' and 9° 55' north of the equator and between the eastern longitudes 79° 42' and 81° 52'. The total land area is 65,610 sq. km. including inland waters of 2,905 sq.km. A length of 445 km. and breadth of 225 km. encompasses tropical beaches, low land, mountains and vegetation. The island consists of a mountainous mass somewhat south of the centre, with a height exceeding 2,500 metres, surrounded by broad plains. The average temperature of tropical low lands is 27°C and in the central hills average temperature drops down to 14°C. The south-west monsoon brings rain to the western, southern and central regions from May to July, while the north-eastern monsoon occurs in the north and east in December and January. The annual average rainfall is around 2,000 mm and the number of rainy days per year is around 90.

Demography - The estimated population in 2008 was 20.217 million while the population density in 2008 was 322 persons per sq. km. Expectation of life at birth in 2006 was 68.2 years for males and 75.8 years for females. The average literacy rate in 2006 was 90.8 % (Male: 92.7 % and Female: 89.1 %). Households with electricity in 2008 were 83 % and the per capita electricity consumption was 416.4kWh.

Legislature - Sri Lanka is a free, independent and sovereign nation. Legislative power is exercised by a Parliament, elected by universal franchise on proportional representation basis. A President, who is also elected by the people, exercises executive power including defence. Sri Lanka enjoys a multi party system, and the people vote to elect a new government every six years.

1.3 Energy Overview

Sri Lanka is a country blessed with year around sun, wind, rains and lush vegetation and surrounded by the Indian Ocean. All these natural resources bear testimony to the ample opportunities the country has to harness for energy needs. In deed, Sri Lanka is a country of renewable energy having nearly 57% of primary energy derived from various sources of energy, mainly from biomass (47%). But the balance primary energy (43%) need is fulfilled by imported fossil fuel which makes the country very vulnerable to price fluctuations and escalations. This has been a major drain of scarce foreign reserves.

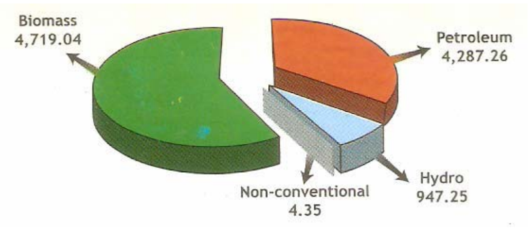


Figure 1.2 – Composition of Primary Energy
(**Source**: Sri Lanka Energy Balance 2007)

Energy requirements in Sri Lanka are satisfied by both locally available sources and those sourced from global energy markets. Biomass, hydro power, wind power and solar power are the four indigenous sources with a high potential for productive use in Sri Lanka, whereas petroleum and coal can be considered the two main sources readily available in the international market for importation. Biomass is the main source of energy, satisfying heating energy requirements in the country, particularly in the domestic sector. While hydro power has already been extensively developed for electricity generation, studies have indicated that there is a large potential for wind power development in the country. Studies are presently underway to establish the availability of offshore petroleum resources within the territorial waters of Sri Lanka [35].

Challenges faced by Sri Lanka's Energy Sector are many. While ensuring a continuous supply of electricity and petroleum products, the growing economy has to manage a strategic balance between indigenous energy resources and imported fossil fuels. As per 2008 data, 17% of Sri Lanka's population is yet to receive electricity supply for household needs. Commercial energy utilities are required to be further strengthened to improve their financial viability and service quality. The involvement of the country's population in the investment, operation, regulation, and delivery of energy services needs to be increased.

1.3.1 Energy Supply [35, 36]

At present, the total primary energy requirement of the country is met with biomass (48.3%), hydropower (11.3%) and imported petroleum (40.3%), while electricity remains the main secondary energy source. The total amount of electricity generated during 2006 was 9,498 GWh out of which 51 % was from oil burning thermal power plants while the balance 49%

was almost entirely from hydro power. The share of electricity generation from non-conventional sources remained very small.

Despite a reduction in petroleum consumption, the total energy demand in Sri Lanka (in terms of secondary energy) increased slightly during the year. The reducing trend of petroleum consumption which continued in 2006 has been largely brought about through increased hydro electricity and biomass usage. In 2006, electricity use increased by 8% while biomass saw an increase of 3%.

The transport sector accounted for 25% of the national energy demand, and the entire energy requirement of the transport sector was met through imported liquid petroleum. The industrial sector energy consumption share was 26% compared with the commercial and household sector share of 49%.

1.3.2 Energy Demand Growth

With the increasing demand for energy to provide for the country's economic and social development, the total primary energy demand is expected to increase to about 15,000 kTOE by the year 2020 at an average annual growth rate of about 3%. Electricity and petroleum sub-sectors are likely to record higher annual growth rates of about 7-8%. Hydro electricity production and biomass-based energy supplies, which are the only large-scale indigenous primary energy resources available in Sri Lanka, are expected to increase only marginally in the near future. This is mainly due to limitations in further hydropower development owing to lower economic viability of exploiting the remaining large hydropower sites and limited use of biomass with gradually increasing standard of living of the population. This means that the country's incremental primary energy requirements need to be supplied mainly by imported fossil fuels in the medium term. In the longer term, possible development of indigenous petroleum resources and accelerated development of non-conventional renewable energy are likely to make a significant change in Sri Lanka's mix of primary energy resources.

A combination of factors has contributed to the emphasis in recent times for generating electricity through less conventional renewable sources. Electrification of rural areas, for instance poses many challenges, foremost amongst which are the high capital investment, operational costs and the difficulties associated with extending grid connected electricity lines to remote areas. In this context renewable sources of energy including solar power, small scale hydro power, wind power, biomass and dendro power, have emerged as an economical and sustainable alternative source to promote medium term electricity generation to the rural populace, albeit in small measure.

1.4 Background of the Development & Utilization of Renewable Energy

1.4.1 Renewable Resources

Due to the geo-c1imatic conditions, Sri Lanka is blessed with several forms of renewable energy resources. Some of them are widely used and developed to supply the energy requirements of the country. Others have the potential for development when the technologies become mature and economically feasible for use. The following are the main renewable resources available in Sri Lanka: Biomass, Hydro Power, Solar and Wind [35].

1.4.2 Biomass

Biomass is the most common source of energy supply in the country with the majority usage coming from the domestic sector for cooking purposes despite the fact that they have access to grid electricity. Due to abundant availability, only a limited portion of the total biomass usage is channeled through a commodity market and hence the value of the energy sourced by biomass is not properly accounted for [35].

Biomass comes in different forms. The following are the most common forms of biomass available in Sri Lanka: Fuel Wood, Municipal Waste, Industrial Waste and Agricultural Waste.

Home gardens and forests supply the major portion of the biomass requirement of the country. A very small amount of biomass is converted to charcoal and electricity. Biomass is mostly used 'as-it-is'. Although there is a potential for biomass based electricity generation, developments are still at their initial stages. The first grid connected biomass based power plant (of l MW capacity) was commissioned in Walapone in October 2004 within the Small Power Purchase scheme of the CEB. In addition, a small scale (approximately 0.3MW) biomass based power plant is operational at the Factory of Haycarb Ltd. in Madampe, producing electricity for factory use, as a supplement to the grid supply [35]. Another subsidiary of Haycarb Ltd (Recogen) is operating a co-generating plant using producer gas of coconut shell and generates 5 MW of power (more details are given in Chapter 9).

Even though the majority of energy needs of the rural population are fulfilled by the use of firewood, there are possibilities of further increasing the use of biomass for energy purposes in the country, especially for electricity generation. Owing to the rapid growth of fuel wood cultivation, the concept of biomass based electricity generation (commonly referred to as Dendro Power) holds much promise for Sri Lanka [35].

The biomass distribution network is quite simple, and in most cases, non-existent. The majority use of biomass is at the domestic level, where the source and the point of use happen to be within the same home garden. Even in industrial usage, the distribution is a one-to-one arrangement, which links the source to the user through a direct biomass transport. The biomass sector operates with very little interaction with the governing structure of the energy sector [35].

1.4.3 Hydro

Figure 1.3 – Village Hydro (**Source**: Energy Forum)

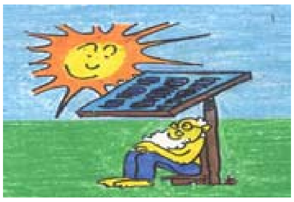
The topography of the country provides an excellent opportunity to harness the energy stored in river water which flows from the central hills of the country to the ocean surrounding the island. Though the use of hydro resource for direct motive power was common in yesteryears, electricity production has become the sole use of hydro resource in recent times. Therefore, hydro contribution as an energy supply source is always through its secondary form which is electricity [35].

The small power producers (SPP) who operate small scale hydro power plants (mini hydro plants) contribute to the primary energy supply through hydro power. In contrast to SPP hydro power plants, which are of 'run-of river' type, Ceylon Electricity Board (CEB) owned large hydro power plants posses storage capacities in the form of reservoirs, enabling these large power plants to be dispatched as and when they are mostly needed in the system [35].

Hydro power is a key energy source used for electricity generation in Sri Lanka. The better part of the major hydro potential has been already developed and they are delivering valuable low cost electricity to the country. Currently, hydro power stations are operated to supply both peaking and base electricity generation requirements. However, a few major sites are still classified as 'not economically feasible' for development. Apart from the grid connected hydro power stations, many small-scale hydro power applications are in operation serving off-grid loads. A substantial number of small scale hydro sites have been identified for future developments [35].

1.4.4 Solar

Figure 1.4 – Solar PV (**Source**: Energy Forum)



Solar energy is used mostly in non-commercial forms. Therefore, similar to biomass, the total usage of solar energy is not quantified properly. However, solar energy is the most extensively used form of energy in day to day life and its supply is unrestricted and persistent throughout the year in most parts of the country. The following are the most common uses of solar energy in Sri Lanka: drying, heating and electricity production. Though not measured and officially reported, substantial use of solar energy is observed in drying and water heating applications [35].

The CEB pioneered the introduction of solar photovoltaic technology in Sri Lanka during the early 1980s and later solar photovoltaic applications saw a significant growth due the dedicated efforts of the private sector.

1.4.5 Wind

Figure 1.5 – Wind Power (**Source**: Energy Forum)

Wind as an energy source is used only in power generation and agricultural water pumping, and that too, to a very small extent.

There is only one grid connected wind energy system in Sri Lanka, which was installed at Hambantota in 1999. This 3MW wind power project consists of five 600 kW NEG Micron wind turbines. The project was implemented by the CEB, on a pilot basis, to study the viability of harnessing this renewable energy source in Sri Lanka. This project also facilitates demonstration of this energy source to the public [11].

Energy Permits have been issued to two winds projects, each 10 MW capacity in the coastal belt of the North Western Province. Three more projects, of 10 MW capacity each are going through the approval process [14].

In Sri Lanka, application of wind pumping is an interesting option for farmers in the dry zone who are practicing agriculture under lift irrigation, especially during the dry season. This is due to the existence of negative correlation between the rainfall and strength of wind. Wind pumping activities in Sri Lanka are of relatively recent origin. The first ever systematic studies on the subject commenced in 1978 with technical assistance from the Government of the Netherlands. A 3m-diameter, six-bladed wind pump was developed, which is now commercially produced in a small number and mostly used for irrigation purposes [11].

1.4.6 Bio Gas

Figure 1.6 - Biogas (**Source**: Energy Forum)

Work on biogas in Sri Lanka dates back nearly two decades. Many governmental and non-governmental organizations have been active in this area at various periods of time. Many of these initiatives lacked sustainability as they were implemented in isolation [12].

The Practical Action South Asia study “Integrating Energy and

Environmental Mismanagement through Biogas – A Country Review" revealed many factors, which have directly or indirectly resulted in the failure of biogas technology. Although unconfirmed data suggests that there are nearly 5,000 biogas units constructed through out the country the above sample survey results indicate that the functioning rate is as low as 28.5%. The success rate, i.e. including plants which have been given up due to arrival of the grid supply, remains at 33% [12].

1.4.7 Contribution by Non-Conventional Electricity Generation

Several non-conventional primary sources have been used for electricity generation in Sri Lanka. Solar photovoltaic systems have been increasingly used from the early 1980s. Small isolated hydroelectric systems have been used in the tea processing industry for over 100 years. Small village-level hydroelectric systems are increasingly used in remote locations for household use. Installation of household solar photovoltaic systems and off-grid, community-based, hydro power systems continued to progress with the financial assistance of the World Bank funded "Renewable Energy for Rural Economic Development" (RERED) project. Given below is the electricity generation from non-conventional Sources [35].

Non-Conventional Primary Source	Gird-Connected (2006)		
	Number of Installations	Average Peak Capacity (kW)	Energy (GWh)
Wind Electricity	1	3,000	2.31
Small Hydro Electricity	57	106,334	344.65
Solar PV	1	18	-
Biomass	2	2,000	1.78
Total	**61**	**111,352**	**348.74**

Non-Conventional Primary Source	Off-Grid (2006)		
	Number of Installations	Average Peak Capacity (kW)	Estimated Useful Energy (GWh)
Off-grid Hydroelectric Estate	32	3,226.2	7,065,472
Off-grid Hydroelectric Village	176	1,358.2	2,260,505
Off-grid Solar PV Home Systems	114,883	4,978.5	5,376,765
Wind Battery Charging Systems	25	8.2	5,747
Total	**115,116**	**9,571.1**	**14,708,409**

Table 1.1 – Non-conventional Electricity Generation
(**Source**: Sri Lanka Energy Balance 2006)

The above table shows that in 2006, total non-conventional electricity generating capacity was 121 MW as against the conventional electricity generating capacity (CEB and non-CEB) of 2,352 MW. Therefore, the contribution of non-conventional primary source is about 4.9% of the total installed capacity of 2,473 MW.

1.5 Summary of Renewable Energy Resources Available

Given below is the summary of renewable resources available in Sri Lanka. The estimated potential was drawn from various sources as described in the following chapters and the estimated exploitable potential by 2015 is from a study carried out by the Development Finance Corporation of Ceylon (DFCC Bank) in 2007 under the RERED project.

Renewable Energy Source	Estimated Potential	Estimated Exploitable Potential by 2015 - MW
Small Hydro	300 MW	300
Solar (PV)	4.5 to 6.0 kWh/m2/day	11
Wind (on-grid)	24,000 MW	50
Biomass (Dendro on-grid)	4,000 MW	90
Biogas	288 MW	-
Wave Energy	13 to 100 kW/m	-

Table 1.2 – Availability of Renewable Energy Resources

Chapter 2

RENEWABLE ENERGY MARKET & INDUSTRIES

2.1 Introduction & Overview

This chapter briefly describes the renewable energy market behaviour of Sri Lanka and major industrial players engaged in either the producing /supplying /distribution of technologies/ machinery/equipment or the producing / conversion of resources.

It is estimated that more than 50 organizations with over 2,000 stakeholders are commercially involved in a rapidly growing renewable energy industry, which includes grid-connected, off-grid community and household based renewable energy systems. The stakeholders include microfinance institutions, commercial and development banks, NGOs, project developers, consultants, and equipment suppliers.

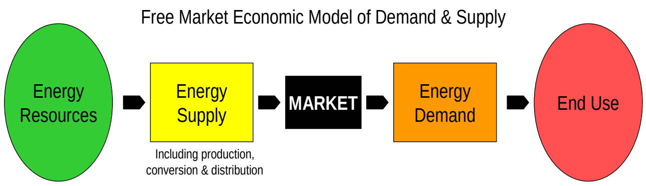


Figure 2.1 (**Source**: Sri Lanka Energy Balance 2006)

The free market economic model of demand and supply which is depicted above is the basis for this discussion. The demand and supply situation of main renewable energy sources in Sri Lanka, viz. Biomass, Biogas, Small Hydro Power (Mini, Micro and Pico), Solar and Wind are discussed in the following sections.

		Solar	Hydro	Biogas	Biomass	Wind
Supply	Availability of the resource					
	Availability of manpower					
	Availability of money					
	Availability of machines					
	Availability of methods					
Demand	Accessibility to the resource					
	End user needs					
	End user awareness					
	End user affordability					
	Reliability of service					
	Availability of methods					

Table 2.1 – Demand & Supply Comparison of RE

The colour code used for the rating is as follows;

	High		Medium		Low

On the supply side, availability of the energy resource, manpower (know-how, skills, capabilities, etc.), money (financing, grants, incentives, etc.), machines (technology, machinery, equipment, etc.), and methods (policies, institutional arrangements, etc.) shall be considered in the discussion. On the demand side, accessibility to the energy resource, end user needs, awareness, affordability (financing, grants, incentives, etc.), reliability of technology and equipment, and methods (policies, institutional arrangements, etc.) shall be considered in the discussion.

As can be seen from the table above, of these five main resources, Solar could be treated as the most developed, next is Small Hydro Power (mini, micro and pico) and followed by Biogas. The Hydro market is found to be fully developed in terms of technology, equipment, construction, financing, maintenance & operation. Biogas has around 78% success rate especially when the Chinese continuous systems are adopted. The Wind market is the least developed. The Biomass market for power generation and thermal applications of industry and commercial sectors is also not developed despite its high potential.

As the Solar and Small Hydro markets are well developed, their dynamism is further elaborated below.

2.2 Solar

Solar Home Systems (SHS) - According to Pradip Jayewardene, President, Solar Industries Association of Sri Lanka, Sri Lanka has the world's most successful rural solar programme. More than 100,000 homes use solar today, this is 2% of all homes in Sri Lanka which is around 5 Million. This is a very significant percentage. Reasons for this phenomenon are the relatively small size of the country, highly distributed rural population, high per capita GDP and more importantly the excellent cooperation between the private sector and the government for over 15 years. End users have made the highest investment by purchasing a solar electricity system.

Solar Industry - How did the cooperation between the government and the private sector work? Firstly, the government acted as the funding agency by obtaining soft loans and providing these funds to private sector financial institutions. These organizations in close cooperation with solar companies offered loans to rural customers to purchase a solar home system. The government also set technical standards for all equipment supplied under the project, provided consumer protection and screened companies who wished to participate. The project also provides grants for companies on a systems sold basis as well as grants for capacity building activities such as training and promotional work. What makes Sri Lanka unique is the quantum of investment in both money and effort that has gone into developing this market. In the period 1997 to 2001 it is estimated that around USD 10 m was invested by the solar industry to build an Island-wide distribution network to ensure that products were available in thousands of villages where end users lived. Considering that almost every sale takes place at the customer's home and the delivery, installation and credit collection also takes place at the home, and that almost 2,000 new customers are coming in every month, one can imagine the logistics of such an operation. This is what the industry has created. The government provided access to long term and lower cost funds and a framework for the private sector to operate in a sustainable manner. Today nearly 15 companies compete in the market, driving down costs, improving quality and service and bringing new innovation. The industry also provides jobs for around 2,000 people. Sri Lanka has proven that solar PV is the least cost option for many rural homes and customers are willing to accept solar as a good alternative to grid electricity. Sri Lanka has achieved this by the far thinking policies of the government, assistance from donors and strong private sector participation [37].

Solar Companies - According to a survey carried out by the Sri Lanka Business Development Centre (SLBDC) in 2005, there were 8 solar companies (Access Solar, Alpha Solar, EB Creasy, Selco Solar, Shell Solar, Softlogic, Solar Dynamics and Suriyavahini) operating in Sri Lanka and among them, Shell Solar was considered as the market leader having about 40% market share while Selco Solar and Access Solar account for around 24% each [7].

Panel Capacity by Solar System - According to the above survey, 42% of the systems surveyed had a range of 20 to 40 Wp capacities of solar panels and 39% of the systems had a range of 41 to 60 Wp capacities of panels [7].

Batteries Installed in Solar Systems - According to the above survey, there were 7 makes of batteries (ABM, Ecosolar, Exide, Incoe, Lucas, Nico and Sandya) installed in solar systems. “Incoe” is considered as the market leader having about 37% market share while “Lucas” and “Exide” account for around 24% and 21% respectively. Therefore, these three makes together have the market share of 81% [7].

Out of 300 systems surveyed, 30% of the batteries installed were 90 Ah capacity while 28% of batteries were 100 Ah capacity. 27% of batteries installed had capacity of 70 A. Most of the batteries replaced from the solar systems had a lifetime of 24 to 42 month period. The weighted average lifetime of the first battery installed was 30.4 months [7].

Through an analysis carried out by J.R. Finucane in 2005 on the growth of the Solar Industry in Sri Lanka under the RERED project, it was found that significant PV market opportunities will remain in the foreseeable future, given targets and pace of rural grid extension programs and the market will be competitive, with new entrants gaining market share and no significant barriers to entry [3].

2.3 Hydro

Grid connected small hydropower capacity has grown from just 120 kW in 1996 to 100 MW in 2006. The development of the industry has been supported with appropriate policy changes, establishing of purchase agreements and pricing mechanisms. This, indeed, is an outstanding achievement and depicts the dynamism of the local entrepreneurship once the right institutional backing and investment climate are set in place for the new industry.

The development of the code of practice for micro hydropower projects or village hydropower projects could be treated as a good indication of the maturity of the market. This code sets out guidelines for design, construction, commissioning and maintenance of micro-hydro projects, with a sound base of civil, mechanical and electrical engineering principles and the background of practical experience in the industry [40].

Under the SARI (South Asia Regional Initiative for Energy) project of the United State Agency for International Development (USAID), Sri Lanka Energy Forum in 2006 developed national micro hydro standards covering three countries: India, Nepal and Sri Lanka. The ultimate goal of the process was to harmonize standards and establish quality programs in the sector and expand the micro-hydro market and provide sustainable energy services to the end users. The indirect objectives of the project were to address the issues such as reducing trade barriers within the SARI region for micro-hydro energy technologies and services as well as ensure sustainable existence of micro-hydro schemes in the region.

Micro-hydro sector in Sri Lanka is mainly linked with the RERED Project and hence the World Bank specifications are already in place. The Technical Committee of Sri Lanka appointed for the above task considered the RERED specification as the baseline of the drafting national standards and sought the ways and means of further developing. The drafts covered code of practices, standards for certain electro-mechanical components, software applications for management practices, training requirements and monitoring measures [10].

Code of Practice - The Sri Lanka Micro Hydro Standards were developed having ensured the financial and technical capability of implementing projects under the ownership of community organizations. In Sri Lanka micro hydro standards are not only for the reference of consultants and contractors but also for the electricity consumer societies. It also provided guidelines for following activities [10];

- Controlling mechanism in place of RERED project
- Comfort to banks and societies while financing projects
- Code of practice for manufacturers and consultants
- Sustainability of the industry
- Guideline for Public Utility Commission (PUCSL) in regulation measures.

2.4 Biomass

Despite its enormous potential, the biomass market for thermal applications of industrial and commercial sectors and also for electricity generation is not developed. The good sign is that many entrepreneurs have begun to sense prospects. Two emerging companies actively involved in this sector by offering unique service packages are featured below.

2.4.1 EnerFab

M/s EnerFab was founded in 2005 with the vision to provide biomass based renewable energy solutions to the local industry. Since then, EnerFab has been offering local industry turn-key biomass technological solutions along with biomass supplied from sustainably grown and harvested energy plantations.

Vision of EnerFab

- Re-Greening of Sri Lanka
- Restoring Sri Lanka's Pristine Environment
- Re-Vitalizing Rural Employment and Affluence throughout Sri Lanka.
- Re-appreciating Sri Lanka's Natural Resources

Mission of EnerFab

- To Promote the growing of trees, shrubs, plantations and living-organisms as a natural and renewable source of food, fertility and fuel
- To promote the construction and installation of equipment for processing Sri Lanka's natural and renewable resources for the environmentally conducive generation of electrical and thermal energy through solar, hydro, biomass and wind
- To design, fabricate, install and operate structures and equipment towards achieving the above.

Figure 2.2 – EnerFab Thermal Gasifier

EnerFab Business Model - The uniqueness of EnerFab is that it offers a total and turn-key solution to its clients. They do not just sell gasifiers and other equipment but the thermal energy requirement in any form (steam, hot water, Thermic fluid, hot gas, etc) as per the client's need. Their service package include, provision of required buildings to satisfy even the architectural needs of the client, all equipment and appliances including the burners, commissioning, operation and maintenance including manpower, sourcing of fuel wood and all other needs to ensure an uninterrupted thermal energy supply to its clients. This is very similar to the ESCO (Energy Supply Company) concept where the service provider guarantees the agreed performance by relieving the client of all associated risks. EnerFab is paid for the unit of thermal energy supplied based on an agreed price which is linked to the market price of fossil fuel replaced.

Of all these elements, from the perspective of the client, supply of fuel wood is the most critical at this stage as the commercially grown wood supply base is not yet developed to meet the demand. EnerFab by taking this burden out of the client has gained a competitive edge in the market. Presently, EnerFab supplies around 50 MT per day of Gliricedia to its existing clientele of around 10 (capacities ranging from 0.3 to 3.5 MW of thermal energy) and maintains a buffer stock of around 1,000 MT. EnerFab sources its Gliricedia requirement from out-growers and maintains a 20 acre nucleus. Their plan is to extend the nucleus to 700 acres. EnerFab is confident of assuring the supply of Gliricedia with a lead time of around just 2 months [55].

According to the Bio Energy Association of Sri Lanka (BEASL), it is estimated that around 250 MT of Gliricedia is being traded currently for industrial/commercial thermal applications and for electricity generation [56].

EnerFab Thermal Gasifier Systems are mostly offered for fuel switching (conversions) from either diesel or LPG gas to biomass. Presently, furnace oil conversion is not economical due to the prevailing fuel prices, but might change with price escalations [55]. A client of EnerFab is featured in Chapter 9 as a case study.

Contact Details

EnerFab (Pvt) Ltd, 207/14 Dharmapala Mw, Colombo 07, Sri Lanka. Tel: +94-11-2686565, Fax: +94-11-4724127, E-Mail: info@efpl.org Web : http://www.enerfabsrilanka.com

2.4.2 Lanka Gasifiers Private Limited

Lanka Gasifiers Pvt. Ltd. (LGL) was established in 2007 and provides distributed energy solutions that rural populations can implement for themselves. Currently, as part of its start up phase, LGL designs, develops, manufactures and deploys Biomass Gasifier Generators.

LGL having implemented Sri Lanka's first village biomass electrification system now implements such projects through independent entrepreneurs or developers. Eight units are in operation.

LGL provides a broad range of services to potential entrepreneurs or developers and through them to the rural people – from robust and economical technology to the sharing of their significant experience in technology, project management and the growing of biomass.

Figure 2.3 – Biomass Electricity Generator of Lanka Gasifiers)

Presently LGL manufactures gasifiers generate 12 kW of electricity using diesel engines and generators supplied by M/s Prakash Diesel of India. They intend scaling-up their units up to 50 kW to cater for the demand for bigger units. LGL claims that it has done away with troublesome water cooling. The gas produced is cleaner and is of high temperature. It has an improved firebox. The unit is designed to burn multi fuel. Upto 40% rice husk also could be used. Fuel consumption is around 15 – 20 kg per hour for a 12 kW gasifier unit.

Contact Details

Lanka Gasifiers Pvt Ltd, 71-1 Gregory's Road, Colombo 00700, Sri Lanka.
Tel/Fax: +94 11 269 1675
Email: **lankagas.info@gmail.com** Web: **www.lankagaslk.com**

Chapter

3

LEADING R&D ORGANIZATONS IN RENEWABLE ENERGY

3.1 Introduction & Overview

This chapter presents the leading R&D organizations in Sri Lanka operating in the area of renewable energy and involved in capacity building, information dissemination R&D and demonstration programmes.

Such organizations could be broadly categorized into three sectors: State, Private and Non-government. Most of the state organizations are involved in research and development, technology improvement and adoption as they are equipped with adequate physical and human resources though most of them are constrained by research funds. The private sector is mostly involved in technology adoption. NGOs are very active in capacity building, information dissemination and demonstration programmes. For their R&D work, they usually collaborate with State sector organizations as they do not possess the required infrastructure and the manpower.

		R&D	Capacity Building	Information Dissemination	Demonstration Programmes
State	NERDC				
	U of Moratuwa				
	U of Peradeniya				
	U of Ruhuna				
	IDB				
	ITI				
NGO	Practical Action				
	Energy Form				
	IDEA				
Private	EnerFab				
	Lanka Gasifiers				

Table 3.1 – Comparison of R&D Organizations

The colour code used for the rating is as follows;

	High
	Medium
	Low

As can be seen from the above table, NERDC in the State sector and the Practical Action in the NGO sector are the most active players in this discipline. EnerFab and Lanka Gasifiers in the private sector are quite strong in demonstration of biomass technologies through their commercially oriented projects. Specific tasks of some key organizations featured above are discussed below in brief.

3.2 National Engineering Research and Development Centre (NERDC)

The National Engineering Research and Development Centre (NERDC) of Sri Lanka was incorporated in 1974 under the State Industrial Corporations Act No .49 of 1957. It has emerged as one of the premier engineering research and development centres in the country. It has placed particular emphasis on activities capable of improving the quality of the life of the people in the country, especially the rural and low-income groups. It has also paid special attention to small-scale entrepreneur development projects, some of the research areas in which the centre has been active in the past are: Renewable energy, provision of electrical power in the rural areas, cost effective building technologies, energy management and environmental engineering, energy efficient lighting systems in rural homes, etc.

According to Jayantha Ranathunga, Chairman of NERD Centre, “All innovations are not necessary results of research. All research may not lead to innovations. Nevertheless the country’s national innovation system will help in deriving useful products, processes and services out of its innovation. Keeping this in mind, the NERD Centre is exploiting the science of engineering to take innovations from its infancy (mind) to adulthood (market)”.

The NERD Centre has a staff of about 340, of which 40 are engineers from various disciplines. 21 are technical assistants and the rest consists of skilled workforce and administrative personnel. Multidisciplinary team of engineers has expertise in a wide range of areas.

The facilities of the NERD Centre include:

- Civil, Electrical & Electronics, Agriculture and Post Harvest, Renewable Energy related Research Departments with necessary laboratories and workshops.
- Internationally accredited laboratory for Solar Photo-Voltaic systems and CFL Lamps Testing.
- A Technology Park inclusive with demonstrational models and prototypes on NERD Technologies.
- Library

NERD Centre resources support in-house projects of national importance. Research activities are also carried out by the Centre with funds obtained from local organizations through submission of project proposals.

The services of the NERD Centre include;

- **Solar Photo-voltaic System Test Facilities** – Testing of Solar PV panels and solar home system components such Batteries, Charge Regulators, etc. to national & international standards.
- **Training of Personnel** – The Centre undertakes training of personnel in areas related to the experience of Centre staff. This training comprises of group training of personnel by way of workshops, seminars.
- **Technology Transfer** – Technologies that have been developed by the centre through in-house R&D projects and funded programmes are transferred to potential entrepreneurs.

The NERD Centre's services can be obtained on request and on payment of the Centre's charges.

The technologies developed and available for transfer are given below (Further details are given in Chapter 8);

- **Biogas Plants** – Sri Lanka Dry-Batch Bio-gas plant could be used as a domestic plant as well as well as large scale Bio-gas cum organic fertilizer production plant. The raw material feeds are straw, vegetable market garbage and selected domestic garbage.
- **Micro-hydro Turbine –** Power generation up to 100 W.
- **Solar Water Heaters & Distillers –** For water heating and distilled water production.
- **Paddy Husk Fuelled Bakery Oven** – Ideal for small & medium scale bakery industry.
- **Wood Gas Stove** – More convenient and more efficient stove that uses fire wood as fuel and therefore is an alternative to the traditional firewood stove.
- **Dryers – Solar & Saw Dust Operated Vegetable Dryer** – The main advantage of this dryer is the ability to operate even in the night time or rainy days.
- **Dryers –Saw Dust / Paddy Husk Fuelled Incorporated with a Blower –** For food and vegetable dehydration.

The Techno Marketing Department is responsible for transferring NERD Centre Technologies.

Biogas – NERD Centre is the pioneer research organization in Sri Lanka that is responsible for the development of the Sri Lankan Dry Batch Biogas unit. This innovation received a silver medal at an international exhibition for environmentally friendly innovative processes (24E Salon International des inventiona, Geneva 1996). The dry-batch system is designed to handle straw arising out of paddy cultivation. The digestion period identified is six months which is also the paddy cropping cycle. The concept is to obtain straw from one crop, digest it for six months and take out the digested material for use as fertilizer for the next crop.

Biodiesel - NERD Centre has tested a vehicle with blends of coconut oil (straight oil) and petrodiesel. Despite a few drawbacks it was reported that running an unmodified diesel engine with blends of coconut oil was technically feasible [40].

Information Services – The Techno Marketing Department is the main Information Centre which provides information to the general public, government and non government organizations, industry, etc. The Technology Park provides information on selected NERD Technologies with the aid of demonstrational models and prototypes. The products made out of NERD Technologies and its services can be bought from the Technology Transferees or the Licensees of the NERD Centre. The information related to the licensees as well could be collected from the Technology Marketing Department.

NERD Centre played a very important role in propagating grid assisted battery charging systems for lighting and television applications throughout Sri Lanka. NERD Centre was also instrumental in popularizing solar thermal systems for producing hot water and solar thermal applications for vegetable drying. In the early 1980's, the NERD centre was able to transfer this technology to local manufacturers and successfully establish a network of manufacturers island wide. [35].

3.3 Practical Action

Practical Action (then ITDG – Intermediate Technology Development Group) was established in Sri Lanka in 1989. After 3 decades of its existence, now it works hand in hand with rural communities, in the development of alternate technologies in a number of such areas such as, agro processing, energy, rural transport and disaster mitigation.

Working together with the communities, Practical Action South Asia aims to build the technical skills of poor people in the region enabling them to improve the quality of their lives and that of future generations.

Practical Action has been promoting a number of renewable energy options over the last few decades with Micro Hydro being one of the earliest.

Micro-hydro - Experiments with Micro Hydro systems began nearly 25 years ago in order to come out with appropriate energy solutions for the poor in remote rural villages that were not connected to the main grid nor had little chance of being connected to the grid. Building on initial success at the ground level, local fabrication was promoted and the systems were stimulated to support wider application. With the first micro-hydro village in the early 90's, Practical Action was able to demonstrate that not only can micro hydro technology that worked for industries could be made to work at village level, but that communities can manage and gain control over the supply of energy to their own community.

More details of Practical Action are given in Chapter 4.

3.4 University of Moratuwa

The University of Moratuwa provides its services as a center of higher learning, research and consultancy in engineering, architecture & other allied professional disciplines.

Extensive studies have been carried out at the Department of Chemical Engineering in the University of Moratuwa on biodiesel production using Coconut oil, Rubber seed oil, Jatropha oil, Neem seed oil, and Waste Cooking Oil (WCO). Local hotels and restaurant chains have shown interest in converting WCO into biodiesel for their own uses [40].

Recently, a diesel three-wheeler was operated with biodiesel that was produced using various types of oil, at the University of Moratuwa, and the engine ran smoothly without operational difficulties. However, long term studies have to be carried out to check the compatibility of material that is used in the fuel system of the engine with biodiesel and to investigate other operational problems that are reported in literature. At present there is a 5L biodiesel reactor at the University of Moratuwa and a fully controlled 50L biodiesel reactor unit with other ancillary units which is currently being designed mainly for demonstration purposes. Once fabricated, the reactor system will be made available to prospective entrepreneurs for them to carry out their preliminary trials before embarking on large scale projects [40].

The Department of Mechanical Engineering of the University of Moratuwa commenced the first ever postgraduate programme in Energy Technology in Sri Lanka in October 1999. This programme, which is structured for an intake of about 20 students, awards a Postgraduate Diploma for completing the course work requirement (one year) or the Degree of Master of Engineering upon the completion of a suitable research project. The total duration is two years. The programme offers a course modules on Energy Sources, Transfer Process, Industrial Fluid Dynamics, Mathematical Techniques applicable to analysis of energy systems, Fuels and Combustion, Solar Energy, Wind Energy, Biomass Energy, Hydel Energy, Energy Conservation & Management, Energy Economics, Design of Energy Systems, Instrumentation & Experimental Techniques, Waste Heat Recovery & Upgrading Systems, Boiler & Furnaces, Building Energy, Advanced Energy Technologies, Rural Energy Systems and Energy & Environment. It is important to state that this is the only course which is comprised of a complete subject module on Biomass Energy. The Master of Engineering projects in the second year of the postgraduate programme are based mainly on research &

development activities related to local energy sector. They are expected to cover research aspects of energy systems rather than product development objectives of those in the undergraduate programme [51].

3.5 Industrial Development Board (IDB)

IDB was established under the Industrial Development Act No. 36 of 1969 for the encouragement, promotion and development of industries in Sri Lanka. Currently, IDB functions under the Ministry of Rural Development.

Objectives

- To promote and develop sustainable industries
- To co-ordinate regional growth and dispersal of industries with employment generation capabilities
- To advise and participate on policy matters related to industrialization
- To promote exports of industrial products
- To provide counseling and other related services
- To acquire, adapt and disseminate new and appropriate technologies
- To assist in local and international trade and SAARC regional co-operation

Services

- Consultancy for Industry
- Design and fabrication of machinery and equipment
- Establishment and development of industries
- Development of products and processes
- Provision of industrial information
- Research and development
- Supplying materials and testing of products
- Entrepreneurship training
- Trouble shooting in industry
- Marketing assistance
- Infrastructure development

In the past, IDB engaged with number of projects related to conventional RETs. A number of stoves for domestic cooking and fuelwood kilns for industrial heating applications (such as brick / tile / lime) have been designed. Experience and resources of IDB together with the links with many medium and small scale industries are good indications of its ability to undertake active role in promotion and commercialization of RETs, especially in industrial and domestic sectors, in terms of awareness, training, design & fabrication, technology transfer, etc.

Chapter 4

INSTITUTIONAL INFRASTRUCTURE & INCENTIVES AVAILABLE

4.1 Introduction & Overview

The first part of this chapter describes the institutional infrastructure available in the country for the promotion and utilizing of renewable energy. The second part focuses on incentives available for the said purpose.

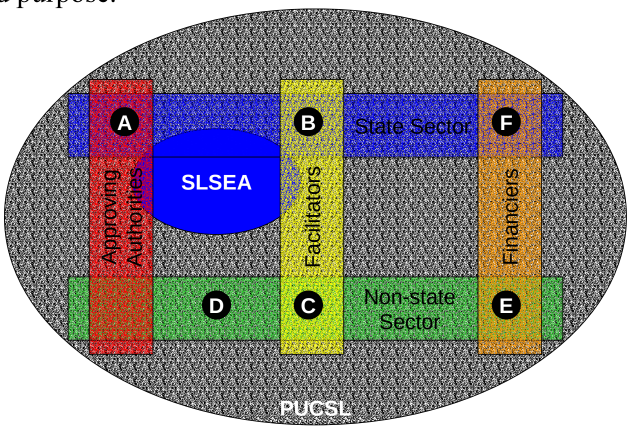


Figure 4.1 – Institutional Arrangement

The above is an attempt to portray the institutional arrangements in Sri Lanka in the sphere of renewable energy. On one hand, these organizations can be broadly categorized as “State” and “Non-state” based on their legal status. On the other hand, these organizations can be further categorized as “Regulators” having project approving powers, “Facilitators” having either facilitation and/or commercial interests and “Financiers” including credit providers and donors. Under this dual categorization, six types of organizations could be identified as follows:

1. Type **A** – State Sector Organizations (with regulatory and project approving powers)
2. Type **B** – State Sector Organizations (with facilitation role)
3. Type **C**– Non State Sector Organizations, NGOs (with facilitation role)
4. Type **D** – Non State Sector Organizations, Private (with commercial interests as well with facilitation role)
5. Type **E** – Non State Sector Organizations, Private Banks (with commercial interests) as credit providers and the Donor Community (with no commercial interests)
6. Type **F** – State Sector Organizations, State Banks (with commercial interests) as credit providers

Sri Lanka Sustainable Energy Authority (SLSEA) is positioned as the apex body with wider powers as described in Section 4.2.2 and has dual functions of both regulation and facilitation and hence is not listed under any type.

All these organizations operate under a regulatory environment created by the Public Utilities Commission of Sri Lanka (PUCSL). The PUCSL promotes competition, efficiency, safety, and quality of service in public utilities, while protecting the interests of the consumers. PUCSL is also not listed under any type.

This multiplicity of organizations on one hand could be viewed as a blessing for the promotion and utilization of renewable energy and on the other hand could be a hurdle especially at the time of project approvals due to bureaucratic hindrances. Therefore, a better coordination of stakeholder organizations, avoidance of duplicity and undue competition, etc. is the need of the hour and in this respect, SLSEA has an uphill task of playing the role of the apex body by making use of the wider powers it is bestowed with through the Act.

Some key players known to the writer at the time of compiling this report are listed below under each category.

It is estimated that more than 50 organizations with over 2,000 stakeholders are commercially involved in the rapidly growing renewable energy industry, which includes grid-connected, off-grid community and household based renewable energy systems. The stakeholders include microfinance institutions, commercial and development banks, NGOs, project developers, consultants, and equipment suppliers.

Type A – State Sector (Regulatory)

	Organization	Role
1	Central Environmental Authority (CEA)	Environmental clearance
2	Public Utilities Commission (PUC)	Regulation
3	Board of Investment (BOI)	Project approvals
4	Mahaweli Authority	Clearance for Hydro projects
5	Airport & Aviation	Clearance for Wind towers
6	Coastal Conservation Department	Clearance for Hydro projects
7	National Water Supply & Drainage Board	Clearance for Hydro projects
8	Irrigation Department	Clearance for Hydro projects
9	Forest Department	Clearance for Hydro projects
10	Divisional Secretaries & Pradesiya Sabhas	General clearance
11	Ceylon Electricity Board (CEB)	For grid availability and capacity
12	Energy Supply Committee (ESC)	Regulation

Type B – State Sector (Facilitation)

	Organization	Role
1	National Engineering Research & Development Centre (NERDC)	R & D (Biomass, Biogas, Wind, Solar, Hydro, Biodiesel)
2	Sri Lanka Standard Institute (SLSI)	Standards & Code of Practices
2	University of Moratuwa	R & D (Biodiesel), Biogas
3	University of Peradeniya	R & D (Biodiesel)
4	University of Ruhuna	R & D (Biodiesel)
5	Industrial Development Board	Development (Biogas, Biomass)

Type C– Non State Sector, NGOs (Facilitation)

	Organization	Role
1	Practical Action	Policy advocacy & technology transfer
2	Sri Lanka Energy Managers Association (SLEMA)	Capacity building (Training, Workshops, Seminars)
3	Energy Forum (www.efsl.lk)	Policy advocacy & technology transfer
4	Integrated Development Association (IDEA)	Promotion of RE, especially cook stoves
5	Lanka Biogas Association (www.lankabiogas.org)	Biogas
6	Federation of Electricity Consumer Societies (www.efsl.lk/fecs.aspx)	Village hydro
7	Village Hydro Energy Suppliers & Manufacturers Association	Village hydro
8	Village Hydro Developers Association	Village hydro
9	Micro-hydro Association	Micro hydro
10	Bio Energy Association of Sri Lanka (BEASL)	Biomass
11	National Energy NGO Network	Promotion of Renewable Energy
12	National Network on Gender & Energy (NANEGE), University of Peradeniya.	Biomass
13	Department of Animal Production & Health	Biogas

Type D – Non State Sector, Private (Commercial & Facilitation)

Equipment suppliers & private developers

	Organization	Role
1	EnerFab (Mr Indika Gallage)	Dendro equipment supplier
2	Lanka Gassifiers Private Limited (Mr Lalith Seneviratne)	Dendro equipment supplier
3	Spectra Industries	Cook Stoves & Dendro equipment supplier
4	Cimplus Lanka (Pvt) Ltd (Mr G.K.Upawansa)	Biogas
5	Eco Engineers (Mr Athula Jayamanne)	Biogas
6	Industrial Services Bureau (Mr Anura Vidanagamage)	Supplying of small scale wind turbines
7	Access Solar	Supplying of Solar PV
8	Alpha Solar	Supplying of Solar PV
9	EB Creasy	Supplying of Solar PV
10	Selco Solar	Supplying of Solar PV
11	Shell Solar	Supplying of Solar PV
12	Softlogic	Supplying of Solar PV
13	Solar Dynamics	Supplying of Solar PV
14	Suriyavahini	Supplying of Solar PV

Type E – Non State Sector, Private Banks (with commercial interests)
& Donor Community (without commercial interests)

	Organization	Role
1	DFCC Bank	Credit
2	National Development Bank (NDB)	Credit
3	Samptah Bank	Credit
4	Hatton National Bank (HNB)	Credit
5	Seylan Bank	Credit
6	SEEDs	Credit
7	Commercial Bank of Ceylon	Credit
8	Ceylinco Leasing Corporation	Credit
9	Lanka Orix Leasing Company	Credit
10	Alliance Finance Company	Credit
11	Sanasa Development Bank	Credit

1	GEF	Grants
2	UNDP	Grants
3	ESCAP	Grants
4	Government of Netherlands	Grants
5	Government of Netherlands	Grants
6	Government of Japan (JICA & JBIC)	Grants
7	Government of Ireland	Grants
8	USAID	Grants

Type F –State Sector, State Banks (with commercial interests)

	Organization	Role
1	Regional Development Banks	Credit

Table 4.1 – Classification of Organizations Involved in Renewable Energy

<u>Note</u>: Apart from what is listed above, there could be many organizations and individuals active in this discipline not known to the writer especially from the NGO and private sector and hence the above should not be treated as comprehensive.

The role of some key organizations are described below.

4.2 State Sector

4.2.1 Public Utilities Commission [51]

The Public Utilities Commission Act (PUC Act 2002), which was enacted in December 2002, established the multi-sector regulatory body, the PUC. The PUC functions as a regulatory umbrella for the public utilities industries. It will initially regulate the electricity sector, with plans to add water and petroleum industries. The powers and functions regulating each sector within the PUC will be provided in industry-specific legislation. The PUC promotes competition, efficiency, safety, and quality of service in public utilities, while protecting the interests of the consumers. The PUC has been vested with the powers of advising the government on all matters such as licensing, regulation, and inspection functions, as well as tariffs and other charges. It also investigates anti-competitive practices and abuses of a dominant position and oversees the activities of monopolies. Initial funding to establish the

PUC has been provided by the Government, but the PUC will generate its own funds over time from licensing fees and other charges on the industry operators.

The Electricity Reform Act, which was also enacted in December 2002, provides for the regulation of companies generating, transmitting, and distributing electricity in Sri Lanka. The administration of the Electricity Reform Act will be vested in the PUC, and the PUC will serve as the economic, technical, and safety regulator for the electricity industry.

4.2.2 Sri Lanka Sustainable Energy Authority [52]

Sri Lanka Sustainable Energy Authority (SLSEA) was established in 2007 by an Act of Parliament of Sri Lanka to develop renewable energy resources, to declare energy development areas, to implement energy efficiency measures and conservation programmes, to promote energy security, reliability and cost effectiveness in energy delivery and information management.

The Act provides wider powers to SLSEA with the special emphasis on the development and promotion of renewable energy. It is evident that great emphasis is placed on renewable energy in the major sections in the Act where the nature of "appointed members" to the Board and "objects" are specified and the "powers', "duties" and the "functions" of the Board are described.

According to the Act, there should be two appointed members, one to represent the renewable energy industry and another person to represent the rural energy service sector. Furthermore, the Chairman of the Board should have experience in the area of renewable energy development or energy conservation and efficiency

One of the 4 objects of SLSEA is to identify, assess and develop renewable energy resources with a view to enhancing energy security and thereby derive economic and social benefits to the country.

The salient feature of the Act is that out of 16 clauses of the "Powers, Duties, and Functions" section, 11 sections either specifically or generally deal with renewable energy as shown below;

1. Identify, conserve and manage all **renewable energy** resources and appropriate conversion technologies, conversion and utilization norms and practices, including the;

    Preparation, maintenance and updating of an inventory of all renewable energy resources in Sri Lanka, indicating the geographical location of sites, exploitable potential, land ownership and existing infrastructure facilities; and

    Preparation, maintenance and updating of an inventory of all renewable energy technologies, indicating their level of maturity for commercial deployment and typical performance data;

2. Develop a conducive environment for encouraging and promoting investments for **renewable energy** development in the country, including:

    Development of guidelines on renewable energy projects and disseminating them among prospective investors;

    Development of guidelines in collaboration with relevant state agencies, on evaluation and approval of on-grid and off-grid renewable energy projects;

Entertainment of applications for carrying out on-grid and off-grid renewable energy projects.

Providing assistance to investors by formulating project proposals in new types of renewable energy resources and technologies.

Exploring avenues and facilitating the process of overcoming technical or any other limitations that retard the growth of renewable energy development, in accordance with the national policy on energy

3. Analyze and recommend policies and prepare plans aimed at promoting and developing **renewable energy** resources, including:

   Preparing long-term development plans with interim targets for specific technologies and promotion and facilitation of the implementation of such plans.

   Devising incentive mechanisms based on principles of competitiveness and specific technologies based on actual energy production.

4. Develop a conducive environment for the encouragement and promotion of investments in **renewable energy** development, energy efficiency improvement and conservation, rural energy services and for ensuring the sustainability and well being of the energy sector in the country, including:

   The promotion of programmes to mobilize funds for renewable energy development, promotion of energy efficiency, improvement and conservation and rural energy services through credit enhancement and other facilities.

   The provision of funds, including subsidies and seed capital for pilot projects in renewable energy development, energy efficiency improvement, conservation and rural energy services that reduce the dependence on imported energy.

5. Conduct preliminary studies and investigations in any geographical area to ascertain the **renewable energy** potential.

6. Collect necessary data and carry out **renewable energy** resource planning and assessment within any development area, subject to any directions that may be given by the Minster.

7. Obtain relevant data required for **renewable energy** planning and assessment, from any public or private institutions or any other sources.

8. Monitor, refine and follow up the approval process of on-grid and off-grid **renewable energy** projects in consultation with relevant agencies and provide technical and other logistical assistance and facilities to such agencies to simplify the procedural requirements and to accelerate the project approving mechanism

9. Facilitate the access to green funds for investors in on-grid and off-grid **renewable energy** projects, for energy efficiency improvement and conservation measures and rural energy services.

10. Provide funds and design, develop and implement credit enhancement facilities, such as loan guarantee schemes and access to commercial credit for investors in on-grid and off-grid **renewable energy** projects, investments in energy efficiency improvement and conservation and knowledge management in the energy sector;

11. Render professional services and undertake projects connected with the development of **renewable energy** resources and the improvement of energy efficiency, energy conservation and demand management for and on behalf of state and private sector organizations, and charge as fees such amounts as may be determine by the Board.

In addition to the above, SLSEA is empowered with various other tasks that have direct relevance to renewable energy but describing them is out of scope of this report.

4.2.3 Energy Supply Committee (ESC) [51]

Energy Supply Committee (ESC) was established in March 2002 by an Act of Parliament with the objective of ensuring adequate supplies of electrical energy, petroleum and other energy requirements and also to regulate the activities of electricity and petroleum sectors.

Current Projects of ESC:
- Power Sector Reforms
- Petroleum Sector Reforms
- Electricity Tariff Study
- Coal Power Development Project
- Transmission and distribution loss reduction of CEB network.
- Mini Hydro Development
- Generation, Transmission and Distribution of Electricity for Areas not covered by the National Grid
- Development of Sri Lanka Renewable Energy Framework
- National Energy Plan

4.2.4 Ceylon Electricity Board (CEB)

The mandate of the Ceylon Electricity Board (CEB) is to generate, transmit and supply electricity. CEB also constructs, maintains and operates the necessary works for the generation of electricity by all means and for the inter-connection of Generating Stations. It also distributes and sells electricity in bulk or otherwise.

4.3 NGO Sector

There are many non-governmental organizations (NGOs) active in the energy sector in the country. They have implemented many rural energy programmes and also played a key role in awareness raising and capacity building of the rural community. Further, the NGO sector in the country collaborates efficiently with private sector activities and is also instrumental in establishing many community organizations. Some of the key NGOs related to the energy sector are described below [51].

In the absence of any government authority to look after the energy requirements for the off-grid population in Sri Lanka, the civil society organizations have become the backbone of the off-grid energy sector. The NGOs and CBOs, during the last 19 years, have contributed to the off-grid energy sector by mobilizing the community and organizing the end users, by conducting research and development, providing micro-financing and by monitoring the after sale services. As a result the off-grid energy technologies have now provided energy services to over 100,000 off-grid households in Sri Lanka. These energy technologies include Solar

PV systems, village hydro systems, bio-gas units, small wind generators and village dendro-power systems. However the NGOs have an uphill task ahead as they still have to reach 1.5 million off-grid households in Sri Lanka [32].

4.3.1 Practical Action

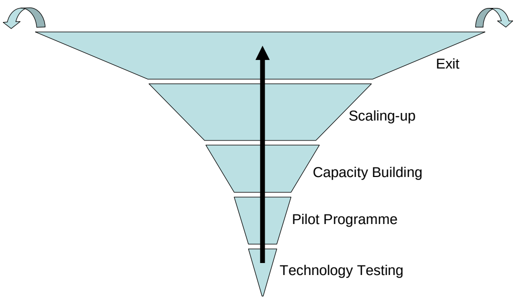
Practical Action (Former ITDG) is an international development agency that promotes appropriate technology options around the world and its Head Office is based in the United Kingdom. Practical Action has been in operation in Sri Lanka since 1989. India and Pakistan are also covered by the Sri Lanka office. Currently it has around 80 employees.

Practical Action has been engaged in the areas of renewable energy (wind, micro-hydro, biomass, biogas, solar, etc.), rural transport, agro-processing, manufacturing, building materials, disaster mitigation, research and policy, and communications. presently, its main involvement are in policy advocacy, standards setting, capacity building, information dissemination through publications, research, technology development, and technology transfer.

Practical Action plays a crucial role in formulation of new policies and reviewing of existing policies by acting as a convener of stakeholder groups and also by preparation of various publications. It is now in the process of developing an Energy Poverty Index for Sri Lanka while engaged in the policy advocacy in the same area. The working model of Practical Action is depicted below.

Figure 4.2 – Working Model of Practical Action

(**Source**: Practical Action)



Working Model of Practical Action

The working process of Practical Action commences with the technology testing to assess the suitability to local conditions. Technology could be either an existing one or entirely a new one. Thereafter, a pilot programme is implemented followed by a capacity building programme for all stakeholders to promote the technology. With the success of pilot and capacity building programmes, scaling up of the equipment, appliances, etc. to the real life conditions is carried out and the same could be considered as the commercialization stage. When the market is developed to a self-sustaining level, a pre-determined exist strategy is executed. The first step of the process – technical testing is usually funded by the parent organization and external financial assistance is sought for pilot programmes. Financial assistance in the form of subsidies is available at the time of commercialization of technologies. The host is expected to contribute maximum of 30% either in cash or in kind.

Hydro - One of the main energy programmes initiated by Practical Action was small-hydro development in the country. Practical Action invested heavily to revive the small hydro power technology that once flourished in the estate sector but went into disuse with the expansion of the national grid system and initiated a number of interventions during the last two decades to accelerate the development of this sector, which includes: (i) Technical Assistance for rehabilitation of abandoned plants, (ii) Development of local engineering capabilities in design, operation and maintenance of small hydro plants, (iii) Operation & maintenance training for operators and mechanics, (iv) Technical assistances for manufacture of Pelton turbines, Electronic Load Controllers and Induction Generator Controllers, and (v) Demonstration and promotion of decentralized, community managed micro-hydro schemes. This was one of the most successful renewable energy programmes in the country and Practical Action won “Energy Globe 2001 International Award” for its contribution for the development of small hydro.

Practical Action also undertook pioneering work in adapting the small hydro power technology for rural electricity supply which is now being used on a commercial scale in the country. This work was begun 25 years ago. Having realized the long-term potential for small hydropower development, Practical Action invested substantial time and money in capacity building to enable local technical personnel to lead the small hydropower industry in Sri Lanka. These training programmes targeted a range of technical personnel – from maintenance technicians in estates to engineers in the government organizations and private companies. Many persons benefited from Practical Action's training programmes and some of them are now holding senior positions in hydropower companies, banks, consulting companies, equipment manufacturing companies and universities.

Grid connected small hydropower capacity has grown from 120 kW in 1996 to 100 MW in 2006. Practical Action is now actively engaged in **Pico-hydro** development.

Wind - Another successful rural energy programme initiated by Practical Action was the wind energy project, which is the development of a small wind turbine for battery charging applications in the rural sector. This was, titled "Small Wind Energy System for Battery Charging". The main objective of the project was to develop a small wind machine that could cater to the electrical energy needs of the rural people, who do not have access to the national grid. The expected outcome of the project was the development of a reliable and cost effective wind energy system with dissemination of the know-how of its manufacture among the interested local manufacturers. The first phase of the project was started in June 1998 and completed in 2001. During the first three years, three demonstration units (of capacity 200 W, rotor diameter 2m and tower height 11 m) were designed, fabricated and field tested. The design is now in the commercial market, and Practical Action is in the process of improving the design further. Further, in December 2003, Practical Action conducted an extensive design course on small wind turbine for engineers [51]. 30 units of wind turbines with the capacity ranging from 150 to 250 W have been promoted to date.

As the solar PV market is fairly well developed in Sri Lanka, Practical Action does not involve in Solar PV promotion but in all other renewable energy options. However, **Solar Wind Hybrid** is promoted as the need arises. So far 12 hybrid units have been promoted (300 W solar PV with 40 W wind turbines). Under **Solar Thermal Systems**, solar dryers for food and fish processing are being promoted.

Under **Bio-fuel**, there is a pilot project in Nikeweratiya to promote bio-diesel using non-edible oil such as Neem, Jathropa, etc. As a principle, Practical Action does not promote any edible oil or Ethanol as bio-diesel to avoid any conflicts with food production. This project is an integrated approach where Plantation, Oil expelling, Diesel processing (85:15 basis), Application of bio-diesel (for water pumping, hand tractors, electricity generation, etc) are being tried out with the collaboration of many partners such as NERD Centre, Universities of Moratuwa, Peradeniya and Ruhuna, and the private sector. In addition to the bio-fuel, other renewable energy technologies such as wind, biogas and solar heating (for dehydration of agro produce) are also used in the integrated demonstration project.

Biogas - Practical Action started a project on developing and popularizing biogas technology in 1996 by carrying out a sample survey to find out the status of biogas technology in Sri Lanka and to learn lessons from the past experiences. This phase was followed by a series of new activities aimed at widespread popularization of the technology [12].

Out of the estimated 5,000 domestic type biogas units of in Sri Lanka, Practical Action was responsible for the promotion of around 1,000 units all over the country adopting three main technologies; Chinese continuous type, Sri Lankan dry batch type (NERD system) and Indian Plug Flow Type. The Chinese system is found to be the most effective.

At the national level in Sri Lanka, biogas technology has a number of benefits such as:

- Waste getting cleared (the environmental management tool)
- Useful fuel gas being generated (the energy generation tool)
- Production of the digestate as a by-product, which is considered to be an excellent soil conditioner (the fertilizer option)

At a commercial scale, two private sector companies; Ambewela Milk Processing Factory and Maxis Poultry are in the process of setting up biogas units with German technology to treat their solid and liquid waste.

Biogas compression is not yet used in Sri Lanka and the University of Moratuwa is engaged in some trails under their research activities.

Practical Action was instrumental in establishing the Lanka Biogas Association (www.lankabiogas.org) in 2008 which is now headed by Prof Ajith De Alwis with a membership of around 100. The Launch of the Lanka Biogas Association has officially herald a new era of development and promotion of biogas in Sri Lanka, as a technology that offers triple benefits: as an effective system in which to manage bio-degradable waste, to produce clean energy and to provide valued inputs to organic agriculture. This is considered as a landmark event in the Renewable Energy Sector of Sri Lanka.

Biogas technology can play a vital role in solving some of the major problems faced by the Sri Lankan societies of the present and future. Biogas utilization should happen in a more systematic way, as it is fast becoming one of multiple end-uses in Sri Lanka [12].

Most of the technologies promoted by the Practical Action are for rural applications. However, its attempt to popularize bicycles (Human Powered Machine) is mostly for urban applications.

Associations - Practical Action was instrumental in establishing many organizations and associations for the promotion of renewable energy; Energy Forum (www.efsl.lk), Lanka Biogas Association (www.lankabiogas.org), Village Hydro Energy Suppliers & Manufacturers Association, Federation of Electricity Consumers Society (www.efsl.lk/fecs.aspx), Village Hydro Developers Association, Integrated Development Association (IDEA), and Micro-hydro Association. For example, Energy Forum was commenced as a Project and later transformed into an independent entity to mainly deal with policy advocacies while Practical Action retaining the focus on technology transfers. Similarly, IDEA was commenced as a Project to promote Cook Stoves.

Resource Assessment - In 2001, Practical Action carried out an assessment of Micro-hydro (by Mr Sumith Fernando) in 10 districts of Sri Lanka identifying over 1,000 sites and also the potential for biogas (by Prof Ajith De Alwis).

Publications - There are many publications to the credit of Practical Action (Research papers, Books, Electronic News letters – e net – Energy Network www.sa-energy.net , Videos – on Wind, Micro & Pico Hydro, etc.) in all three languages (English, Sinhala & Tamil). Practical Action took the lead in the preparation of; Micro-hydro guidelines, Operation & maintenance manual for micro-hydro, and Micro-hydro standards (Code of practice).

South-South Technology Transfer - Practical Action has created a good platform for South-South technology transfer. Micro-hydro technology of Sri Lanka was promoted in India with special emphasis on social organization and technical aspects while the Bio-fuel technology is transferred from India.

4.3.2 Energy Forum

The Energy Forum was established in 1991 with the participation of renewable and decentralized energy technology NGOs, private-sector firms, government agencies, and prominent energy community members in Sri Lanka to address their common issues. The Energy Forum which was originally a project of ITDG (now Practical Action) became a non profit organization in 1999.

The Energy Forum is working to promote renewable and distributed energy options to alleviate poverty, to address energy capacity deficiencies, and to protect the environment. As a network of individuals and organizations from government institutions, Provincial Councils, the private sector, NGOs, utilities, universities and research institutions, the Energy Forum serves as a network hub for non-partisan energy information and research. The Energy Forum specializes in grassroots community awareness-raising and has created close working partnerships with community leaders, business leaders, provincial councils and individual officials, policy makers, journalists, school children and teachers and other NGOs and community-based organizations.

Energy Forum acts as a partner for local and global renewable energy initiatives and promotion of fair and sustainable energy policy.

Particularly, in the year 2001 a survey on off-grid biomass based electricity generation potential was conducted by Energy Forum under funding by the World Bank. The survey identifies that almost all the dry-zone off-grid villages in Sri Lanka have enough sparsely used croplands that can be effectively used to establish energy plantations for supplying fuelwood to generate electricity for the consumption of off-grid households. [51].

The great success of Energy Forum has been its bottom-up focus. Starting from the grassroots, the Energy Forum convinced local Community Based Organizations of their role in addressing the energy needs of the communities they serve.

One of the key achievements of the Energy Forum has been the establishment of the Federation of Electrical Consumer Societies (FECS) to give end users and consumers a voice in the decision-making process regarding off-grid energy. The FECS now has around 150 ECS members, representing over 6000 off-grid powered households.

4.3.3 The Federation of Electricity Consumer Societies

This is a community organization that functions through the joint action of Electricity Consumer Societies attached to isolated rural hydro electricity plants distributed throughout Sri Lanka. The FECS has an active membership of 104 Electricity Consumer Societies and its Executive Committee consists of 12 members representing 6 districts in Sabaragamuwa, Southern and Uva Provinces, 4 Provincial Energy Officials and 2 National level experts. 10,250 families currently obtain electricity from these plants, covering a total population of around 51,000. FECS receives considerable backstopping support from the Energy Forum.

4.3.4 Integrated Development Association (IDEA)

IDEA is the major organization, which co-coordinated, monitored and responded to the needs of the stove development community which comprises of several government and non government organizations operating at provincial, district and community levels. CEB stove programme set up the Integrated Development Association (IDEA) to continue stove dissemination efforts with the guidance of a few development experts. Practical Action, which assisted CEB in the stove dissemination effort, recognized IDEA as the Partner Organization.

Practical Action provided technical inputs and secured funding for IDEA to continue with dissemination of stoves in rural areas thus filling the vacuum created by the withdrawal of CEB. IDEA being a NGO with a future vision was able to shell the rigidity enforced by the CEB thinking which enable to accommodate a wide spectrum of development issues, which could not be addressed within the CEB objectives. Creation of IDEA was an important initiative for sustainability of stove activities in Sri Lanka since the main objective was to implement and support projects related to stove. Therefore, IDEA had the freedom, mandate and commitment to focus on stoves only without diluting their efforts on other projects.

Figure 4.3 – “Anagi 1 Cook Stove

At present there is no significant foreign funding for stove activities except the support provided by Asian Regional Cookstove Programme (ARECOP) for networking activities for which IDEA act as the focal point. A network of district level NGOs has been formed with the support and guidance of ARECOP [51].

IDEA serves as the national focal point of the ARECOP and a member of the INFORSE. Its activities include networking and capacity building of NGOs in the promotion of wood stoves and kitchen improvement, including the Anagi Stove, promotion of improved combustion systems in brick kilns and bakeries and promoting large wood stoves for income generating activities, off grid micro hydro village electrification, capacity building of NGOs and CBOs in proposal writing and sustainable development activities and advocacy to promote rural energy planning and policy concepts [44].

4.3.5 Bio-Energy Association of Sri Lanka (BEASL)

Figure 4.4 – Gliricedia

All the interested parties in biomass energy have got-together to form Bio-Energy Association of Sri-Lanka (BEASL) with the mission of “to be the leading voice in the country for the bio energy industry”. The main objectives of BEASL are to build support for the industry throughout the country’s legislature, administration and funding agencies, through tax incentives, increased biomass research and regulations and other policy initiatives. BEASL also interacts directly with the general public, farmer organizations and other relevant institutions to ensure that bio-energy provides a sustainable development means to alleviate poverty. In order to offer well considered opinions and advice for the formulation of necessary policies and plans BEASL has been incorporated as an association under the Companies Act.

Pioneering members of BEASL have long strived to promote the use of indigenous resources for power generation and thus reduce the increasing dependence on imported fossil fuels for both generation of electricity and thermal energy requirements.

In the backdrop of poser shortages in the past years and the looming threat of further shortages and the escalation of costs of energy, the value of Biomass energy is at last being realized and has received the attention of the government authorities due to the effort of organizations like BEASL.

BEASL was instrumental in convincing GOSL to declare Gliricedia as the 4th commercial crop in Sri Lanka and to have a reasonably attractive tariff for grid-connected biomass electricity generation.

4.4 Incentives

Incentives can be broadly categorized as "Financial" and "Non-financial". Financial incentives are the outright grants, subsidies and loans available on concessionary terms. Provision of free services such as training and advisory services could be treated as non-financial incentives.

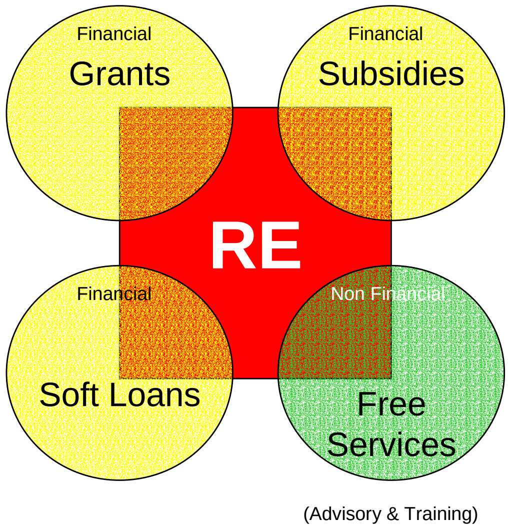


Figure 4.5 – Incentive Regime

All these forms of incentives are available or had been available for the promotion and utilization of renewable energy options in Sri Lanka in varying degrees, at different times, in different regions for different target groups. In some cases, these incentives are available as a package while in some cases it is just one of them depending on the need. Some incentives have been introduced with a clear plan of phasing out with exit strategies.

In the early days, many NGOs such as Practical Action (formerly ITDG) operating in this field offered grants for the developers as well as end users. Soft loans schemes such as ESD, RERED and even E-FRIEND, consisted of grant components. Some Provincials Councils such as "Uva" and "Sabaragamuwa" offered financial incentives to offset the upfront cost of low-income end users of Solar Home Systems and Village Hydro projects. Free services of State, NGO and even private sector are available mostly in the form of training and advisory services.

Some of the incentives available are briefly described below.

4.4.1 Grant Mechanism of ESD & RERED [9]

The grant mechanism of Energy Service Delivery (ESD) and Renewable Energy for Rural Economic Development (RERED) projects for the solar industry reflects the objectives of the five main stakeholders:

- Building a market around proven systems and ease of administration (Administrative Unit, DFCC)
- Reducing grants over time with a clear exit strategy (GEF)
- Providing incentives to deepen the market and enabling access for the rural poor (IDA)
- Assuring sustainability of successful product lines and increasing scale (Solar Industry)

- Affording quality and choice at reasonable prices (Consumers)

The grant mechanism developed by adopting the above objectives precludes subsidies for already viable solar products; limiting grants only to systems smaller than 60Wp during the first year, then only to those smaller than 40Wp during years 2 and 3, and finally only to systems smaller than 20Wp during the last two years of project implementation.

The follow-on RERED Project tried to accommodate the interests of the five key stakeholders in structuring the GEF co-financing grant. The maximum co-financing grant under the RERED Project was set at a value lower than what was available under the ESD Project.

Size of panel	ESD Project (1997- 2002)	RERED Project		
		First Year 2003) Effective from Oct 2002	Second and Third Year (2004/5) Effect from 31st July 2004	Fourth and Fifth year (2006/7)
10 <20 Wp	100 US$	40 US$	40 US$	40 US$
20 <40 Wp	100 US$	70 US$	70 US$	No Grant
40-60 Wp	100 US$	70 US$	No Grant	No Grant
Above 60	100 US$	No Grant	No Grant	No Grant

Table 4.2 – Grant Phasing Out Scheme
(**Source**: Sri Lanka Solar Industry Market Survey)

The GEF grant program was structured with a clear exit strategy in place. The grant of US$70, given for systems above 60Wp was removed in October 2002 with the changeover from ESD to RERED. The grant of US$70, given for the systems above 40W was then removed on 01 June 2004. As the grant removal was properly planed, all the relevant parties were well informed.

4.4.2 Government Subsidy for SHS [9]

In addition to the above grant scheme, the Government of Sri Lanka (GOSL) provides a consumer subsidy of Rs. 7,500 (initially Rs10,000) per system per householder in the, Sabaragamuwa, Uva and Northern Eastern provinces.

4.4.3 E-FRIENDS Loan Scheme [47]

Environmentally Friendly Solutions Fund (E-FRIENDS) is a concessionary loan scheme implemented by National Development Bank (NDB) with JICA supports through a Japanese ODA loan. Though E-FRIENDS is specially meant for environmental protection projects, renewable energy projects are also benefited by this loan scheme as they are qualified under environmentally friendly projects. More details are given in Chapter 6.

4.4.4 Promotion of Eco-efficient Productivity (PEP) Project

Promotion of Eco-efficient Productivity (PEP) project was implemented by The Ceylon Chamber of Commerce with the financial assistance from The Royal Netherlands Embassy. PEP provided technical and financial assistance to Private Sector organizations to adopt best practices in cleaner production and environment management. Renewable energy projects (Biomass & Biogas) project also benefited from this project. Eligible projects received up to 50% of the total project cost as a grant subjected to a ceiling of LKR 5 million (USD 43,500) per project. The technical and financial assistance from the PEP Project was limited to private sector organizations having fixed assets of less than LKR 50 million (USD 435,000) excluding land and buildings. Preference was given to Cleaner Production (CP) initiatives of women entrepreneurs. The companies participated in the Project had to agree to share the experiences/results with other organizations, who could replicate such activities. Project commenced in mid 2006 and concluded in early 2009. Two projects benefited from this project are presented as case studies in Chapter 9.

4.4.5 Government Subsidy for Gliricedia Plantation

In order to promote the supply of Gliricedia as a commercially grown wood for biomass heat and power applications, GOSL has offered a grant of LKR 7,500 per ha (USD 65) for 'under plantation' of Gliricedia in commercial plantations, especially in coconut estates.

However, BEASL questions the effectiveness of this grant as it is not going to make a significant impact on the upfront cost of planting. So far only around 500 acres has come under this grant scheme. Instead, BEASL is in the opinion that it would be more effective if the grant is offered on the basis of a Gliricedia plant at the rate of LKR 10 per plant (USD 0.1) rather than on land extent [56].

Chapter 5

POLICIES FOR THE PROMOTION, UTILIZATION & DEVELOPMENT OF RETs

5.1 Introduction & Overview

This chapter describes the policy framework of Sri Lanka for the promotion, utilization and development of renewable energy.

After a decade of deliberations, debates and discussions, Sri Lanka now could boast of its formal document on energy policy which came into effect in 2008. Though there is no specific policy yet on renewable energy, the Sri Lanka National Energy Policy has emphatically addressed the promotion, utilization and development of renewable energy as described in the following sections.

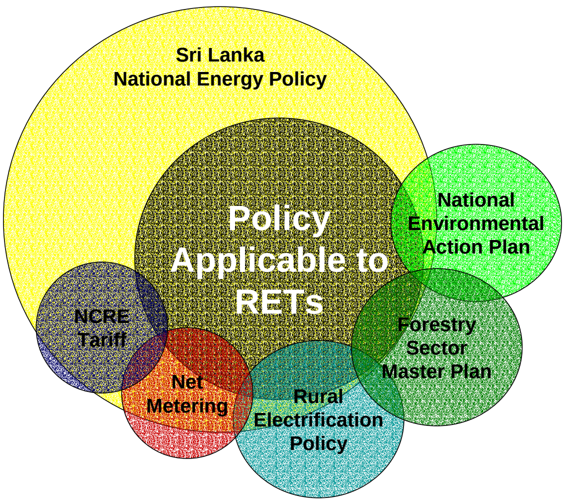


Figure 5.1 – Policy Framework

As spelt out in the national energy policy, the formation of Sri Lanka Sustainable Energy Authority (SEA) is another step in the right direction. It was established under Act No 35 of 2007 of the Democratic Socialist Republic of Sri Lanka and functions under the purview of the Ministry of Power & Energy.

A closer look at this Act (Act No 35 of 2007) reveals that much greater emphasis is placed on the promotion, utilization and development of renewable energy with wide ranging powers for resource allocation, development, etc. This aspect is dealt in Chapter 4 in detail.

SEA has the **Vision** to make an energy secure Sri Lanka and functions with the **Mission** to guide the nation in all its efforts to develop indigenous energy resources and conserve energy resources through exploration, facilitation, research & development and knowledge management in the journey of national development by protecting natural, human and economic wealth by embracing best sustainability practices.

In the journey towards an energy secure Sri Lanka, SEA has set three primary goals; one of them is "10% of all energy forms generated from non-conventional renewable energy resources by 2015 across all areas including electricity, transport and domestic sectors". This is a direct derivative from the national energy policy.

Other policies such as Rural Electrification Policy, National Environmental Action Plan and Forestry Sector Master Plan have implications on policies applicable to RETs in varying degrees.

The latest addition is the Cabinet of Minister's decision at the end 2008 to introduce "Net Metering" for electrical utilities in the country which allows customers who generate renewable energy to get paid for it when it goes back into the grid.

Many policies attempt to compensate for cost-related barriers by providing additional subsidies for renewable energy in the form of tax credits or incentives, by establishing special pricing and power purchasing rules, and by lowering transaction costs [43].

The following sections describe the above mentioned policies in detail.

5.2 National Energy Policy and Strategies of Sri Lanka [4]

The National Energy Policy and Strategies was prepared by a panel of experts and was presented to the Sri Lanka Parliament on 19th February 2008 and is now fully effective. This shall be reviewed and revised after a period of three years.

The National Energy Policy of Sri Lanka spells out the implementing strategies, specific targets and milestones through which the Government of Sri Lanka and its people would endeavour to develop and manage the energy sector in the coming years in order to facilitate achieving its millennium development goals. Specific new initiatives are included in this policy to expand the delivery of affordable energy services to a larger share of the population, to improve energy sector planning, management and regulation, and **to revitalize biomass as a significant resource of commercial energy**. Institutional responsibilities to implement each policy element and associated strategies to reach the specified targets are also stated in this document.

This policy document consists of three sections;

1. "**Energy Policy Elements**" consists of the fundamental principles that guide the development and future direction of Sri Lanka's Energy Sector.
2. "**Implementing Strategies**" states the implementation framework to achieve each policy element.
3. "**Specific Targets, Milestones and Institutional Responsibilities**" state the national targets, and the planning and institutional responsibilities to implement the strategies.

5.2.1 Policy

The "Energy Policy" consists of nine (09) elements of which the fourth (4th) element is devoted for the promotion of indigenous resources and it is reproduced below:

Promoting Indigenous Resources - Indigenous energy resources will be developed to the optimum levels to minimize dependence on non-indigenous resources, subject to resolving economic, environmental and social constraints.

Minimum dependence on non-indigenous resources and optimum development of local energy resources will minimize the vulnerability of energy supplies to external factors such as the international socio-political environment. Further, it also eases pressure on the country's balance of payments. The Energy Policy includes necessary initiatives to vigorously implement the country's oil and gas exploration programme.

5.2.2 Implementing Strategies

Implementing strategies suggested for the Promotion of Indigenous Resources are as follows:

1. The use of economically viable, environment friendly, non-conventional renewable energy resources will be promoted by providing a level playing field for developers of non-conventional energy resources to compete and supply energy at the best price through transparent procurement processes.

2. Concessionary financing will be sought to implement the remaining medium scale hydroelectric projects, which are economically, environmentally and socially viable, but not viable under normal commercial terms. Pricing of electricity generated would, however, be on commercial terms.

3. Necessary incentives will be provided and access to green funding including Clean Development Mechanism (CDM) will be facilitated to develop non-conventional renewable energy resources to ensure their contribution to the energy supply in special situations, even if their economic viability is marginal.

4. A facilitation agency dedicated to the systematic planning and promotion of non conventional renewable energy resources will be established.
   ***Note**: Achieved by the establishment of SLSEA.*

5. Oil and natural gas resources will be explored and commercially exploited; both public and private sector investment will be promoted in this regard.

6. Biomass-based energy projects will be developed in areas where land resources are available, enabling new industrial activities in such areas, emphasizing on creating rural income generation avenues.

7. Research and development on adopting new and emerging technologies and practices, particularly in the use of non-conventional renewable energy, to suit local conditions will be promoted.

8. Focused attention will be drawn on development of biofuels as an alternative energy resource for the transport sector.

9. Initiatives of other sectors and institutions to enhance biomass supplies, convert biomass and other waste to energy will be encouraged and supported where appropriate.

In addition to the above, under general strategies, there are some specific references on renewable energy as follows:

1. Measures will be taken to obtain maximum benefits from international arrangements such as the Clean Development Mechanism, which would benefit the global environment and in the process facilitate the financing of energy efficiency improvement as well as renewable energy development projects in the country.

2. A central agency will be empowered to ensure that the prescribed policy measures are implemented in respect of energy efficiency and non-conventional renewable energy development.
   ***Note**: Achieved by the establishment of SLSEA.*

3 Research and development addressing energy sector issues will be encouraged and promoted. Existing research institutions will be supported to undertake research and development on energy, with a view to creating a specialized national centre for energy studies.

5.2.3 Specific Targets, Milestones and Institutional Responsibilities

This section of the policy document deals with specific targets and milestones to be achieved when implementing the energy sector strategies identified. Further, the institutions responsible for implementation of these strategies are also identified in this section against each activity. Relevant sections are reproduced below;

Electrification of Households

Electricity will be made available to all feasible areas by extending the national grid and focused rural energy initiatives using **off-grid technologies**. Capital subsidies available for grid-connected households will be extended to households seeking off-grid electricity, through the Provincial Authorities.

Medium-term targets for electrification of households through grid extension

Year	Total households to be provided access to the grid
2003	65% (actual)
2006	75%
2010	80%
2015	85%

Table 5.1 – Medium-term Targets for Electrification of Households through Grid Extension (**Source**: Sri Lanka Sustainable Energy Authority)

Medium-term Targets for **off-grid electrification** of households

Year	Total households using off-grid electricity systems
2003	2% (actual)
2006	4%
2010	6%
2015	8%

Table 5.2 – Medium-term Targets for Off-grid Electrification of Households (**Source**: Sri Lanka Sustainable Energy Authority)

Institutional responsibility: Ministry of Power and Energy shall prepare a long-term electrification plan, updated every year. Public Utilities Commission of Sri Lanka (PUCSL) would be responsible for its implementation, with the support of the electricity utilities, SEA, Provincial Councils and other stakeholders.

Fuel Diversity and Security

1 The electricity sub-sector shall rapidly move from the present two-energy resource (hydropower and oil) status to a multiple resource status.

2 The Government shall not initiate or entertain any proposal either by the electricity utilities or private developers to build power plants that will use oil, oil-based products or fuels of which the price is indexed to the oil price, unless they are required to be included in the generation expansion plan due to technical limitations in other plant types. This moratorium on oil-based power plants shall be factored into the Long Term Generation Expansion Plan (LTGEP) and shall remain in force until 80% of Sri Lanka's electrical energy supplied to the national grid is from non-oil based resources. The strategy of the Government shall be to immediately diversify into a third energy resource. To ensure maximum possible security against price and supply fluctuations, and to ensure the growing demand is reliably met, this third energy resource shall be coal. The LTGEP studies confirm the viability of this strategy. Non-conventional Renewable Energy (NCRE) shall be the fourth energy resource in this diversification and security strategy.

3 Every player in the petroleum sub-sector downstream retail business shall maintain a strategic fuel reserve equivalent to a minimum of 30 days' consumption at any given time. Every effort will be made to replace petroleum-based fuels with indigenous biomass and biofuels in industrial thermal applications and transport applications by encouraging such fuel switching initiatives through appropriate incentives, including facilitation of access to green funding such as CDM.

Institutional responsibility to implement this fuel diversity and security policy and to achieve targets will lie with the PUCSL, electricity utilities and petroleum sub-sector downstream players. The Long-Term Generation Expansion Plan (LTGEP) shall reflect the above strategy and milestones. LTGEP shall be a 20-year plan, updated at least once in two years.

Non-conventional Renewable Energy (NCRE) Based Electricity in the Grid

1 NCRE Resources include small-scale hydropower, biomass including dendro power, biogas and waste, solar power and wind power. These are the leading sustainable, non-conventional forms of renewable energy promoted in Sri Lanka for electricity generation into the grid. In addition, other NCRE resources such as wave energy and ocean thermal energy are also encouraged where appropriate.

2 Commercial development of biomass will be encouraged and facilitated as a new rural industry, allowing rural poor to engage in fuel wood farming and participate in the mainstream economic activity by supplying electricity to urban load centres.

3 The Government will endeavour to reach a minimum level of 10% of electrical energy supplied to the grid to be from NCRE by a process of facilitation, including access to green funding such as CDM. The target year to reach this level of NCRE penetration is 2015.
***Note**: By end 2007, country has achieved 3.5%* [24].

4 A cost-optimal Long-term Non-conventional Renewable Energy Plan (LTNCREP), which shall provide interim targets for specific NCRE technologies, upper thresholds of pricing, and resource costing will be prepared. The LTNCREP shall be a 20-year plan, updated at least once in two years.

5 A review of technical limits and financial constraints of absorbing NCRE will be carried out and will be followed by a technical and financial barrier removal exercise, with external support and expertise where necessary.

6 The NCRE strategy shall not cause any additional burden on the end use customer tariffs. If justified, the Government may subsidize the energy utilities for this purpose.

7 The Government recognizes that certain NCRE technologies would require incentives to ensure their capacity build-up to contribute to the national NCRE target. These incentives shall be provided on a competitive basis, in which the NCRE developers shall bid for a share of the NCRE target, subject to a price ceiling. NCRE incentives shall be technology-specific and based on actual energy supplied to the grid.

8 To make available the incentives for NCRE technologies, the Government will create an 'Energy Fund', which will be managed by the SEA. This fund will be strengthened through an energy cess, grants received from donors and well wishers, as well as any funds received under CDM. This fund will be used to provide incentives for the promotion of NCRE technologies and strengthen the transmission network to absorb the NCRE technologies into the grid.

9 NCRE developments will not be charged any resource cost (royalty) for a period of 15 years from the commercial operation date. Resource costs charged from selected NCRE technologies after the 15th year of commercial operation shall be used to finance incentives for further NCRE development, through the Energy Fund.

Institutional responsibility to implement this NCRE strategy and to achieve targets shall lie with the PUCSL and SEA. The SEA shall prepare a cost-optimal Long-term Non-conventional Renewable Energy Plan (LTNCREP). Implementation of the LTNCREP shall be promoted and facilitated by SEA.

5.3 Sri Lanka Rural Electrification Policy [6]

The Sri Lanka Rural Electrification Policy expresses the intentions of the Government of Sri Lanka to enable greater access to electricity and to enhance the economic and social development. The government has devised a number of schemes to encourage and support the rural electrification program.

- A Regulatory Framework
- Cost reflective electricity tariff setting
- Third party access to the networks
- Subsidy Mechanism for Rural Electrification

A Regulatory Framework
The government will assign separate responsibilities for (i) planning, monitoring, policy setting, licensing and permits; (ii) establishing regulations; (iii) compliance and (iv) conflict resolution, arbitration and adjudication. Small stand alone systems such as village-hydro schemes and possible mini-grid systems with other forms of electricity generation in rural areas will be subject to a separate fast-track and less cumbersome licensing process while maintaining the required safety standards.

Cost reflective electricity tariff setting
A tariff regime that enables cost recovery at a reasonable return on investment will be allowed, particularly in isolated mini-grid systems in rural area accepting the principle of differential pricing. Further, the system of regulation will ensure that bulk supply tariff of the main grid will be made cost reflective so that any isolated mini-grid can compete with the main grid supply on a level playing field.

Third party access to the networks
Small producers of electricity will be allowed to sell directly to any consumer connected to the main grid using the distribution and transmission network at a cost reflective network service charge.

Subsidy Mechanism for Rural Electrification
A subsidy mechanism for rural electrification based on principles of economic efficiency, transparency and social equity may be established to support rural electrification programmes. Financing for these subsidies will be made available through government contributions and donor assistance. The government will provide a framework to ensure that all electricity supplier to rural consumers can compete on equal terms. Any subsidies will be made available to all parties interested in rural electrification on a competitive basis.

5.4 National Environmental Action Plan [23]

The National Environmental Action Plan (NEAP) 1998-2001 has been prepared to set the national environmental agenda for the 21st Century. The NEAP is presented in two sections. Section 1 is on strategy to pursue sustainable development, and defines the policies, institutional shifts and actions needed to meet the environmental challenges that will confront the country in the short and long terms. Section 2 presents the sectoral perspective, which includes an analysis of nine key sectors: land, water, biological resources, coastal and marine resources, industry, minerals, **energy**, built environment, and environment and health.

Related to the **energy** sector in particular, the following are the recommendations;

- Carry out an environmental assessment for the entire energy sector and encourage energy auditing.
- Review energy policy and electricity generation plan to address environmental concerns.
- Conduct feasibility study on use of alternative fuels, especially RE sources for power generation, industry and transport.

Recommendations for **biomass** promotion are as follows.

- Encourage establishment of village wood-lots where possible with private sector participation and home gardens.
- Improve efficiency of biomass utilization through the use of fuel wood gasifiers and energy-efficient fuel wood cook stoves.
- Develop collection, storage and processing of urban biodegradable wastes for biogas generation and develop technologies for biogas storage and use.

5.5 Forestry Sector Master Plan [23]

The Forestry Sector Master Plan has proposed policies and strategies to optimize the forestry sector's role in national **energy supply** and assist people in meeting their **energy needs**. The following are the measures to deal with the major issues with regard to forestry plantation.

To reduce the widening gap between sustainable supply of and demand for energy in specific localities, the following measures are recommended;

- Promote agro-forestry to increase the supply of bioenergy.
- Block fuel wood plantations should not be promoted, because they are not profitable. Put emphasis on private and community planting of multiple–use trees.
- Special attention should be paid to improving access to natural resources, for example, through the development of joint forest management systems or allocation of land to the landless.

To create a supportive institutional environment to address the problem of energy and fuel wood scarcity, the following measures are recommended;

- Put emphasis on providing a supportive policy and a legal framework for enhancing people’s rights and opportunities to manage the local resource base and respond to resource scarcity, for example, by improving land tenure, and provision of extension, technical assistance, training, credit and other support systems to village people.
- Relax regulations on felling and transporting trees grown on private lands.
- Develop a national bioenergy strategy, and establish a single agency responsible for coordinating the implementation of this strategy.

Further, the following strategies are highlighted for the promotion of fuel wood plantation as the main biomass source for future energy applications.

- Maintain an adequate percentage of fuel wood plantations in national reforestation programmes.
- Encourage planting multiple tree species in home gardens with the objectives of increasing productivity and providing an additional income to the owners.
- Plant multipurpose tree species on available spaces along the state roads, stream banks and other available lands owned by institutions to create a supplementary source of fuel wood as a by-product.
- Provide state lands on a long-term lease with suitable tree tenure arrangements to anyone willing to plant trees.
- The fuel wood-consuming industries should make every effort to have their own fuel wood plantations wherever possible.
- Make arrangements to provide credit facilities and other necessary incentives, including tax concessions.
- Convert around 15 % of uneconomical tea lands into fuel wood plantations with fast-growing and high calorific value fuel wood species having coppicing ability.
- Design training courses for GOs, NGOs and plantation organizations working in forestry and tree production systems at different levels to plan and implement integrated tree-based farming systems.

5.6 Net Metering [24, 25]

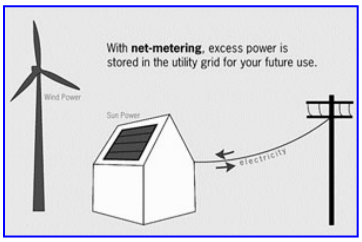


Figure 5.2 – Net-metering
(**Source**: Lanka Business Online)

In August 2008, the Sri Lankan Cabinet of Ministers granted the approval for electricity distributors to commence Net Metering, where customers would be able to generate small amounts of renewable energy, 'export' to the national grid, and only pay for the 'net' amount of electricity used. This policy decision would encourage customers to generate their own electricity through renewable sources of power such as solar, hydro or biomass in their own premises.

Sri Lanka is among the first few developing countries to introduce Net Metering, and that too free of charge, except for the initial charge for a one-time charge for a new meter and protection equipment. Total flexibility is allowed to the customer to choose the type and size of his renewable energy facility, and the customer is free to switch on and off whenever he likes.

Only power generated in the customer's own premises could be 'exported'. Customers would not be paid cash for excess power over a meting period (usually a month) but they would be able to carry the excess power forward to be used in the future. Customers would then have two-way metres installed.

Both Ceylon Electricity Board (CEB), and Lanka Electricity Company (LECO) customers could apply for a license and sign a 10-year agreement under the purview of SEA.

The net metering would be limited to a capacity 13 kW for single phase consumers. Individuals who want to generate more than 40 kW would have to sign an existing standardized power purchase agreement where a tiered tariff applies.

5.7 Fuel Wood Plantation [32]

With the intention of promoting biomass for power generation as well as for the thermal applications in industry and commercial sectors, GOSL in 2005 took some progressive policy decisions to promote the commercial growing and utilization of fuel wood:

Figure 5.3 – Gliricedia under Coconut Plantation

- An Inter Ministerial Working Committee was established to identify the issues to be addressed to promote the growing and utilization biomass fuels. This Committee has submitted its final report. The Government is in the process of implementing the recommendations of this committee.
- The Ministry of Plantation Industries has decided to support and promote fuel wood crops by including *Gliricidia* as the fourth major plantation crop under the ministry.
- The Coconut Cultivation Board has decided to give a subsidy of LKR 7,500 (nearly USD 65) per ha for inter-planting *Gliricidia* in coconut lands.
- The Coconut Development Authority has initiated action to support the use of SRC wood as a fuel for the desiccated coconut industry.

5.8 Non Conventional Renewable Energy Tariff [33]

In April 2009, SLSEA has announced the new rates for electricity purchased by CEB from Non-conventional Renewable Energy (NCRE) Sources under Small Power Purchase Agreements (SPPAs). The tariff and the SPAA will continue to be standardized and non-negotiable. The tariff is cost based and technology-specific, and the developers have the option of selecting either a three-tier tariff or a flat tariff. The SPPAs will continue to be applicable to projects with a rated generating capacity up to 10 MW, and will be valid for a period of 20 years and extendable by mutual consent. This tariff will remain unchanged until further notice and the tariff review process is initiated strictly on necessity.

Mini-hydro, Wind, Biomass (Dendro) – means sustainably grown firewood, Agricultural & Industrial Waste, Municipal Waste, Waste Heat Recovery have been identified as NCRE for this tariff system.

Option 1, i.e. three-tier tariff consists of a fixed rate, operation & maintenance (O&M) rate, and a fuel rate. Three tiers are 1-8 years, 9-15 years and 16-20 years and the fixed component of the tariff is arranged in a descending manner. In the case of mini-hydro and wind there will be a royalty to the government after 16th year.

Option 2, i.e. flat tariff consists only of an all inclusive fixed rate for the entire period of 20 years. Extension after the 20th year will be at the same rate as for an Option 1 project. Given below is the Option 2 tariff.

Technology	All Inclusive Rate (LKR/kWh) For years 1-20
Mini-hydro	14.58
Wind	23.07
Biomass (Dendro)	18.56
Agricultural & Industrial Waste	13.88
Municipal Waste	15.31
Waste Heat Recovery	9.55

1 USD = 115 LKR

Table 5.3 – Non-conventional Renewable Energy Tariff
(**Source**: Sri Lanka Sustainable Energy Authority)

5.9 Biofuel Guidelines & Regulations [40]

The National Energy Policy has identified fuel diversification in the transport sector and the promotion of biofuels as a high priority research and development need. The policy also encourages biofuel development for the transport sector.

The Ministry of Petroleum & Petroleum Resources Development in Sri Lanka has developed the "Guidelines to be implemented for the formulation and usage of alternative fuels in Sri Lanka". The guidelines have been formed considering the production, economics, by-products, storage, specifications, quality control, emissions and environmental concerns, pricing and marketing of specifically bioethanol and biodiesel for transport applications for blending with petroleum fuels. This provides a stepping stone to commence the production and use of liquid biofuels at a national scale in Sri Lanka [40]. The selection of an agency to issue licenses for the potential investors is yet to be done.

5.10 Public Utilities Commission [51]

GOSL has begun major reforms in regulating certain industries, initially focusing on the state-owned utilities. Historically, the regulation activities have been the responsibility of the various ministries. However, the ministries also had direct links to the operations of the agencies they regulated. These dual roles as owner and regulator raised conflicts of interest. For example, the regulation of the power sector was the responsibility of the Ministry of Power and Energy, and the same Ministry also presided over the management and operations of the Ceylon Electricity Board, the state-owned electricity company.

To remove the conflict of interest, the Government has begun to establish autonomous regulators, authorities, or commissions that focus solely on regulation, while the ministries will maintain their functions in setting policy directions for the industry and the owning the public enterprises.

Another trend in the reform agenda is a shift away from single-industry regulatory agencies to multisector regulators. The benefit of a multisector regulator includes lower costs-both direct and indirect-fewer overlapping regulatory jurisdictions, and more consistency in regulation across industries.

This new generation of regulatory agencies includes the Public Utilities Commission (PUC), Consumer Affairs Authority (CAA), and the proposed Financial Services Authority (FSA). In addition there are number of other Commissions and Authorities with similar objectives.

Chapter 6

FINANCIAL INSTITUTIONS SUPPORTING RE PROJECTS & THEIR CURRENT STATUS

6.1 Introduction & Overview

This chapter provides information on financial institutions supporting renewable energy projects along with the present status of projects funded. Depicted below is an overview of dedicated funding mechanisms in the past and in the present.

Period	Project	Funding	Admin	Focus	PCIs
1997 - 2002	ESD	**Credit** - WB / IDA USD **19.7** m **Grant** – GEF USD **3.8** m	DFCC Administrative Unit	70% Mini Hydro 28% Solar	6
2003 - 2007	RERED	**Credit** - WB / IDA USD **75** m **Grant** – GEF USD **8** m	DFCC Administrative Unit	67% Mini Hydro 32% Solar	11
2008 - 2011	RERED-AF	**Credit** - WB / IDA USD **40** m **Grant** – GEF Balance from ESD & RERED	DFCC Administrative Unit	?	11 ?
2009 - ?	Commercial Bank	**Credit** – WB/IFC USD **15** m **Grant** – GEF, Ireland & Japan	Commercial Bank	Upgrading Renewable Energy Projects	?

Figure 6.1 – Dedicated Funding for Renewable Energy

The funding landscape of Sri Lanka in renewable energy projects witnessed a dramatic change in 1997 with the successful negotiation of GOSL with the International Development Association – IDA (Concessionary credit arm of the World Bank) to secure a concessionary credit line (USD 19.7 m) supplemented with a grant component (USD 3.8 m) from Global Environmental Facility (GEF). The Energy Service Delivery (ESD) project was the result of this initiative which was operative from 1997 to 2002.

Following the tremendous success of ESD, the Renewable Energy for Rural Economic Development (RERED) project was launched in 2003 by broad basing the development objectives with the enhanced credit line (USD 75 m) from the same funding source. A GEF grant of USD 8 m was made available for the RERED project.

At the end of RERED project in 2007, and again due to its resounding success, an additional credit line amounting to USD 40 m was made available by the same funding organization for the extended phase of RERED project operative from 2008 to 2011. The remaining grant components of ESD and RERED are available for the extended RERED. A private sector oriented and independent administrative unit was established under the DFCC Bank to steer and administer the project (initially ESD and thereafter RERED) including the grant disbursement on behalf of GOSL. Six Participating Credit Institutions (PCIs) participated in ESD and the number increased to 11 in RERED.

With the success of above projects and with the valuable experience gained, the Commercial Bank of Ceylon - CBC (one of the PCIs) has managed to tie up with International Financial Corporation - IFC (Private credit arm of World Bank) for 50% risk sharing of renewable projects undertaken by CBC. Initially, IFC will cover USD 15 m.

In addition to the above dedicated credit facilities, some renewable energy projects (biomass based power generation) have benefited from other credit lines such as Environmentally Friendly Solutions Fund (E-FRIENDS) though it is not meant for the promotion of renewable energy projects. The principal objective of this credit line made available by the Japan Bank of International Cooperation (JBIC) is to prevent industrial pollution in Sri Lanka. The National Development Bank (NDB) and the Participating Credit Institutions (PCI) provide long-term loans at low-interest to enable industries to reduce their pollution. Loans will be either for investment in anti-pollution equipment and facilities or for technical environmental protection training costs.

Further details of the projects mentioned above are explained in following sections.

6.2 Energy Service Delivery Project – ESD [18, 2]

The ESD Project was implemented during 1997 – 2002 by the GOSL, with World Bank and GEF assistance. The ESD Project comprised three components – a credit programme, a pilot grid-connected wind farm of 3 MW and a capacity building component for the Ceylon Electricity Board (CEB). The Administrative Unit (AU) set up within DFCC Bank was the executing agency for the ESD Credit Programme component and the CEB was the executing agency for the other two components.

6.2.1 ESD Project Credit Programme

The ESD Project Credit Programme provided the basis for a market-based approach to the introduction of renewable energy development in Sri Lanka. It was designed to promote private sector and community based initiatives for the provision of electricity services through grid-connected mini hydro projects, off-grid village hydro schemes and solar photovoltaic electrification of rural homes. The ESD Credit Programme resulted in a dramatic increase in the development of grid-connected and off-grid renewable energy projects, prepared and implemented by the private sector and village communities.

At completion, the ESD Project Credit Programme had met or exceeded all targets:

- 31 MW of mini hydro capacity installed through 15 projects against a target of 21 MW
- 20,953 solar home systems (SHS) installed, with a total capacity of 985 kW, against a revised target of 15,000
- 350 kW of capacity through 35 village hydro schemes serving 1,732 beneficiary households against a target of 250 kW through 20 schemes.

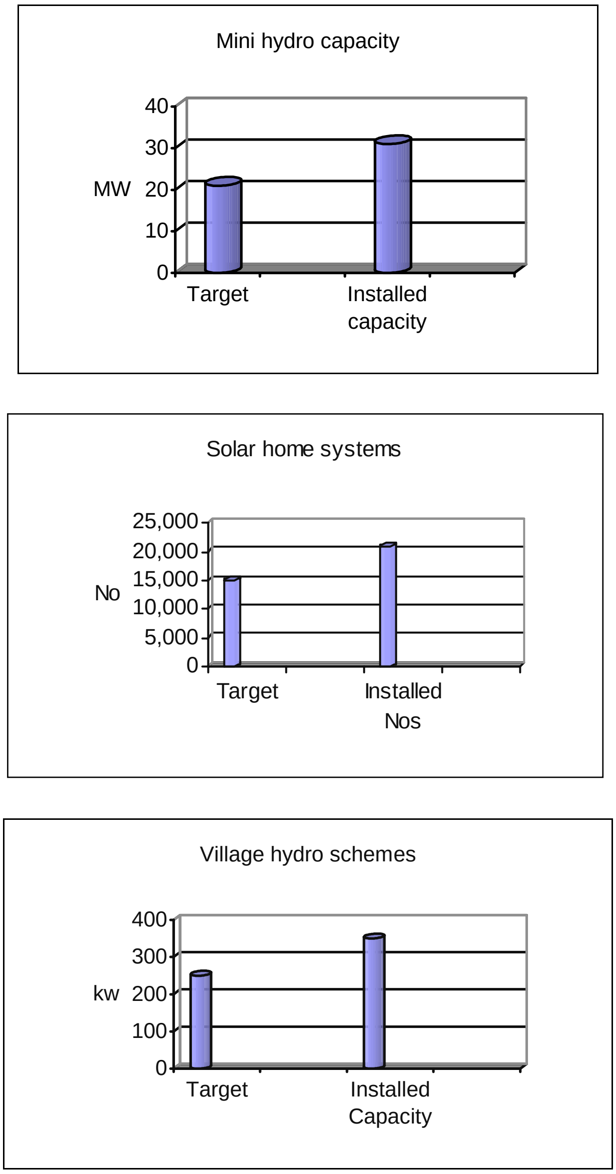


Figure 6.2 – ESD Project Targets & Achievements
(**Source**: Energy Sector Unit – World Bank)

The ESD Credit Programme was assisted by a US$19.7m line of credit from IDA of the World Bank and a US$3.8m grant from GEF. Loans for individual investments or subprojects were disbursed through participating credit institutions, namely DFCC Bank, National Development Bank (NDB), Hatton National Bank (HNB), Sampath Bank, Commercial Bank and Sarvodaya Economic Enterprises Development Services (SEEDS).

The Credit Programme provided medium to long-term funding to private investors, non-governmental organizations (NGOs) and co-operatives for:

- Off-grid electrification infrastructure through village hydro (OGVH) schemes and solar home systems (SHS)
- Grid-connected mini hydro (GCMH) projects and
- Other renewable energy investments.

Off-Grid Projects, following an initial period of market development, entered a phase of rapid and sustained growth during the final two years. The follow-on Renewable Energy for Rural Economic Development (RERED) Project builds on the success of the ESD Project.

6.2.2 Pilot Wind Farm

Figure 6.3 – Wind Farm
(**Source**: Sunday Observer)

In 1999, a pilot wind farm supplying an annual rated capacity of 4.5 Gwh commissioned in a 17 ha land closer to Hambantota town in the South under the ESD project, was successfully linked to the national grid. The wind farm comprises of five 600 kW turbines (total of 3 MW). The CEB continues to monitor and record operational data from the wind farm and learn from the experience in integrating such projects with the national grid. In 2006, the wind farm generated 2.31 Gwh [35].

6.3 Renewable Energy for Rural Economic Development RERED [2]

Following the success of the ESD project, the RERED Project was launched in 2002 to provide electricity access to rural households and small and medium enterprises through the deployment of off-grid renewable energy technologies as well as to promote private sector power generation from renewable energy sources.

The specific objectives of the RERED project include expanding commercial use of energy generated from renewable sources and fostering rural economic development and thereby improve quality of rural life by providing access to electricity. The credit support made available under both projects played a pivotal role in nurturing the sector.

Following the successful implementation of ESD project, several other financial institutions, including commercial banks, leasing companies and micro finance institutions displayed a keen interest in participating in the implementation of the follow-on RERED project. In addition to the 06 PCIs involved in the successful ESD project, 05 new PCIs were selected under the RERED project, namely Seylan Bank, Ceylinco Leasing Corporation, Lanka Orix Leasing Company, Alliance Finance Co and Sanasa Development Bank.

A total of USD 83 m was committed to Sri Lanka under the RERED project.

The two renewable energy development projects have enabled the electrification of almost 130,000 rural households as at 31st March 2009 [18]. The project initiatives have furthermore provided a firm foundation for entrepreneur and technical capabilities as well as financing capabilities.

6.4 RERED Additional Financing – [2,18]

With the full commitment of RERED Project credit line, the need to seek additional sources of long term funds to foster the continued growth of the renewable energy sector was identified. GOSL, with a view to addressing the issue, requested the World Bank for supplementary financing for the RERED Project through IDA credit.

With the signing of the RERED Additional Financing agreement between the GOSL and the World Bank, the RERED project, which was implemented over the period 2002-2007, has been extended until 2011. IDA provided an additional USD 40 m line of credit for RERED Additional Financing.

6.5 Projects Implemented under ESD and RERED [18]

Given below are the Off-Grid Village Electrification Schemes implemented and Solar Home Systems installed under ESD, RERED and RERED-AF from 1998 to 2008.

Off-Grid Village Electrification Schemes Completed under ESD (1997-2002), RERED (2003-2007) & RERED Additional Financing (2008-2011) Projects											
	ESD Project					**RERED**					**RERED AF**
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Cumulative Capacity kW	0	22	75	128	350	661	810	1,011	1.171	1,432	1,577
Cumulative Number of Households	0	140	365	573	1,732	2,548	3,817	4,587	5,129	5,869	6,425

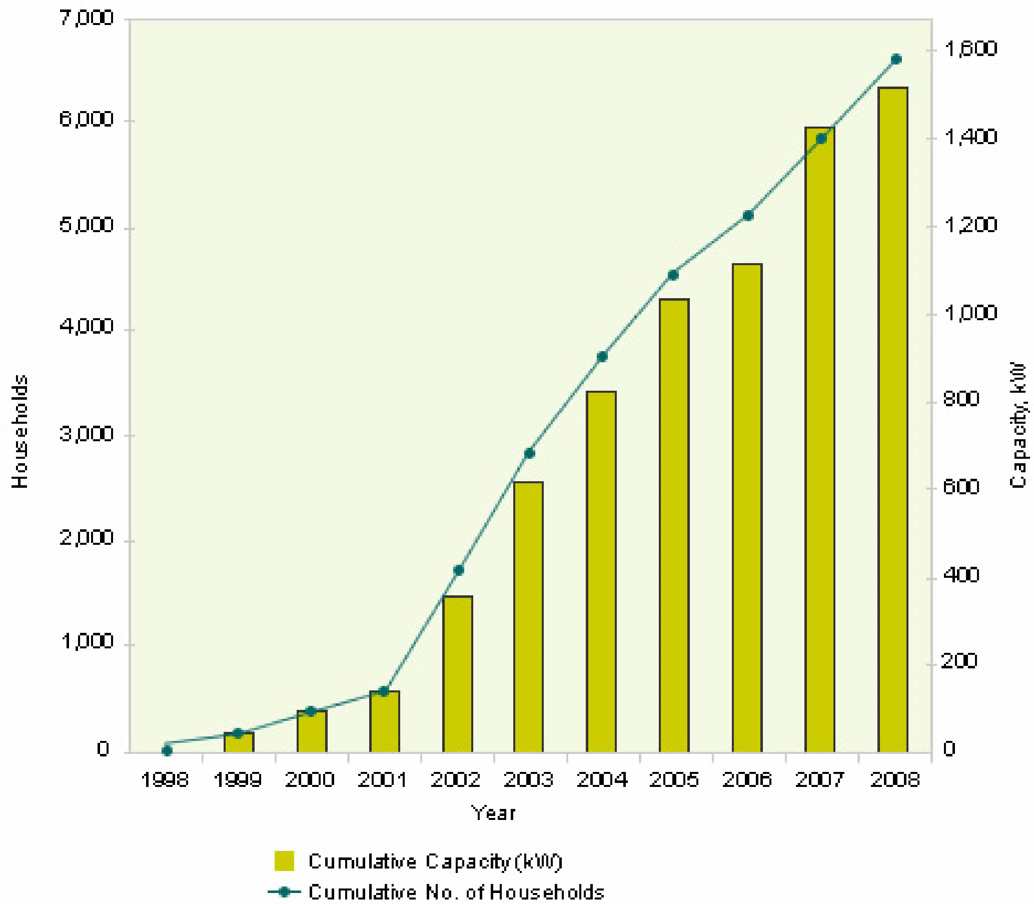


Figure 6.4 – Performance of ESD & RERED – Off-grid Village Hydro
(**Source**: *http://www.energyservices.lk/statistics/esd_rered.htm*)

Solar Home Systems Installed under ESD (1997-2002),

RERED (2003-2007) & RERED Additional Financing (2008-2011) Projects											
	ESD Project					RERED					RERED AF
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Cumulative Capacity kW	1.6	25.6	108.6	615.8	984.6	1867.9	2904.2	3909.9	4624.2	5170.2	5548.6
Cumulative Number of Systems Installed	50	683	2574	13316	20953	39530	62834	83773	101551	115195	124800

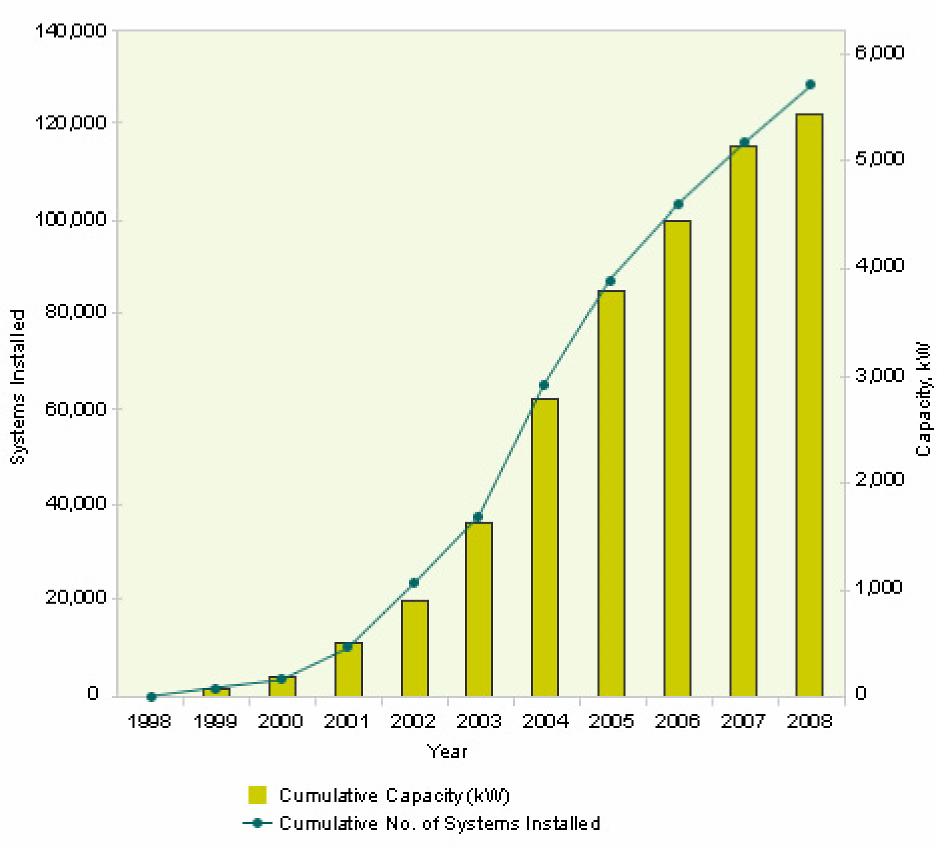


Figure 6.5 – Performance of ESD & RERED – Solar Home Systems
(**Source**: *http://www.energyservices.lk/statistics/esd_rered.htm*)

6.6 Project Performance in Facilitating Finance [2]

Achievement of project disbursement targets - The long term financing arrangements extended under both ESD and RERED credit programs, have been identified as a key attribute that enabled PCIs to meet project funding targets. The credit facility provided the end user access to liquidity for both capital investment and working capital on affordable terms. While some project developers required long term financing to meet high infrastructure costs coupled with relatively long term cash flow generation, other developers, such as solar system developers needed access to affordable finance. Some developers sought readily accessible working capital. The financing structure of the two projects successfully addressed the needs of the various end users. The availability of long term financing to PCIs was a pre-requisite to match the long pay back periods, in particular of village and mini hydro projects.

Payback period and financing costs - The ESD and RERED credit programs had been structured to effectively support the sector in terms of pay back as well as the rate of interest. Loans to sub borrowers incorporated maturity periods up to 10 years, while the rate of interest under RERED was pegged to the least volatile and least costly benchmark in the country, the Average Weighted Deposit Rate (AWDR).

PCIs that receive refinance at AWDR extended sub loans at variable margins over AWDR, re-priced semi annually. The terms associated with grid connected mini hydro projects were typically AWDR plus 4% to 5% for maturities of 6 to 8 years, while the terms for off-grid projects were AWDR plus 4% to 6% for similar maturities. Solar home systems were however typically linked to AWDR plus a minimum margin of 10% for maturities of 2 to 4 years, primarily due to high administrative costs involved. The long term nature of the repayment program together with the reasonable interest rate structure, matched the long term requirements of mini hydro developers.

Recoveries - The suitability of the above financing schemes is reflected in the satisfactory collection ratios reported by PCIs that have been in excess of 95%. It is, however, pertinent to note that some PCIs that extended sub loans for solar projects up to 5 year tenures had experienced difficulties in recoveries in the latter years. The delays in collection were attributed to additional maintenance expenses incurred by the end user, such as replacement of batteries used in solar home systems. Some PCIs thereafter disbursed sub loans to end users for periods of 3 to 4 years. This strategy had reportedly resulted in a marked improvement in their collection ratios.

6.7 Viewpoints of PCIs [2]

M.Boyagoda - Consultant commissioned by the Ministry of Finance, Government of Sri Lanka under the RERED Project to Evaluate the Capital Market Constraints to Financing Renewable Power Projects in Sri Lanka, conducted interviews with selected PCIs and other stakeholders in order to make an objective assessment of their commitment to promote renewable energy projects as well as to ascertain specific concerns in funding the sector. The following salient observations reflect the broad consensus among the stakeholders.

1. Project lending under both ESD and RERED schemes to promote rural electrification had been mostly committed for mini hydro projects. Two PCIs had, however, focused on financing solar home systems. 70% of disbursements under the ESD project were for mini hydro projects, followed by solar projects that received 28% of the funds. Meanwhile 67% of the RERED credit line had been deployed to fund mini hydro projects and 32% for solar projects.

2. Most PCIs had engaged in a syndication process to synergize technical skills and minimize risk exposure. Technical expertise was available inhouse with some PCIs, while some others obtained outside assistance.

3. The average loan tenor ranged from 6 to 8 years, besides a grace period of 1 to 2 years. The rate of interest on an average amounted to AWPLR + 5% for mini hydro projects, while solar projects received lending at a flat rate ranging from 10% p.a. to 12% p.a.

4. One PCI reported exposure to this sector of 5% of their total asset book while some PCIs are considering the imposition of a sector exposure limit.
5. The lack of power generation at optimal capacity was a concern reported by PCIs. Power generated reflected only 35% to 40% of expected capacity, the reasons for which are presently being investigated.

6. Since most of the optimum sites for mini-hydro projects are already in use, the cost of developing less favourable sites could be considerably higher resulting in the escalation of project cost estimates.

7. A time lag of 2 to 3 years is reported in the legal process relating to the acquisition of land, while project cost estimates could escalate in the interim.

9. Lack of proper planning on the part of the CEB in supplying electricity access to under privileged areas. The possibility of connection to the national grid has at times prompted borrowers to defer solar system implementation plans. This is primarily due to end user preference to obtain grid connectivity rather than a solar powered energy option.

10. Recovery issues were experienced in some instances. One PCI that focused on solar home systems had disbursed almost 60% of that portfolio to the North and East provinces, the recovery of which is doubtful under present conditions. Some PCIs had incurred losses associated with the tsunami. While the overall recovery rate is very satisfactory, approximately 95%, such incidences have prompted PCIs to consider requesting equity contributions up to 40% for future lending.

11. Financing of renewable power projects would be costlier, due to depreciation of the rupee on the one hand and increasing cost of raw material such as solar cells, in the international market, on the other hand.

12. A lack of enthusiasm was witnessed in assisting wind power projects which remain in an experimental stage, as well as biomass projects due to possible constraints in raw material supply.

13. While PCIs remain committed to promoting the sector, doubts were expressed in deploying their own financial resources to fund renewable power projects, in the absence of RERED type assistance due to the inherent high asset liability mismatches that could be compounded by engaging in long term fixed rate lending. Given PCIs cost profiles any lending out of own resources would be pegged to the AWPLR plus a probable margin of 5%. This would expose the producer to a severe interest rate risk.

6.8 E-FRIENDS Loan Scheme [47]

Environmentally Friendly Solutions Fund (E-FRIENDS) is a concessionary loan scheme implemented by National Development Bank (NDB) with JICA supports through a Japanese ODA loan.

E-FRIENDS provides loans to private companies via Participating Credit Institutions, in order to support private companies' medium and long-term investment in environment improvement activities including the introduction of anti-pollution technologies. E-FRIENDS also finances the expenses for consulting services and training, which is required by private companies to obtain technological and environmental support to implement environmental improvement activities. So far, E-FRIENDS has provided some seven billion rupees (LKR) for approximately 800 projects. The financing framework is shown in the below diagram [47].

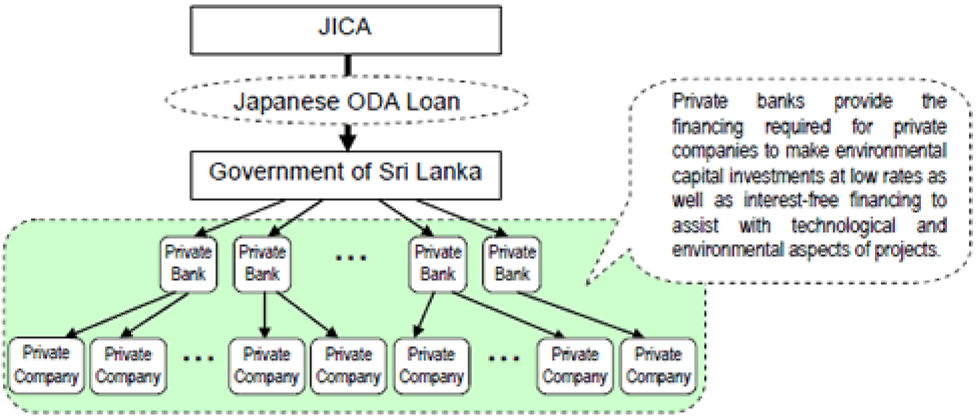


Figure 6.6 – Financing Framework of E-FRINDS Loan Scheme
(**Source**: http://www.jica.go.jp/english/news/press/2009/090420.html)

Renewable energy projects are also benefited by this loan scheme as they are qualified under environmentally friendly projects.

Principal Terms & Conditions for Sub-Loans under the Credit Component: [48]

- Loan Amount: Up to 100% of the project cost subject to a maximum of LKR 20 million (USD 174,000).
- Equipment that has both pollution control function and results in a substantial increase in profitability will be eligible for loan amount covering 70% of the cost.
- Repayment Period: Maximum 10 years
- Grace Period: Maximum 2 years
- Security: Normally a mortgage on the project assets
- Interest Rate: 6.5 %

E-Friends Interest Free Loan under the Technical Assistance Component: [48]

- The interest free technical assistance loan is available to cover the consultancy costs directly related to the project, which is to be implemented under the E-Friends scheme.
- Interest Free Loan Amount: Up to 75% of the cost subject to a maximum LKR 750,000 (USD 6,520).
- Repayment Period: Maximum 5 years
- Grace Period: Maximum 12 months
- Security: Normally mortgage on project assets

Participating Credit Institutions (PCIs): National Development Bank, DFCC Bank, Hatton National Bank, Commercial Bank of Ceylon, Sampath Bank, Seylan Bank, and branches of these banks.

6.9 CBC – IFC Project [19, 20]

The International Finance Corporation (IFC) and Commercial Bank of Ceylon (CBC) signed an agreement in June 2009 to upgrade renewable energy projects in Sri Lanka. According to the agreement IFC will share 50 percent of the risks of the renewable energy projects undertaken by the CBC.

The project follows a unique "distributed generation" approach, with smaller scale production of electricity at or near energy demand improving reliability of supply and lowering pollution by using renewable sources. The project is expected to produce economic benefits for local project developers including small and medium enterprises.

Initially the IFC will cover USD 15 m of the renewable energy projects of the commercial bank. This includes over USD 10 m micro hydro projects implemented and two wind power projects of 10 and 20 MW to be implemented in the Puttalam district.

IFC will share its financing, project structuring capability and benchmark data for renewable energy technologies with Sri Lanka. IFC will also help enhance the bank's ability to appraise projects using these technologies. An advisory component funded by the Government of Ireland and Japan and Global Environment Facility will help the CBC to build the capacity and skills needed to implement the program.

Most of the prime hydro power potentials in the country have already been exploited. The remaining are sub-prime projects where the risk is high. Other renewable energy options that CBC has focused are wind and bio-mass, which are both risky ventures. Climate changes and other technical factors that would obstruct the power generation can thwart revenue flows of these projects and so the bank will have to face credit risk. Under the agreement the IFC shares 50 per cent of such risks, he said.

6.10 The Netherlands Development Finance Company [22]

The Netherlands Development Finance Company (FMO) is the international development bank of the Netherlands. FMO invests risk capital in companies and financial institutions in developing countries.

FMO has been invited to arrange up to USD 55 m debt for South Asia Energy Management Systems Inc. (SAEMS) for a portfolio of 12 small hydro power projects (SHP) in Sri Lanka and Uganda with a combined capacity of 58MW.

SAEMS was established in February 2006, to undertake the development, construction, acquisition, ownership and long term operation of hydro-electric and other renewable energy projects and cellulosic ethanol biofuels production facilities world-wide. The portfolio consists of eleven projects in Sri Lanka and one in Uganda. Five SHPs were acquired by SAEMS and are operational (18.5MW), four SHPs are under construction (29.3MW) and three are under development (10.2MW). The total investment amounts to USD 83.5 m, of which FMO itself will invest USD 31 m, USD 20 m by means of a senior loan and USD11 m by means of a mezzanine loan.

6.11 Future Funding Needs [2]

Both the ESD Project and the RERED Project were concerned with addressing the issue of providing long term financing support for renewable energy investments. Such measures have served the purpose excellently, with capacity installed often surpassing targets. However, given the magnitude of the task still ahead, the need to formulate a viable long term financing mechanism to augment electricity generation, transmission and distribution throughout the country, remains a critical need.

The funding needs of the sector has been assessed given the estimate considered in the National Energy Policy and Strategies for Sri Lanka, that of 10% of electricity generation to comprise from renewable energy. While sources attributed to the Central Bank estimates that new power plants of 200 MW would be required annually to meet the growth in demand, it is anticipated that nearly 350 MW of the above requirement would comprise of new generating capacity to be installed through renewable resources by the year 2015. The additional funding requirement to facilitate the above increase in renewable energy capacity is estimated to be approximately US$ 242 million. The refinance component of 80% would amount to US$ 193 million.

6.12 Proposed Renewable Energy Support Bond – RESB [2]

As a means of sustaining the growth of both on-grid and off-grid renewable resource based power projects in the context of the imminent completion of RERED, the GOSL is at present evaluating the possibility of issuing a LKR 2,000 million (USD 17.4 m) Renewable Energy Support Bond (RESB).

Electricity is a priority sector that has thus far been subsidized by the government and backed by donor support. The government has not only extended concessionary finance to the sector, but has also assumed the credit risk of PCIs as well as the exchange risk associated with foreign financial assistance for the purpose of developing the sector.

Financing of long term projects through the local debt market would only happen at a price, given the fairly under developed state of the market. Thus the success of small scale power projects would be dependent on the financial support that is made available. The proposed RESB has taken into account this need for a further financial subsidy for the sector.

Salient features of the RESB proposal:

1. The issuer would be the Treasury.
2. The bond would be of long tenor, 10 to 15 years and would incorporate a variable coupon linked to TBill, TBond, AWDR or AWPLR together with a premium thereon.
3. In the alternative, the bond may also be issued at a discount to face value, based on market expectations.
4. The bond may be offered on a tender as for TBills, as a debt listed on the Colombo Stock Exchange or take the form of a private placement.
5. The proceeds from the bond issuance would be made available for partial refinance of project loans extended by PCIs. The rate of interest considered for refinance to PCIs is the AWDR.
6. PCIs would obtain refinance directly from CBSL and service obligations to CBSL on due dates.
7. CBSL would create a sinking fund from the debt service payments from PCIs to settle coupon payments and to redeem the bond at maturity.
8. The fund would be invested by CBSL in an interest earning instrument until its liquidation. The interest would be credited to the fund.
9. Any shortfall arising between the liquidated sinking fund and the redemption dues, would be funded for instance through a Treasury subsidy.

6.13 Administrative Unit [21]

RERED's Project Management Unit was converted to a body responsible for developing renewable energy strategies and addressing implementation issues. This unit is currently the focal agency for the structuring of a proposed renewable energy bond. The unit also has responsibility for administering the off-grid subsidy rolled out by the Government. Its challenge is to further develop the renewable energy industry so that it functions even in the absence of external financing.

Chapter 7

SCOPE FOR UTILIZING RENEWABLE ENERGY

7.1 Introduction & Overview

This chapter describes the scope for the utilizing of renewable energy in Sri Lanka.

In order to improve the quality of life among the lesser-privileged segments of people who have no access to electricity to meet their energy requirements, it has become necessary to explore sustainable energy alternatives. Based on Sri Lanka's geographical positioning in terms of its tropical climate and natural terrain, Sri Lanka has a very high potential to draw on forms of renewable energy sources to meet this need. Endowed with a tropical climate, the potential for solar energy is very high. The terrain is highly conducive to tap hydropower, which has accounted for around 54 percent (in 2007) of total installed capacity of state utility. The opportunities for producing localized hydropower through micro (village) and mini hydropower technologies are also considerably high. In addition, the long coastal lines surrounding the island of Sri Lanka with several windy locations also provide tremendous scope for tapping wind power. In this context, the applications of RETs have a distinct advantage of being able to be used in localized settings and provide effective delivery without a centralized supply mechanism [9].

The National Energy Policy of Sri Lanka is focused on the promotion of renewable sources of energy as a means of addressing the supply inadequacies and sets out several initiatives and concessions to developers as explained in Chapter 5. The government has set itself a minimum target of 10% of national grid electricity to comprise of renewable energy sources by the year 2015 [2].

A study carried out by DFCC Bank in 2007 under the RERED project, has estimated the potential from renewable energy technologies in Sri Lanka by the year 2015 as follows [2];

Energy Source	Estimated Potential by year 2015
Solar Energy	11 MW
Wind Energy	50 MW
Mini Hydro Energy	300 MW
Biomass Energy	90 MW

Table 7.1 – Estimated Renewable Energy Potential by 2015 by DFCC Bank
(**Source**: DFCC Bank)

However, the total renewable energy potential in Sri Lanka is found to be quite substantial, especially in Wind and Dendro as shown in the below table [31].

	2006 (MW)	Potential (MW)
Mini-hydro (on-grid)	106	300
Mini-hydro (off-grid)	1.4	-
Dendro (on-grid)	2	4,000
Wind (on-grid)	3	24,000
Solar (on-grid)	0.035	-

Table 7.2 – Estimated Renewable Energy Potential
(**Source**: Reference 31)

It is hard to estimate the potential of off-grid Mini-hydro as well as on-grid Solar. As the on-grid Mini-hydro potential is expected to be fully harnessed by 2015, Sri Lanka has to rely on Dendro, Wind and Solar to increase its share of non-conventional renewable energy in the energy supply portfolio. Though there is a potential for Tidal and Wave energy, development of these sector will take a considerable period of time.

7.2 Hydro Power

Small streams in the upper catchments as well as major rivers of Sri Lanka offer considerable potential to generate hydroelectric power. The potential for large scale hydro plants have already been harnessed by CEB.

A study to assess the small hydro potential in Sri Lanka (focusing largely on the **plantation sector**) was concluded in 2002 by Sunith Fernando for Intermediate Technology Development Group – ITDG (now Practical Action) with the funding of The Royal Norwegian Embassy in Sri Lanka, the results of which are presented below.

The total estimated small hydro potential at the 257 surveyed sites in 2002 was 97.4 MW (see Table below), which was distributed among the three site categories as: 24.4 % in old estate sites, 21.2 % in new estate sites and the remaining 54.4 % in non-estate sites. The highest potential encountered in the study was 5,192 kW on “Kuru Ganga” while the lowest capacity of 5 kW was found in one of the old estate sites, Maria division of “Waltrim Estate”. Capacity utilized in old estate sites was estimated as 6.1 MW. Distribution of all sites by the estimated exploitable small hydro potential is as follows; in 81 % (209 sites) of the surveyed sites, the potential lies in the range 0-500 kW. Within this range, 22 % of sites have a capacity of less than 50 kW and 25 % lie between 50 kW and 100 kW. In the range of 500 kW to 4000 kW (48 sites) nearly 70 % of sites have capacities between 500 kW and 1500 kW [34].

Site Classification	Number of Sites	Utilized Potential (MW)	Exploitable Potential		Highest Site Capacity (kW)	Lowest Site Capacity (kW)
			MW	% of Total		
Old estate sites	137	6.1	23.668	24.4	1,665	5
New estate sites	71	-	20.723	21.2	1,127	8
Non-estate sites	49	-	53.016	54.4	5,192	44
Total	**257**	**6.1**	**97.407**	**100**	**-**	**-**

Table 7.3 – Estimated Exploitable Small Hydro Potential
(**Source**: An Assessment of the Small Hydro Potential in Sri Lanka – Practical Action)

Site classification is as follows;

Old estate sites - These are sites where there are or had been hydro plants in the past.
New estate sites - A new location found within the boundaries of the particular tea estate.
Non-estate sites - A site located outside an estate, mostly on state land.

According to the distribution of non-estate sites by district, the highest potential of 26,800 kW was found in Ratnapura district, followed by Kegalle district with 9,972 kW. Almost all non-estate sites were found on state land, often interspersed with village settlements, some bordering forest reserves. Therefore, development of these sites is likely to face social and environmental issues to some extent [34].

A study carried out by DFCC Bank in 2007 under the RERED project [2], has estimated that mini-hydro capacity will be increased up to 300 MW by 2015 [2].

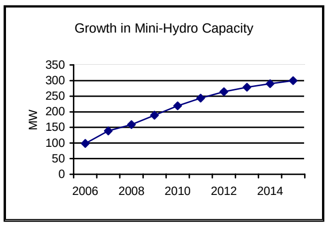


Figure 7.1 – Estimated Growth in Mini-Hydro Electricity Generating Capacity
(**Source**: DFCC Bank)

7.3 Biomass Energy [32]

Given below is the biomass availability in MT per year estimated by BEASL in 2005:

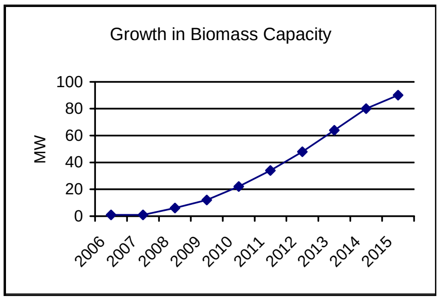
Type	MT / Year	%
Rice Husk available from commercial mills	179,149	6.2
Biomass from Coconut Plantations available for industrial use	1,062,385	37
Sugar bagasse	283,604	8.3
Bio degradable garbage	786,840	27.4
Saw dust	52,298	1.8
Off cuts from timber mills	47,938	1.7
Biomass from home gardens Such as Gliricidia	505,880	17.6
Total	**2,873,880**	**100**

Table 7.4 – Estimated Availability of Biomass
(**Source**: Reference 32 – BEASL)

Power generating potential - It has been noted that the consumption of fuel wood for generation of electricity using currently available technologies, and equipment, whilst meeting all environmental and other conditions is about 1.2 –1.5 kg/KWh (in 2005). Calculations on the national potential for Dendro power in Sri Lanka by BEASL have estimated this to be in excess of 4,000 MW annually generating over 24,000 GWh. This is nearly 4 times the total hydropower potential in this country. The conclusion may therefore be drawn that the Dendro potential in the country is adequate to meet our electrical energy demand for many decades [32 – pp22].

Land availability - The most realistic assessment of the area of land available for commercial fire wood plantation would be 470,000 ha. This would be considered as the best starting point. Figures as high as 1.6 million have been quoted for under used scrub, however, the question of ownership and approval for change of use might not be automatically forthcoming. It would seem that a shortage of land for Short Rotation Coppice (SRC) would not be a serious constraint for Sri Lanka [32 - pp33].

Tea plantation - In 2002, the area under tea plantation was 180,000 ha. This area includes marginal tea lands with lower stocking of productive bushes. Assuming 10% of the total tea area is marginal and not suitable for tea cultivation, such areas could be profitably used for raising fuel wood. About 50% of the marginal lands could be used for fuel wood for processing tea and the rest could be used for raising fuel wood for domestic use [32-pp39].



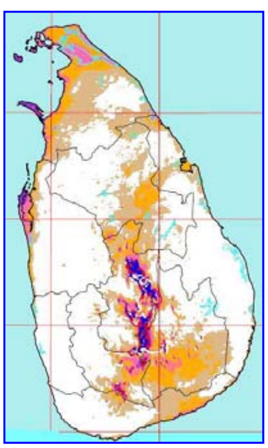
Electricity production using solid biomass fuels is still a developing industry. In the longer term, grid connected biomass generation (using the full range of possible technologies), may become competitive; the greatest potential is for small scale embedded generation using gasification, pyrolysis or high-speed steam engine-based plant [6].

Figure 7.2 – Estimated Growth in Biomass Electricity Generating Capacity
(**Source**: DFCC Bank)

A study carried out by DFCC Bank in 2007 under the RERED project [2], has estimated that biomass power generation will be increased up to 90 MW by 2015.

7.4 Wind Power [6, 11, 26]

Figure 7.3 – Wind Resource Map of Sri Lanka
(**Source**: Wind Energy Resource Atlas of Sri Lanka and the Maldives, National Renewable Energy Laboratory)



Until the era ended in year 2000, scant information on wind resource prevented Sri Lanka from enjoying wind power. With the advent of new technology backed by foreign financial aid, Sri Lanka commenced wind energy studies followed by pilot scale wind power projects. There are several comprehensive studies done extensively on the wind resource of Sri Lanka. The first one to emerge was the “Wind Energy Resource Assessment in Puttalam and Central Regions of Sri Lanka” as a result of a collaborative attempt of the Ministry of Power and Energy Sri Lanka, CEB, and UNDP/GEF Renewable Energy Project. The report elaborates the availability of wind resource, wind energy potential, and the reliability in terms of wind speed and consistency, etc. The study identified potential wind sites in the country along with the financial and economic viability of establishing wind driven power generation plants.

According to the “Wind Energy Resource Atlas of Sri Lanka and Maldives” compiled by the National Renewable Energy Laboratory (NREL) under USAID technical assistance in 2003, there is nearly 5,000 km^2 of windy area with good to excellent wind resource potential in Sri Lanka out of which 4,100 km^2 is in inland and 700 km^2 is in the costal belt. Therefore, the land extent with wind energy potential is around 6% of the total land area (65,610 sq km^2) of Sri Lanka. Based on a very conservative assumption of 5 MW per Km^2, it could accommodate around 20,000 MW

capacity wind power plants. The total potential is as high as 24,000 MW if windy lagoons are also considered [26].
The above values may be further enhanced with the future advancement in wind technology as it would be possible to utilize wind resource which is now at a moderate level. It would be equivalent to 16.7 % of the total area of the country (11,000 Km^2 out of 65,610 Km^2) having wind power generating potential. According to these approximations, Sri Lanka has an overall wind potential of more than 55,000 MW [26].

The above wind potentials are calculated based on the available land area in the country excluding the national parks and reserves, bird sanctuaries, archaeological or cultural sites and cities or capitals which are the pre excluded areas for such a project.

However, NREL stressed that additional studies were needed to accurately assess the practical resource by accounting for the transmission grid and accessibility.

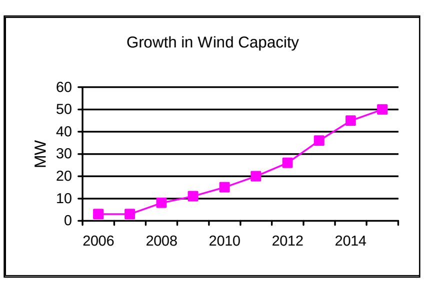
As a result of those studies, wind maps graphically depicting the wind resource distribution in the country and the estimated wind energy prospects in such areas are now available in the public domain.

The above wind resource map of Sri Lanka shows the wind resource values with provincial boundaries. It clearly shows that the wind power availability in the good and excellent range is extended from the Northern tip of the Kalpitya Peninsula (in the North West) to the Karativu islands near Portugal Bay through Mannar and Delft Islands (in the North) and in the central highlands (Indicated in blue – excellent and purple - good). The central highland regions include the extreme Northern part of the Central Province, the Southern part of the North Central Province, and the Northern parts of Uva and Sabaragamuwa provinces. Finally, coastal areas in the South-Eastern part of the Southern Province and the Southern tip at Dondra are estimated to have moderate resources. Another prominent coastal region with good resource is the strip from Hambanthota to near the Eastern border of the Southern Province.

According to the wind measurements by the CEB, good wind potentials exist in Southeast and Northwest of Sri Lanka. Hambantota and Kalpitiya areas have been identified as suitable places for a grid connected Wind Parks. A conservative estimate, excluding the wildlife reserves and agricultural lands, leads to an estimated wind potential of at least 200 MW in the southern coastal areas. However, the cost of electricity generated by wind is still not competitive with renewable sources such as mini-hydro [11].

A study carried out by DFCC Bank in 2007 under the RERED project [2], has estimated that wind capacity will be increased up to 50 MW by 2015.

Figure 7.4 – Estimated Growth in Wind Electricity Generating Capacity
(**Source**: DFCC Bank)



According to the current development in this field and the possibility of harnessing the wind potential in the North with the civil war coming to an end, DFCC estimates would be easily surpassed.

Already, SLSEA has issued Energy Permits to two private developers for 20 MW (10 MW each) in Kalpitiya area. Application for another 30 MW (3 units of 10 MW) is being processed by SLSEA [14].

Ten (10) MW plant builts by M/s Senok Wind Power using the wind turbines of Suzlon Energy, India in Kalpitiya region is expected to be completed in 2010 [28]. M/s Hayleys group is building a 10 MW wind power plant at Nirmalapura in the Kalpitiya peninsular in Puttalam. The plant will have seven 1.5MW turbines [29].

The inconsistencies of estimates of different parties shows that, further studies are needed, especially wind data measurements in various locations to accurately assess the practically realizable potential by taking various constraints and restrictions such as accessibility of sites, grid availability, etc. in to consideration.

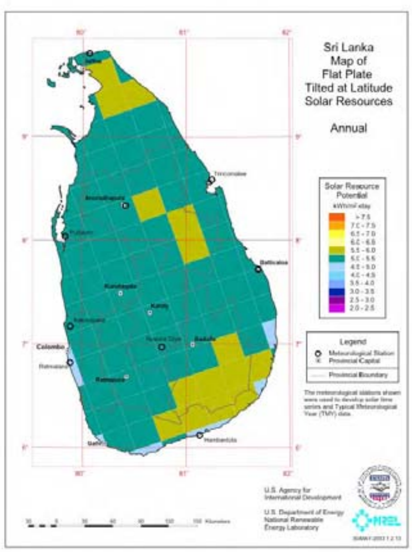
SLSEA has already commenced the collection of wind data in 4 locations out of the 10 locations planned [14].

7.5 Solar Power

Sri Lanka lies within the equatorial belt (between 6 and 10 degrees north of the Equator), a region where substantial solar energy resources exist throughout much of the year in adequate quantities for many applications, including solar water heating, solar electricity, and desalination. Many applications of solar energy are currently in use for meeting remote electrical loads throughout much of the non-electrified regions of Sri Lanka. The potential exists for significant expansion of the use of this renewable energy.

According to the "Solar Resource Assessment for Sri Lanka & Maldives" compiled by the National Renewable Energy Laboratory (NREL) under USAID technical assistance in 2003, annual solar resource in Sri Lanka ranges from 4.5 to 6.0 kWh/m2/day [27].

Figure 7.5 – Solar Resource Map of Sri Lanka
(**Source**: Solar Resource Assessment of Sri Lanka and the Maldives, National Renewable Energy Laboratory)



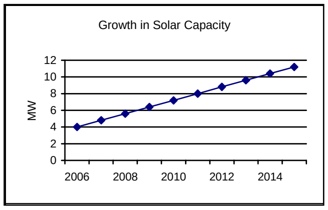
The above study shows that ample resources exist throughout the year for virtually all locations in Sri Lanka for PV applications, such as solar home systems and remote power applications.

The variability in global horizontal solar resources is relatively small across most of the country, despite the impact of terrain characteristics on cloud formation. The resource generally varies spatially at most 20% to 30% during any given season. The highest resources are in the northern and southern regions, and the lowest resources are in the interior hill country [27].

The seasonal variations in solar resources in Sri Lanka can be somewhat greater at specific locations, for example ranging from 4.5 to 6.5 kWh/m2/day in the hill country and the effects of the changing directions in wind flow and storm patterns between the southwest and the northeast monsoons are quite sharp. During the southwest monsoon, with airflow generally from the southwest to the northeast, the lee side of the mountains (the northeast portion of the country) shows quite high solar resources. During the northeast monsoon, the southern and western portions of the country show higher resources. However, the highest resources occur during the hot dry period from March and April when the transition between the northeast and the southwest monsoon occurs [27].

A study carried out by DFCC Bank in 2007 under the RERED project [2], has estimated that solar power generation will be increased up to 11.2 MW by 2015 [2].

Figure 7.6 – Estimated Growth in Solar Electricity Generating Capacity
(**Source**: DFCC Bank)



In Sri Lanka, solar power has got a head start over others and is the fastest growing renewable resource, particularly because of its rural roots. The industry grew from nothing in 1996 to 15-odd companies that have helped install more than 100,000 units, mostly in homes of poor rice farmers. It is now growing at an average of 20,000 units a year [30].

Pradip Jayewardene, a founder member of the Solar Industries Association and a pioneer in the private-led solar industry in Sri Lanka, said "Because the industry is growing and demand is outstripping supply globally, the technology is getting costly. We have sun all year on but the panels and other equipment to tap this source are getting more expensive, because the demand is 75 times the supply. The huge demand for suppliers of equipment is driving up costs." [30]

7.6 Bio Gas Energy [12]

A study on the potential of biogas from biomass sources (Human waste, Municipal solid waste, Landfills, Livestock waste, Agricultural waste, plantation industries) in Sri Lanka carried out by Practical Action estimates a total power generation potential of 288 MW of which includes 86 MW from livestock waste [44].

Many biogas (anaerobic digestion) technologies are commercially available and have been demonstrated for use with agricultural wastes and for treating municipal and industrial wastewater. Where unprocessed wastes cause odor and water pollution such as large dairies, anaerobic digestion reduces the odor and liquid waste disposal problems and produces a biogas fuel that can be used for process heating and/or electricity generation.

Solid waste is collected and disposed at a large number of unprotected sites. The problem is most acute in the Colombo Metropolitan Area (CMA) and in other major cities such as Dehiwala-Mt. Lavinia, Moratuwa, Kandy, Galle, etc. Even in remote areas, solid waste dumps have become a common sight. The Colombo municipal area produces about 750 metric tones daily and the figure for the whole metropolitan area is about 1,000 – 1,100 MT/day. The composition indicates that about 85% of the waste is organic and has moisture content of about 60-75%. This data has been largely determined for the waste arising in the Colombo area [12].

7.7 Biodiesel [40]

Production of liquid biofuels especially ethanol requires knowledge, experience, and a substantial amount of capital investment, Therefore, setting up of small scale ethanol production units (in Sri Lanka) is neither economically nor technically viable.

Ethanol production in Sri Lanka is approximately 12 million litres per year and is produced using sugar cane molasses at 2 sugar factories. This ethanol is of potable grade and this amount is not even sufficient to meet demand for local ethanol. Therefore, another 5 million litres of potable ethanol are imported in addition to the commercial grade ethanol [40].

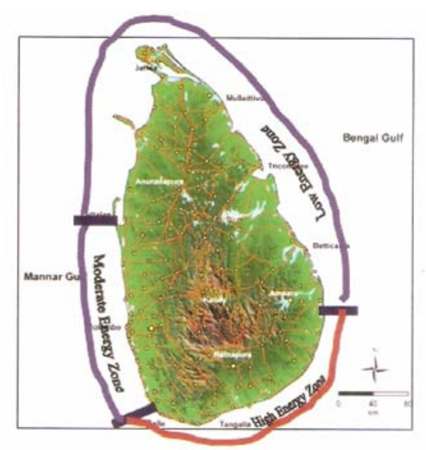
However, small scale biodiesel production facilities can be installed even at village level and run by persons with some scientific background. Feedstock required for these units can also be obtained locally. Yet the cost of production may be high in these units due to the scale of operation and the inability to recover unused reactants and by-products. The first ever rural level, community based, small scale biodiesel production facility in Sri Lanka was set up by Practical Action with help from University of Ruhuna, Peradeniya, Moratuwa and NERDC. There are plans to run a tractor and a generator using the biodiesel produced by this unit for community based activities without any charge. This facility could also be used to educate, encourage and motivate people towards the use of biofuels and help in breaking the myth and various concerns refgarding the use of biodiesel [40].

Biodiesel is also not yet produced on a commercial or pilot scale in Sri Lanka [40].

7.8 Wave Energy

As waves are primarily driven by the wind, areas near the Equator tend to have lower wave potential. The best wave climates, with annual average power levels between 20-70 kW/m of wave front or higher, are found in the temperate zones (30-60 degrees latitude) where strong storms occur. However, attractive wave climates are also found within ±30 degrees latitude where trade winds blow with the lower power levels being compensated by the smaller wave power variability. Annual average wave power is approximately 14 kW/m in the vicinity of Sri Lanka. It is reasonably close to estimate 15 kW/m as being suitable for generation at competitive prices [6].

Figure 7.7 – Wave Energy Map of Sri Lanka
(**Source**: Reference 50 – Energy Forum)



The only alternate energy source for which a tariff system has been formulated by the Ministry of Power and Energy is wave energy. According to the government calculations, this is the cheapest form of alternative energy.

Waves are stable in the South of Sri Lanka since there is no land mass all the way to Antarctica. Strong storms are rare. The wave energy potential of 1 meter off the southern coast of Sri Lanka is about 13 KW in January. It rises to 100 KW by May. The Ministry of Power and Energy estimates that stable electricity can be obtained at a plant factor of 67% [50].

7.9 Tidal Power [6]

With an absence of a major estuary and with a low tidal range (approx 0.7 m) there would be limited opportunity for a barrage-type tidal station in Sri Lanka. However, with estimated currents of 3 m/s in the Palk Strait there may be opportunities to develop a tidal stream [6].

Chapter

8

INDIGENOUSLY DEVELOPED RETs.

This chapter provides information on indigenously developed renewable energy technologies by Sri Lankan organizations. Such technologies are presented under different renewable energy sources along with the contact details of persons responsible.

8.1 Biomass

8.1.1 Biomass Rice Cooker

Figure 8.1 – Biomass Rice Cooker
(**Source**: NERDC)

This biomass cooker is specially designed to burn coconut shells. It can cook 01 kg of rice in 40 minutes and could keep the cooked rice warm for a period of about 8 hours without any additional fuel. It has the capacity to boil about 03 liters of water and to cook about 100 “string hoppers” at a time. Unlike in traditional biomass rice cookers, it never over cooks rice and never blackens the container.

Contact Person: Eng. P. Bandara. **NERD Centre.** www.nerdc.lk

8.1.2 Wood Gas Stove (LANKA SHAKTHI)

Figure 8.2 – Wood Gas Stove (Natural Draft) - (**Source**: NERDC)

This wood gas stove is more convenient and more efficient and uses firewood as fuel. It is a good alternative to the traditional firewood stove and is also a close competitor to LPG cookers.

The efficiency of this wood gas stove is around 30% to 35% as against 8% to 10% efficiency of traditional three stone firewood stoves. Furthermore, inherent deficiencies of traditional firewood stoves such as smoke emission and carbon deposit on utensils do not exist with wood gas stoves. It is easily movable even when it is in operation and the outer casing is touchable with a naked hand without getting burnt.

Figure 8.3 – Wood Gas Stove (Forced & Natural Draft) - (**Source**: NERDC)

600 to 700 grams of wood chips is sufficient for one hour’s operation of the cooker and it provides sufficient heat for preparing a complete meal for an average family. Dry wood chips of sizes between 1/2” x 1/2” x 1/2” to 1” x 1” x 1” are ideal for this stove but slight variations of size may not significantly affect the efficiency. 1” x 1” size pieces of

coconut shells and pieces of thin firewood sticks of 8" long also could be used.

The stove is operated by filling the inner chamber (combustion chamber) with dried wood pieces and then firing from top. Small amounts of kerosene may be used for initializing the flame. Perforations ensure that air is taken from the base and the sides of the stove. As the layers below the flame are heated up, the wood tends to initially emit volatiles and the process of gasification commences, with fuel being consumed from the top downwards. It has been found that the combustion efficiency improves with this type of product heat losses and wastage is further reduced [32-pp43].

Contact details: nerdcentre@nerdc.lk **NERD Centre.** www.nerdc.lk

8.1.3 Saw Dust Fired Vegetable & Fruit Dehydration Machine

Figure 8.4 – Saw Dust Fired Vegetable & Fruit Dehydration Machine
(**Source**: NERDC)

In this machine, heat required for dehydration is provided by two hearths of saw dust. Air is supplied by an electrical fan run on a single phase electricity supply (230 V).

Normally about 20 kg of food stuff can be dehydrated within 8 hours. Electrical energy requirement is around 0.6 kWh and the saw dust consumption is around 30 kg.

Contact details: nerdcentre@nerdc.lk **NERD Centre.** www.nerdc.lk

8.1.4 Low Cost Bakery Oven

Figure 8.5 – Low Cost Bakery Oven
(**Source**: NERDC)

Saw dust or chaff may be used as fuel in this bakery oven. It is easier to operate than traditional bakeries for which firewood is used as fuel. In addition to its low cost operation, quick heat up time, relatively small space requirement and the movability from place to place are other advantages when compared with traditional firewood fired bakery ovens. Using this oven, a batch of bread can be baked in every 45 minutes.

Contact details: nerdcentre@nerdc.lk **NERD Centre.** www.nerdc.lk

8.1.5 Modified "Anagi Cook Stove"

Sustainable Energy Authority modified the "Anagi Cook Stove" to improve its efficiency by around 10%. After the improvement, technology was transferred to an existing manufacturer of Anagi Cook Stove in Allawwa.

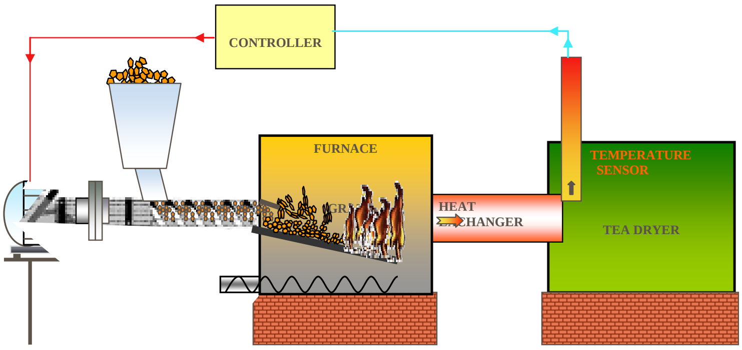
Contact Person: Mr Wimal Nadeera, nadeera@energy.gov..lk, **Sustainable Energy Authority,** www.energy.gov.lk

8.1.6 Improvement of Biomass Combustion Efficiency of Tea Driers

Figure 8.6 – Improvement of Biomass Combustion Efficiency of Tea Dryers
(**Source**: NERDC)

Tea production consumes both thermal and electrical energy in the ratio of about 85:15. Thermal energy, produced by burning of firewood or fuel oil, is used for withering and drying processes. Wood in log forms is extensively used in many tea factories in Sri Lanka. It has been found that two parameters are directly responsible for low combustion efficiency (50 %) of existing furnaces. Those are high moisture content (43 %) and inappropriate sizes (5 mm to 130 mm in diameter and 510 mm in length) of the wood logs.

Figure 8.7 – Schematic Diagram, Improvement of Biomass Combustion Efficiency of Tea Dryers
(**Source**: Reference 51)



The NERD Centre conducted a study at a tea factory to reduce thermal energy usage of tea dryers. Wood chips were introduced instead of wood logs as fuel. By considering less cost of preparation, high moisture removal rate and less wastage, it was found that wood chunks of size 40mm X 40mm X 7mm would be more suitable to be used as fuel wood for tea dryers.

The pilot scale plant is in operation at the same factory, introducing a wood chipper, new grate and controlled screw feeder to feed wood chips to the existing dryer furnace, without applying any modifications to the furnace. The screw feeder is equipped with a control system, to control wood chip feeding rate to the furnace and hence to maintain the desirable temperature inside the dryer.

The tea industry uses large quantities of wood and overall has made little move towards improving the drying technology. Traditional systems consume approximately 2.4 kg of fuel wood to produce 1 kg of made tea. A new process consists of a screw feeder for feeding the wood chips on to a specially designed fire grate, which facilitates the spreading of wood chips for easy burning. Hot air temperature is continually recorded and is used to control the speed of the screw feeder motor through a variable speed drive. Tests have indicated that the efficiency using this equipment is around 75% up from 40% with the traditional driers [32-pp43].

The net saving of fuel wood is about 45% by weight. The other advantages observed are reduction of warming up period, significant saving of wood chips with the application of screw feeder control, improvement of quality of tea due to the constant temperature inside the dryer and the less environmental pollution than that with the fossil fuel burning. With a parallel, fuel wood plantation project (e.g. Gliricidia), the required fuel wood supply can be maintained as needed, while creating employment for the villagers. On the other hand, deforestation can be minimized while reducing the green house gas emissions by improving the combustion efficiency.

Thermal pollution associated with the stack gas emission could be reduced by heat recovery for a dryer in order to dehydrate wood chips. Therefore, this process is not only energy efficient but also environmentally friendly.

Contact Person: Eng. S.K Munasinghe, (shan@nerdc.lk) . **NERD Centre.** www.nerdc.lk

8.1.7 Gasifier Burners

Figure 8.8 –Thermal Gasifier
(**Source**: **-** EnerFab)

EnerFab has adopted the gasifier technology transferred from Anchur India (EnerFab is the sole agent of Anchur of India) to suit local conditions. EnerFab claims that they have done extensive research and managed to design a very effective gasifier burner.

Contact Person: Eng. Indika Gallage, (info@efpl.org). **EnerFab.** www.enerfabsrilanka.com

8.1.8 Improved Firebox for Gasifers

Figure 8.9 –IC Engine System for Electricity Generation
(**Source**: **-** Lanka Gasifiers)

Lanka Gasifiers claims that it has done away with troublesome water cooling of conventional gasifiers. Gas produced is cleaner and is of high temperature. It has an improved firebox. Unit is designed to burn multi fuel. Up 40% rice husk also could be used. Fuel consumption is around 15 – 20 kg per hour for 12 kW gasifier unit.

Contact Person: Eng. Lalith Seneviratne, (lankagas.lalith@gmail.com). **Lanka Gasifiers Private Limited.** www.lankagaslk.com

8.2 Wind

8.2.1 Small-scale Wind Turbines

Figure 8.10 –Small Scale Wind Turbine
(**Source**: **-** NERDC)

In the case of small-scale wind turbines, different types of control mechanism are used to protect them from high wind speeds, i.e. when the wind speed exceeds the rated value. In the tilted up type small-scale wind turbines, the rotor is free to move around horizontal as well as vertical axis. As such, when the wind speed exceeds the rated value, the rotor tilts upwards and sideways and comes to a stable position with an inclination towards the direction of the wind thus controlling the component of the wind responsible for power generation (as well as the rotational speed of the rotor). A study carried out by NERD Centre describes how a mathematical model is developed by using the D' Alambert's principle to investigate the complex behaviour of the wind turbine during the transient period and the stable position. In this model, the modified BEM codes are used to predict the aerodynamic forces on the rotor. The combination of the blade element with the momentum theory makes it possible to evaluate a field of induced velocities around the wind rotor. Yaw movements are modeled by considering dynamic responses of wind vane and compared with the derivations of the unsteady slender body theory.

Contact Person: Eng. Mahinsasa Narayana, (narayana@nerdc.lk). **NERD Centre.** www.nerdc.lk

8.2.2 Multi-blade Wind Mill for Water Pumping

Figure 8.11 – Multi-blade Wind Mill for Water Pumping
(**Source**: - NERDC)

This multi-blade wind mill could be used for water pumping (for domestic, agriculture or industrial purposes) from shallow wells on depth not exceeding 7.5 m where the electricity supply from national grid or from community grids is not available. In turn, the battery power could be used for household lighting and for the operation of TVs and radios. The unit consists of a multi-blade wind mill, a tower, a water pump and other accessories.

The minimum speed of the wind required is 4 m/sec for the operation of this wind pump having a rotor diameter of 4m and 8 blades. The capacity of the wind mill could go up to 2 kW. It has a pumping capacity of around 3,000 l/hr at a wind speed of 5 m/sec.

Contact details: nerdcentre@nerdc.lk **NERD Centre.** www.nerdc.lk

8.2.3 Two-blade 100 W Wind Mill for Battery Charging

Figure 8.12 – Two-blade 100 W Wind Mill for Battery Charging
(**Source**: - NERDC)

This two-blade wind mill could be used for battery charging where the electricity supply from national grid or from community grids is not available. In turn, the battery power could be used for household lighting, for the operation of TVs and radios and the powering of community and rural healthcare centers. The unit consists of a two-blade wind mill with the rotor diameter of 2.1m, a steel tower not exceeding a height of 20m, 100 W permanent magnet 3-phase generator, AC-DC converter and other accessories. Blades are made out of treated timber and further protected by weather shield paints. Charging starts even at a wind speed of 3 m/sec and 150 rpm rotational speed of the wind mill.

It has a charging capacity of 1 or 2 batteries of 12 V simultaneously at a wind speed ranging from 3 to 15 m/sec.

Contact details: nerdcentre@nerdc.lk **NERD Centre.** www.nerdc.lk

8.3 Biogas

8.3.1 Batch Type Lankan Biogas Generator

Figure 8.13 – Batch Type Lankan Biogas Generator
(**Source**: - NERDC)

This biogas generator developed by NERD Centre uses freely available straw, Water Hyacinth, Salvinia, Gliricidia, etc. as main feeding material, charged usually at six monthly intervals. In urban areas, market garbage can be used as feeding material.

Construction of the generator includes a digester, gas holder unit containing three 45 gallons barrels and other connections and accessories.

If the digester is charged with about 1,000 kg of straw and small amount of cow dung and urea or Gliricidia, after about 2 weeks, gas generation starts and continues for a period of over 6 months. Daily gas production is about 1 m^3 at a pressure slightly higher than that of atmosphere. There is no formation of scum and hence handling and maintenance is easy.

One other major advantages in the NERD Centre model is that the remaining waste, after the digestion, is nitrogen rich fertilizer, Therefore, the owner of this gas generator gets high quality fertilizer as a by product, which he can use in his own farm or sell to outsiders.

Contact details: nerdcentre@nerdc.lk **NERD Centre.** www.nerdc.lk

8.4 Hydro

8.4.1 Water Turbine (100 W)

Figure 8.14 – Water Turbine 100 W
(**Source**: - NERDC)

This 100 W water turbine is suitable for charging of batteries where the electricity supply from national grid or from community grids is not available. In turn, the battery power could be used for household lighting and for the operation of TVs and radios.

The hydro requirements for the operation of this turbine are a small water stream with a head of around 6 to 10 m and a flow rate of around 3 to 5 l/sec. Efficiency of the turbine including the losses in the penstock is said to be around 50%.

The entire unit consisting of the turbine cover, rotor, and water inlet tube are made out of mild steel and then galvanized or coated with fiberglass. The generator is directly coupled to the turbine. Depending on the requirement, either 230 V AC or 12 to 24 DC could be obtained.

Contact details: nerdcentre@nerdc.lk **NERD Centre.** www.nerdc.lk

8.4.2 Pico-hydro

Figure 8.15 – Pico-hydro
(**Source**: - Practical Action)

It is guesstimated that there are over 3,000 Pico-hydro (less than 1 kW with low heads of around 1.5 m) units operating in Sri Lanka mainly in Sabaragamuwa and Southern Provinces providing electricity to 1 or 2 households from each unit. However, their efficiencies are found to be as low as 8%. Practical Action has improved the technology to achieve an efficiency level of around 32% and there are 4 demonstration units now in operation. The intention is to attain an efficiency of around 40%. The efficiency of micro-hydro and mini-hydro is said to be around 50% and 80% respectively. Though the real potential is not ascertained as it would be quite a difficult task, there is a possibility of introducing this technology to many irrigation canals all over the island as a low head of 1.5 m is easily attainable.

Contact Person: Mr Rohitha Ananda, rohitha.ananda@practicalaction.org.lk, **Practical Action,** www.practicalaction.org, www.janathakshan.org

8.4.3 Pump-turbines

Trials are underway to assess the possibility of using water pumps as turbines for electricity generation.

Contact Person: Mr Rohitha Ananda, rohitha.ananda@practicalaction.org.lk, **Practical Action,** www.practicalaction.org, www.janathakshan.org

8.5 Solar

8.5.1 Solar Distiller

Figure 8.16 – Solar Distiller
(**Source**: - NERDC)

The frame and the blacken corrugated surface of this solar distiller is completely made of ferro-cement and covered with a sheet of glass. This distiller with the surface area of 4m x 1.2m could produce around 4 l of distilled water on a good sunny day.

Distilled water generated from this unit could be used for industrial purpose (as battery water) or for drinking purpose with mineral supplements especially in coastal areas where the ground water is normally saline. Two distillers of standard size are adequate to produce the drinking water requirement of an average household. When used for drinking purposes, it is recommended to collect the condensed water directly in a clay container in order to have a pleasant taste and smell.

Size of the solar collector area could be reduced from 4m x 1.2m to 0.9m x 1.2m if aluminum is used for the construction instead of ferro-cement but the cost will go up proportionately.

Contact details: nerdcentre@nerdc.lk **NERD Centre.** www.nerdc.lk

8.5.2 Solar Dryer for Vegetable & Fruit Dehydration

Figure 8.17 – Solar Dryer for Vegetable & Fruit Dehydration
(**Source**: - NERDC)

This solar dryer is designed to dehydrate around 8 to 12 kg of fruits or vegetables within 18 hours with a solar collector of around 32 ft2. The ability to use a saw dust hearth on a cloudy day or after sunset makes this dryer suitable for uninterrupted drying.

Contact details: nerdcentre@nerdc.lk **NERD Centre.** www.nerdc.lk

8.6 Bio-oil

8.6.1 Bio-oil

Laboratory tests have been completed to use non-edible bio-oils for cook stoves and for oil lamps. Fields tests are yet to be carried out.

Contact Person: Mr Rohitha Ananda, rohitha.ananda@practicalaction.org.lk, **Practical Action,** www.practicalaction.org, www.janathakshan.org

———

Chapter

9

CASE STUDIES ON DISSEMINATION, UTILIZATION & TRANSFER OF RETs

9.1 Introduction & Overview

This chapter features 5 case studies of which 2 case studies have been selected from the case study compendium of the recently concluded “Promotion of Eco-efficient Productivity” (PEP) project implemented by The Ceylon Chamber of Commerce with the financial assistance from The Royal Netherlands Embassy where the writer was a member of the Expert Committee for project evaluation.

The PEP Project can claim the credit for encouraging and introducing Dendro power as a practical feasible alternative to the fossil fuel for the industry when financial institutions were reluctant to assist. The PEP Project was also directly responsible for introducing Dendro energy to the Sri Lankan Ceramic Sector which was placed in a back to the wall situation due the unprecedented escalation of fuel prices. [45].

In addition to the above 2 cases, 3 more cases are also explained that have made significant impacts. One was extracted from the publication – “Best Practices for Micro-Hydro Development” written by Kiran Dhanapala and Priyantha Wijayatunga in 2006 for Practical Action South Asia Programme [38].

9.2 Biomass – Wood Gasification Technology for Thermal Energy
Lanka Walltiles Meepe (Pvt) Ltd [45]

The ceramic sector of Sri Lanka has been under pressure with the cost of energy for a long period as a major user of LPG. This case study is on the replacement of fossil energy supply (LPG) through biomass energy. Use of biomass sources and the subsequent implementation of heat within the spray drier is a significant implementation. Savings made per month is significant and a higher energy security level has been obtained. The local economy too would benefit by the additional opportunities created through the development of biomass supply network. Various biomass sources have been employed and show the potential in depending on local resource availability to meet ones energy needs.

Details of the company:

- Established in 1996 under the management of Lanka Walltile PLC
- Manufacturing 4500 m2/day of wall tiles and floor tiles using double fast firing
- technology for both local and export market
- Employment for 304 skilled personnel

Problems or issues encountered:

- High cost of energy (LPG)

Technology adopted to overcome the problems or issues:

- Wood gasification technology to produce heat in order to dry ceramic sludge in the spray drier

Description of the technology:

- Chopped *Gliricidia*, Cinnamon hard wood, coconut shell and Ipil ipil stems allowed to dry in a large ventilated store house with transparent roofing
- Wood grabber load wood to an electrically operated trolley that transport the wood towards the feeding hopper of the gasifier
- A bucket hoist load the wood to the feeding hopper
- The Syn gas is cleaned by a cyclone and a wet scrubber
- A wet blower transfers the gas to a separation chamber to remove tar
- The gas is cooled in a chiller unit to 55 ^{o}C, mist is separated and successively filtered by a saw dust filter and a bag filter
- Dry gas is sent to specially designed triple fuel (LPG, kerosene and Producer gas) burner to produce heat at 450 ^{o}C
- This heat is used in spray drier to dry ceramic sludge into powder form

Photographic evidences of the developments:

		
Trolley to transport wood and wood grabber	Bucket hoister	Gasifier
		
Cyclone & scrubber	Filter	Triple fuel burner

Figure 9.1 – Wood Gasification for Thermal Applications
(**Source**: PEP Project)

Investment:

- By the company – LKR 40 million (USD 348,000) – E-friends loan at 6.5% interest.
- By PEP Project – LKR 5 million (USD 43,500) – Grant
- Payback period – 10 years
- Annual turnover of the company – LKR 1.3 billion (USD 11.3 million)

Overall achievement:

- Saving of LKR 2.3 million per month (USD 20,000/=) from replacement of LPG with Dendro power

9.3 Biogas - Desiccated Coconut Industry
S.A.Silva & Sons Lanka (Pvt) Ltd. [45]

This desiccated coconut mill opted to use biogas systems (Anaerobic technology) based on its waste stream as a solution to its wastewater problem. The biogas so generated is directed to the process boiler unit where a considerable fuel saving has been achieved.

Details of the company:
- Established in 1989 as a family business
- Processing 150,000 coconuts per day
- 90% of the production is for the export market
- Provides full time employment to 50 persons

Problems or issues encountered:
- High fuel cost for boiler operations
- 120,000 L of high organic strength effluent with nuisance odour
- No treatment facility for discharging effluent

Technology adopted to overcome the problems or issues:
- Biological treatment system using Up-flow Anaerobic Floating Filter (UAFF)

Description of the technology:
- Wastewater rich with coconut washing and coconut water is passed through oil and grease trap to remove oil
- Neutralization of acidic wastewater by lime in a holding tank
- Anaerobic digestion of high-strength wastewater in three up-flow anaerobic digesters connected in series
- Biogas generated used for the boiler operations
- Supernatant is sent to the facultative pond for polishing of the effluent
- The discharge is sand filtered for removal of suspended solids
- Treated waste water is to be used for the irrigation of coconut plantation

Photographic evidences of the developments:

	
Settling tank	Biogas reactors

Figure 9.2 – Biogas in Desiccated Coconut Industry
(**Source**: PEP Project)

Investment:
- By the company – LKR 6.65 million (USD 58,000)
- By PEP Project – LKR 2.85 million (USD 25,000) – Grant

Overall achievement:
- Biogas as fuel to the boiler save 5% of fossil fuel requirement
- Minimization of pollution due to effluents

9.4 Off-grid Village Hydro

Kandal Oya [38]

Village Overview - Kandal Oya is a remote rural village in the Kegalle district. It is largely an agricultural community having a reasonable household income. The villagers as a community have been capable of investing in a village hydro scheme. The demand for electricity, mainly for lighting and other household requirements, was relatively high.

Project Overview - The project consists of a 10 kW stand-alone induction generator with an Induction Generator Controller (IGC) and presently it serves about 88 households. This has been financed through the ESD project of the World Bank. The scheme is owned by a limited liability company formed by the membership of Electricity Consumer Society (ECS) consisting of connected households. This is a legal entity set up to facilitate the management and to support long term financing and repayment.

There is no obvious seasonality on demand for power. Supply of energy is uniform due to the site being in heart of the wet zone with a good rainfall through out the year. No forced outages had been experienced in the short history of the plant. Distribution of power is regulated voluntarily with each household being allowed a maximum of 100 watts at a charge of LKR 250 per month (USD 3.57). Unlike other sites, tariff is determined by loan installment and the remuneration of the operator rather than on a flat Rupee per kW charge per household.

The "demonstration effect" of Katepola village hydro scheme resulted in the pre-feasibility study by Practical Action at the request of ECS of Kandal Oya in late 1996. The project feasibility assessment, design and supervision of construction were done by IDEA, an NGO based in Kandy. A local technician manufactured the turbine. Technology selection, suppliers, contractors etc. were arranged through Practical Action and recommended technicians.

The search for funding was a long process and Practical Action and individual villagers bore the costs. ECS sought help from institutions such as the Sabaragamuwa Provincial Council and Janasaviya Trust Fund. Finally, it managed to obtain a loan of LKR. 500,000 (USD 7,143) with a grant component of LKR 270,000 (USD 3,857) from the ESD project through the assistance of Practical Action. The contribution of the villagers was two-fold: LKR 3000 (USD 43) and labour in construction. The only delay in the project was at the start owing to the delays in loan application approval and funding which came in early 1998.

The original membership of the ECS was confined to 80 households. Their main energy sources were kerosene oil and pre-charged batteries. Apart from fuelwood, the fuel was mainly used for heating-related activities including cooking. In addition to supplying energy to these households, the scheme provides electricity to the village hospital and the temple. Further, it has been planned to supply electricity to the village school and the teachers' quarters. Apart from lighting, the end-use includes battery charging, ice making, vulcanizing and a proposed grinding mill. These end-uses were selected through a ballot in the ECS depending on the village's requirement and the entrepreneurs' abilities in sustaining the activity.

9.5 Wind Power Improves Islanders' Quality of Life in Sri Lanka

Figure 9.3 – Battalngunduwa Island
(**Source**: Reference 49)

The small island of Baththalangunduwa, about 10 km off the West Coast of Sri Lanka, is the setting for a power system that was designed to supply reliable power to remote areas of Sri Lanka while promoting renewable energy as a long-term, cost-effective energy solution.

The project was conceived by USAID Sri Lanka, and funded by the US Asia Environment Program's "Council of State Government" grant. This provided the seed capital to provide the study and equipment for a power supply (wind turbines and backup diesel generator) to a remote island off the west central coast of Sri Lanka.

This island is scarcely 4 km long and less than 1 km wide, housing about 3,000 fishing families who live in basic palm-frond huts, with little fresh water, basic sanitation, no health facilities and no power grid. The local lifestyle consists of fishing in the early mornings, then preparing and drying the fish, and repairing nets in the afternoon and evenings, limited by the lighting available from kerosene lamps or small generators. There's one school, a church, a mosque, and a store.

As well as providing the immediate benefit of power to a group of households, the project was intended to become the model for similar development on the many un-powered fishing islands off the Sri Lanka coast. The power system is maintained under an owner/manager, who is responsible for revenue collections from those receiving power, and allocating these funds to managing and maintaining the system. The project sets up an independent power producer who operates under a profit motive to maintain the power supply. The promoters felt that it was a more valid model than purely grant-funded capital works with no financial mechanism for their continuation past the duration of the project.

An additional monitoring program was provided to log a year's worth of performance data. This provides the information to establish a carbon credit value of the offset in carbon dioxide that would have otherwise been generated by diesel power in a conventional power system. Monitoring will yield a power input/output summary which will then be audited by C-Trade, a project sponsor, for establishing a benchmark for similar carbon offset values of such projects. This may provide a means of funding similar project under upcoming carbon trading facilities where sponsor companies can buy carbon credits in exchange for seed capital for similar projects.

Success Indicators - Power customers have continued to enjoy the added benefits of this clean, low-cost and silent power supplied mainly from wind. Winds average over 6 meters per second for most of the year, so power has been abundant and the batteries are kept charged. Often the manager has even extended power availability past 10 p.m. and rarely uses the backup diesel. It was a pleasure to see fishermen sitting outside the open air movie house, mending nets in the spotlights while enjoying the raucous "Bollywood" music blaring into the night! Recently the system manager and store owner Mr. Mudaladi has undertaken to purchase an additional wind turbine to add to the system so he can power a refrigerator for offering cold drinks to his customers. He's proud of his "wind powered store" and wants to add a "wind powered refrigerator."

Lessons Learned - There were some "teething" problems because of the difficulties of the site, including the high tide impinging on the foundations for wind turbine towers, and the highly corrosive salt environment attacking some components of the power boards and turbines. A re-fitting of turbine and some power hardware was undertaken to upgrade the turbine components to resist these humid, salty conditions. Data-logging has had ongoing problems because of the corrosive environment, and data has been intermittent in quality due to sensitive instrument problems. A refit of the data logger system is planned to upgrade the anemometer and logging components

Next Steps - USAID has indicated interest in implementing similar wind/battery "mini grid" projects using this model in other parts of Sri Lanka. As the USAEP program has ceased, there may be other mechanisms available to sponsor such projects, but self-funding initiatives will be the ultimate aim for spreading the technology beyond Aid [49].

9.6 Cogeneration

Recogen Ltd

Figure 9.4 – Cogeneration
(**Source**: Reference 51)

This is the world's only pollution-free charcoaling plant that converts the energy released in the process into electricity. This effort was recognized at national level in 2007 with the top award in the 'Development of Eco-materials/Eco-friendly Processes for Industry' category at the National Science and Technology Awards [46].

Conceptualized and developed by Haycarb PLC and built by Recogen Ltd, its wholly-owned subsidiary, the plant at Badalgama converts coconut shell into charcoal in a mechanized process that uses 'Pyrolysis' (carbonization in the absence of oxygen) and combusts the methane-rich gasses released, a major pollutant, to run a steam turbine that produces electricity for the national grid [46].

Designed as a backward integration to supply charcoal for Haycarb's activated carbon manufacturing operations, the patented process replaces the environmentally hazardous traditional charcoaling pits, captures and uses volatile gasses that would otherwise enter the atmosphere, generates electricity and produces high-grade charcoal for its parent company [46].

Nearly 10 years in research, development, engineering and operation, Recogen (derived from 'Recover and Generate') represents an investment of LKR 1 billion (USD 8.7 million). It comprises of 6 charcoaling reactors that produce 60 Tonnes of charcoal a day, generate 5 MW of power and earn the country carbon credits of 46,000 Tons a year under the Kyoto Protocol for the avoidance of methane and carbon dioxide emissions and the reduction of fossil fuel usage.

It is estimated that about 430 thousand tons of CO2 emission will be reduced by this Project over the crediting period from April 1, 2009 to March 31, 2019 [47].

Chapter 10

BARRIERS FOR TRANSFERRING RETs

10.1 Introduction & Overview

This chapter presents the barriers for the transferring of renewable energy technologies. Some barriers are generic and common to all renewable energy options while some are specific. Wherever possible, such specificities shall be highlighted in the following presentation.

Often the result of barriers is to put renewable energy at an economic, regulatory, or institutional disadvantage relative to other forms of energy supply. Many of these barriers could be considered "market distortions" that unfairly discriminate against renewable energy, while others have the effect of increasing the costs of renewable energy relative to the alternatives [43].

All barriers could be broadly classified into 5 categories and often they are not mutually exclusive.

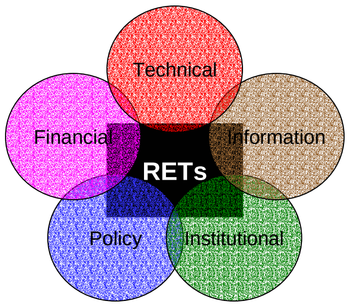


Figure 10.1 – Barriers for Transferring RETs

Barriers are summarized in the table below under each category and their degree of influence on a particular RE option is also mentioned as either "Specially Applicable to" or "Not Applicable to".

Category	Barriers	Generic	Specially Applicable To	Not Applicable to
Technical	Resource supply constraints.		Dendro	
	Grid constraints		Hydro, Wind & Dendro	
	Harmonics distortions in the grid		Wind & Solar	
	Lack of R&D	√		
	Sophisticated technologies		Dendro	
	Reliability issues of technology	√		
	Maintenance issues of equipment	√		

Financial	High initial cost	√	Wind & Dendro	
	High interest rates	√		
	High transaction cost	√	Hydro	
	High risks & uncertainties		Wind, Dendro	
Information	Lack of resource data for project planning	√		
	Lack of information on supply & demand	√		
	Lack of information on cost/benefit, performance, and O&M	√		
	Lack of training, education, etc.	√		
Policy	Lack of national priority for RE	√		
	Subsidies for some fossil fuel	√		Dendro
	Subsidized electricity tariff for low end users	√	SHS	
	High taxes & import duties			
	Transport restrictions of biomass		Dendro	
	Strict environmental regulations	√	Hydro, Wind	
	Electricity distribution monopoly by utilities	√		Biogas
	Restrictions on locations & constructions	√	Wind, Dendro	
Institutional	Lack of recognition of RE by national planners	√		
	Procedural delays for project approvals	√	Hydro	
	Bureaucratic red tapes	√		
	Inefficiencies of approving authorities	√		
	Poor coordination between institutions	√		
	Donor driven projects	√		

Table 10.1 – Barriers for Transferring RETs

Some major barriers are further described below.

10.1.1 Technical Barriers

Resource Supply - In the case of renewable energy based systems such as ***Wind*** and ***Wood fuel*** fired plants (***Dendro*** thermal power), it was found that lack of assurance of resource supply or availability are the major barriers for their promotions [42].

In the case of ***Dendro*** power, quality of raw materials is also a constraint. This leads to poor combustion efficiencies and keeping the quality of raw materials.

Reliability - In the case of renewable energy based systems such as ***Wind*** and ***Wood fuel*** fired plants (***Dendro*** thermal power), it was found that reliability of technologies themselves is a major barrier for their promotion [42]. A low or moderate level of customer satisfaction with technical performance of ***SHS*** has also been reported.

Technology Sophistication - Almost all modern RETs, especially electricity generation technologies, are sophisticated and new to the country and technical expertise and facilities for design, manufacture, promotion and sale, operation and maintenance are still lacking for the successful implementation of RE projects. There are very few local manufacturers and agents who are involved in RE projects, and the existing maintenance networks are not adequate at all. This lack of expertise and facilities is a major technical barrier. At present, there is no familiar technology, except ***ICSs***, that has been properly designed, monitored and assessed in the country. The design and raw materials required to set up RE plants are not based on the resources available locally. This would lead to high initial costs as well as the local community finding it difficult to understand, adopt, operate and maintain the systems, resulting in reduced productivity. Also, this would result in delay in attending to urgent repairs and necessary maintenance. The country is currently in a technology-learning phase [23].

R&D - R&D and demonstration are essential for the successful implementation of RETs. Although there are a number of universities and R&D organizations, the research base required for implementation of national-level RE programmes is as yet undeveloped because of the lack of well-coordinated and appropriately funded research projects, in addition to their limited capacities [23].

Technical Deficiencies - Operational inconveniences and lack of appliances in ***Biogas*** systems and maintenance difficulties in ***Wind*** systems.

Grid Constraints - Inadequate absorptive capacity of the Sri Lankan power system (National Grid) to accommodate renewable sources is considered as a major barrier. According to a study conducted by "Siemens Power Technologies International Ltd." in 2005 for the preparation of "Technical Assessment of Sri Lanka's Renewable Resource Based Electricity Generation" under the RERED project, it was found that with the future development of the network, 2008 network will allow a maximum of 330MW to be connected. Similarly the 2012 model will allow 640MW and the 2013 model 690MW [5].

Harmonics - According to the above study, Harmonic Currents from sources such as rectifier/inverter systems will greatly increase the total harmonic distortion experienced on the network. ***Photo-voltaics*** and ***Wind generation*** systems connected to the network via power electronics will act as sources of odd harmonics [5].

Intermittent Sources - Renewable energy is often an "intermittent" source whose output level depends on the resource (i.e., ***Wind*** and ***Sun***) and cannot be entirely controlled [43].

10.1.2 Financial Barriers

Financing - In ***SHS***, consumer finance supply is a major constraint to continued growth, and may be contributing to reduced sales levels.

The present loan schemes of local banks and other financial institutions do not accommodate small-scale RE projects, unless they are integrated with an income-generating activity (such as a rural industry), in addition to providing fuel for domestic energy applications. Such a limitation is based on their past experience of poor recovery of loans in rural areas [23].

Proven, cost-effective technologies may still be perceived as risky if there is little experience with them in a new application or region. The lack of visible installations and familiarity with renewable energy technologies can lead to perceptions of greater technical risk than for conventional energy sources. These perceptions may increase required rates of return, result in less capital availability, or place more stringent requirements on technology selection and resource assessment [43].

High Initial Cost - In the case of renewable energy based systems such as ***Wind*** and ***Wood fuel*** fired plants (***Dendro*** thermal power), it was found that lack of financing instruments and high initial cost are the major barriers for their promotion [42].

As initial costs of RE technologies are too high, dissemination of such technologies requires a supportive financial environment and subsidies, at least during the initial stage of adoption. Most of the financial institutions do not have a separate identified credit line for the energy sector [23].

Even though lower fuel and operating costs may make renewable energy cost-competitive on a life-cycle basis, higher initial capital costs can mean that renewable energy provides less installed capacity per initial dollar invested than conventional energy sources [43].

Interest Rates - Interest rates for Renewable Resource Based Electricity Generation (RERBEG) projects are high compared to those for the conventional power plants.

Long Delays - Inadequate information and past experience of success and reliability of RE projects in the country have resulted in long delay in approving loans and reluctance to finance these projects in general [23].

Transaction Cost - High transaction cost due to high cost of resource assessment, planning, developing project proposals, approvals, negotiating finances, and negotiating power-purchase contracts with utilities.

Risk & Uncertainties - As fuel price risk is associated with ***Biomass*** energy, financiers may look for higher risk premium in ***Dendro*** projects [43].

10.1.3 Policy Barriers

Low Priority for RE in National Planning - RE has been given the lowest priority in energy planning and policy-making. There are no institutions responsible for the promotion of RETs in the country, resulting in the lack of national-level coordination among different agencies [23].

Energy planning in the country has been carried out at the national level with emphasis on commercial fossil fuels [23].

Development thinking in the country promotes and favours only commercial and modern fuels. There is a lack of awareness and proper assessment of the role played by traditional fuels because traditional fuels do not fall within the cash economy. Despite the fact that the major energy consuming sector is the cooking sector and biomass is the major energy resource there is no government policy to address the related issues. As a result there is no institutional mechanism or organizational structure to initiate and sustain any interventions other than the few isolated activities carried out by a few NGOs and GOs on a short term project basis [44].

Taxes & Duties - Taxes as well as duties for Renewable Resource Based Electricity Generation (RERBEG) projects are high compared to those for the conventional power plants.

Taxes are levied on all the imported as well as local components and services of RE-based plants sold in the local market. But at present, developers of any large conventional power generation plant enjoy tax benefits, which give a competitive advantage to conventional power generation over RE-based generation [23].

Regulations - Policy barriers to the development of RE systems lie in environmental regulations, tax systems, electricity sector regulation, electricity tariff, etc. [23]

Environmental Regulations - The CEA, which is the main body overseeing environmental policy and regulatory processes in the country, has not overlooked the RE sector. However, at present, the regulatory framework governing the use of natural resources in mini-hydro projects, which is equally applied to other RE-based schemes, is unclear and characterized by a multiplicity of institutions at various levels. Further, the local governments' capacity for environmental regulations is generally weak [23].

Monopoly of Electricity Distribution - According to the electricity sector regulations, only CEB has license to generate and directly sell electricity to consumers, apart from Lanka Electricity Company (LECO) operating in a limited distribution area. Any other independent party can generate and sell electricity to the CEB, which, in turn, will sell it to the customers. However, distribution rights are not given formal clearance, and growth of the RE sector in general requires a clear process and institutional mandates [23].

Utilities may not allow favorable transmission access to renewable energy producers, or may charge high prices for transmission access. Transmission access is necessary because some renewable energy resources like ***Windy*** sites and ***Biomass*** fuels may be located far from population centers. Transmission or distribution access is also necessary for direct third-party sales between the renewable energy producer and a final consumer [43].

Tariff - The CEB electricity tariff for the domestic sector is heavily subsidized for the lower slabs of consumption, into which over 50 % of the consumers fall. This makes grid-connected electricity cheaper, for domestic consumers, than electricity from RE-based decentralized sources [23].

Fossil Fuel Subsidies - Lighting in rural communities in the country is usually based on kerosene lamps, and kerosene is a subsidized commodity across the country. Electricity from decentralized generating schemes is also mainly used for lighting, and, therefore, a cost comparison is always made with kerosene [23].

Many argue that renewable energy "costs more" than other energy sources, resulting in cost-driven decisions and policies that avoid renewable energy. In practice, a variety of factors can distort the comparison. For example, public subsidies may lower the costs of competing fuels [43].

Restrictions on Locations and Construction - ***Wind*** turbines and ***Biomass*** combustion facilities may face building restrictions based upon height, aesthetics, noise, or safety, depending on the location. ***Wind*** turbines have faced specific environmental concerns related to locating along migratory bird paths and coastal areas [43].

Land Issues – This is applicable especially for ***Hydro*** projects particularly in the lands of the Forest Department. These lands are available only on short term lease (1 year) whereas funding agencies require around 20 year lease. SLSEA is mandated to take over such lands (either individually or under the proposed 'Energy Source Area' declaration) and make available for the investors and developers on long lease. However, this is yet to be implemented.

10.1.4 Information Barriers

Data - In comparison with other energy systems, commercialization of RE systems involves many stakeholders and many resources. Development of RE requires an area-based (decentralized) approach. Collection and analysis of data on energy supply and demand should be carried out in each locality to design appropriate RETs. Such activities should be carried out by different institutions at different levels, and there should be proper coordination and interaction among these institutions [23].

Training & Education - In particular, village-level social organizations are very weak in promoting new technologies. Limited experience and exposure of the rural populace to community development activities has contributed to poor organizational skills in initiating and implementing RE schemes. Lack of technical expertise to carry out pre-feasibility studies at community level is a major hindrance to the identification of possible sites and technologies. Also, rural communities are yet to be taught specific installation, operation and maintenance skills, which most modern RETs demand. The absence of such skill development institutions and programs in the country act as a barrier to the promotion of RETs [23].

The markets function best when everyone has low-cost access to good information and the requisite skills. But in specific markets, skilled personnel who can install, operate, and maintain renewable energy technologies may not exist in large numbers. Project developers may lack sufficient technical, financial, and business development skills. Consumers, managers, engineers, architects, lenders, or planners may lack information about renewable energy technology characteristics, economic and financial costs and benefits, geographical resources, operating experience, maintenance requirements, sources of finance, and installation services. The lack of skills and information may increase perceived uncertainties and block decisions [43].

Awareness & Education - Lack of proper education at different levels is a barrier to the effective transfer of information on RE technologies. Awareness of RE technologies and associated environmental aspects among the general public is minimal. There are no specific subject modules on RE in the curricula of primary and secondary education systems. Even at tertiary level, the relevant subjects are taught only in some engineering fields of specialization [23].

Consumer Perception - The social status associated with modern fuels, technologies and related conveniences offered, push the consumers to perceive traditional technologies as primitive and not keeping with the modern standards. However, with a strong policy to support R & D activities to improve efficiencies and convenience of existing technologies using traditional fuels such as in wood gasifier stoves, "Anagi stoves", biogas stoves, large improved stoves for commercial activities and improved combustion systems in thermal applications in brick. Pottery, limekilns etc, could help to change such perceptions and build confidence of the consumers [44].

10.1.5 Institutional Barriers

Donor Driven Projects - At present, there are many GOs and NGOs involved in RE activities, but in an uncoordinated manner. These organizations have limited capacity and resources to undertake RE projects successfully. Moreover, their involvement and interests, in most cases, are just driven by the availability of funding for particular projects rather than influenced by long-term national interests, thus failing to have a real impact [23].

Institutional Inefficiencies - An institutional barrier to the effective promotion of RETs also lies in the inefficient functioning of government institutions as a result of delay in decision-making and implementation, high organizational costs, leakage of funds, non-accountability, etc. [23]

Linkage Issues – Lack of coordination between project approving authorities is a major hindrance for project approvals.

Capacity and Competence Issues – Lack of and incompetent human resource in project approving authorities is a major hindrance for project approvals.

Priority Issues – National importance of promoting renewable energy is not well understood by many including project approving authorities.

Chapter 11

STRATEGIES FOR FUTURE DEVELOPMENT OF RENEWABLE ENERGY

11.1 Introduction

This chapter suggests the strategies to overcome the major barriers for the development and promotion of renewable energy described in Chapter 10. Strategies suggested are of two types: (1) generic strategies that are valid for all renewable options (2) specific strategies applicable for a particular renewable option. Generic strategies are presented under the 5 categories stated in Chapter 10 while specific strategies are presented under each renewable option.

11.2 Generic Strategies

11.2.1 Strategies to Remove Technical Barriers

- **Testing of technologies for the suitability to local conditions.**

Commercializing partially developed or wrong technologies had been a major constraint in promoting renewable energy technologies. When the technologies and equipment are promoted by profit oriented private entities, sometimes, there is a tendency to maximize profits by putting out sub standard items to the market. When this is done by researchers or technology adopters, sometimes, due to their over enthusiasm, there is a tendency to publicize their achievements or successes prematurely. As the general public is still very skeptical about the reliability of RETs, even a slight mistake on the ground would lead to disasters as negative messages run fast. Once a mistake is done, correction takes a longer time. In order to prevent the occurrence of such mistakes, testing of technologies to assess their suitability for local conditions in terms of cost, technical performance, operational and maintenance needs, availability of manpower, compatibility with the environment and existing utilities / infrastructure, etc. needs to be properly established before allowing the technology/equipment to be promoted. For this purpose, there must be a dedicated organization with adequate physical and human resources and more importantly with legal and regulatory powers. Even an exiting entity with a wider exposure to the discipline of renewable energy could be assigned with this task. Testing of Solar PVs by NERD Centre is the closest happening to this concept.

- **Technology demonstration.**

Technology demonstrations could play a big role to allay the fears of prospective users and financiers. Though this is happening to a certain extent with government, NGOs, donors and even the private sector support, such programs have been limited by numbers, their significance and also by their scales. In the recent past, there were a couple of such demonstration projects either not functioning as desired or completely abandoned due to various reasons such as, market distortions (price changes), resource supply constraints, technological failures, etc. In many such situations, promoters had been forced either to stall or abandon the projects in the absence of a properly executed support mechanism. According to the Act of SLSEA, it is empowered for this task and hence what is required is to formulate a scheme to position SLSEA in this role by making use of its “Energy Fund”.

- **R&D capacity enhancement.**

R&D capacities of both the State sector as well as the Private sector organizations need to be strengthened. As described in Chapter 3, State sector organizations active in renewable energy field are very few in number and they are severely constrained with research funds, competent and adequate manpower, restrictive rules and regulations and also their interaction with prospective users. The private sector seems to be more effective in adopting technologies as they are commercially oriented and closer to the industries and other users of RETs than State sector organizations. PEP project explained in the second part of Chapter 4, made financial assistance for technology adoption and even for R&D of Private sector organizations. Though only a few were benefited due to the short period of the project and the limited budget, the concept was well tested and proved to be a success. However, going beyond donor supported project level assistance, such a scheme needs to be properly institutionalized.

- **Promoting hybrid systems.**

Due to the intermittent nature of some resources, especially Wind and Solar, if the economics are right, it is always advantages to promote renewable energy options in dualities to enhance the plant factors. In this way, a solar and wind hybrid could provide energy day and night, on cloudy and sunny days, and on windy and still days alike.

- **Grid connectivity.**

Grid connectivity is a major constraint for on-grid dispersed small power producers. Grid capacity in terms of the absorptive capacity, network extension, harmonics generation, etc. are the challenges faced by the utility (CEB) in accommodating newcomers. These deficiencies should be systematically addressed by realizing the importance of increasing the non-conventional renewable energy electricity generation as a national priority but not with prejudices and negative sentiments to discourage small power producers.

- **Harmonics control.**

It would be an important task for R&D organizations and also for the suppliers / venders to minimize Harmonics Currents generated from rectifiers / inverters of grid-connected Photo-voltaic and Wind generation systems to make them less problematic for the utilities to accommodate them.

- **Grid-connectivity package.**

For the convenience of both small power producers and utilities, “Grid-connectivity” systems (hardware and software as applicable) need to be made available as off-the-shelf technology packages developed under a certain standard acceptable to utilities. Some work in this regard is presently carried out by NERD Centre.

11.2.3 Strategies to Remove Financial Barriers

- **Concessionary credit facilities.**

Despite many attempts for the promotion of renewable energy, in many RE options, especially in Wind and Dendro, high up-front cost, high risk involved, resource supply issues, etc. makes credit providers to look for higher returns. Rapid propagation of SHS in Sri Lanka could be mainly attributed to the availability of concessionary loans through projects like ESD and RERED. Therefore, until such time the market is developed and matured to operate on its own, concessionary credit facilities should be made available to vulnerable renewable options at least during their early years of market penetration. As in the case of ESD, RERED and E-FRIENDS, government initiatives and guarantee are vital to secure donor funding for this purpose.

- **Guarantee fund.**

Already there is a guarantee mechanism under the purview of SLSEA for the funding of energy efficiency projects with the financial assistance of JBIC. However, renewable energy projects are not included in this scheme. Similar facility is required for the promotion of renewable energy projects as credit guarantees to cushion the perceived high risk for credit providers.

- **Involvement of State sector banks.**

Most of the credit facilities with donor assistance such as EDS, RERED and E-FRIENDS did not recognize State sector banks as PCIs as they did not fulfill certain eligibility requirements of donors. However, towards the latter part of the second phase of RERED, some Regional Development Banks operating directly under the Central Bank of Sri Lanka were brought in. Within a short period of time, these banks were able to disburse a significant amount of credit especially for SHS and other off-grid village programmes mostly due to their outreach in the grass-root level and low transaction cost. However, two leading banks; Bank of Ceylon and People’s Bank are yet to be recognized under the currently operating concessionary credit programs. Though the State sector banks may not be efficient and customer oriented compared to Private sector PCIs, they could play a big role in promoting the renewable energy options as they are more development oriented than private sector banks. If they are brought into the systems and their capacities are built, they will continue to operate even in the absence of external financial assistance.

- **Capacity building of banks.**

Except in some development banks and in a few private banks, the majority of the bank employees, especially the credit officers are not very comfortable in evaluating technically oriented projects due to their less awareness and understanding and hence the general tendency is either to differ or to avoid. This should not be treated as an intentional rejection but a human nature to operate in comfort zones. Therefore, it is pertinent to bridge this gap and bring renewable energy projects also into their comfortable lending portfolio. It would not only improve the level of acceptance but also minimize processing delays.

- **Reducing transaction cost.**

As initial costs of many renewable projects are relatively high, it is important to keep all other costs down. Credit providers could contribute by way of removing unnecessary procedures and paper works.

11.2.3 Strategies to Remove Policy Barriers

- **National priority.**

Though there is a very supportive policy framework, host of stakeholders and an institutional mechanism, there is still a missing link which is the national priority assigned to development and promotion of renewable energy. It appears that as a nation, Sri Lanka has not properly understood the importance of RE in terms of its enormous potential and also the need to reduce the dependence on imported fossil fuel. There are many divisions and contrasting opinions among individuals and institutions and even within the promoters of different RE options. There are many extremists as well; some advocate fossil fuel based secondary energy options while some believe and argue that RE is the only option. Some even go to the extent of promoting just one RE option claiming its superiority over other options. Under this situation, it is important to have a cohesive national approach with open mind without prejudices and self interests.

- **Recognition of RE in national energy planning.**

Due recognition to RE is not yet given in national energy planning. For many, ‘energy’ means only the ‘electricity’ and ‘thermal energy’ is taken for granted as this need is mostly met by the informal sector of biomass, solar, etc. Though the national energy plan has to be sanctioned by PUCSL, planning responsibility lies with CEB – the only electrical utility in the country. Therefore, naturally the focus would be the ‘electricity’ and that too with the grid-connected supplies. As such, an independent and impartial institution which is knowledgeable and competent in RE should be a part of the national energy planning team. SLSEA could play this role. Provincial representation is also a must as the availability and the potential for RE is high in remote areas.

- **National policy for domestic level biomass use.**

Though the primary energy needs are predominantly satisfied with biomass, especially the domestic and rural energy needs, there is no national policy and an institutional mechanism yet to support and regulate this sector. The unorganized nature of this sector poses many difficulties in bringing it under a meaningful policy frame work but should not be disregarded as it is a vital contributor to energy needs.

- **Tariff rationalization.**

Those who are advocating RE have managed to convince the policy makers to have somewhat attractive tariff structure for grid-connected, non-conventional renewable energy electricity generation. However, some believe that the tariff fixing process needs to be further rationalized based on facts and figures but not on the lobbying power of a particular interest group. The tariff structure for electricity also has a great influence on promoting RE as low consumers of electricity are subsidized to a greater extent for social and political considerations. Such consumers have no incentives to look for RE options.

- **Fossil fuel subsidy.**

Fossil fuel price also has a great influence on promoting RE. Kerosene is heavily subsidized at the expense of petrol for social and political considerations. As kerosene is mostly used for lighting in rural areas and for cooking in urban areas, such consumers have no incentives to look for RE options.

□ **Environmental regulations.**

In order to popularize and propagate RE, CEA needs to take RE friendly stance at least for a few years by relaxing certain restrictive regulations and approval procedures.

□ **Import duties and taxes.**

As initial costs of many renewable projects are relatively high, it is important to keep all other costs down. Therefore, import duties, taxes and other levies on RE equipment, appliances, etc. need to be removed or reduced at least in par with BOI approved bigger projects that enjoy such benefits.

□ **De-monopolization of electricity distribution.**

CEB is the sole authority of electricity distribution through the national grid. Distribution in one part of the capital is handled by LECO which is a subsidiary of CEB. Some decades ago, when the national grid was not expanded, some provincial cities had their own power generating and distribution systems run by municipalities, town councils and local authorities. All of them had mini grids and most of them were oil based and the city of Nuwaraeliya in the hill country was powered by a mini-hydro project. However, due to the sub-optimal level of their operation and also with the gradual expansion of the national grid, all of them were taken over by CEB. Therefore, mini grid systems are not a new concept in Sri Lanka. With the need to accommodate small power producers and also to promote self contained combined power and heat generation for industrial applications, mini grid systems could be reconsidered by allowing private investors also to generate, distribute and sell electricity using non-conventional renewable energy sources. This would also pave the way for healthy competition among electricity sellers which would benefit the consumer. Recently introduced Net Metering is a welcome move of CEB and LECO. The time is right for CEB to consider other possibilities such as "wheeling" practiced in other countries.

11.2.4 Strategies to Remove Information Barriers

□ **Data collection & updating mechanism.**

The effort of SLSEA in preparing annual "Sri Lanka Energy Balance" is highly commendable which provides the macro picture of the country's energy situation in terms of installed capacity of electricity generation, demand and supply. The focus is more on electricity generation and petroleum products as there are dedicated organizations responsible for these two sectors. A similar effort should be taken to compile and publish data on RE such as availability of resources, supply and demand, etc. on annual basis for the benefit of investors, project promoters and also for researchers. It will not be an easy task as there are no dedicated organizations as in the cases of electricity and petroleum and also due to the informal nature such resources and their applications. There had been many successful attempts from time to time by different organizations to assess RE resources. Such assessments became very useful for RE promotions. But a proper mechanism to continuously update such data and publicize has not yet materialized. There will be a high demand for such information from private investors and the availability of information would drastically reduce project formulation costs and processing time.

□ **Capacity building of local authorities.**

Local authorities in provinces have to play a fairly big role in the approval process of RE projects but they lack necessary competence and skills in handling such tasks. The end result is the undue delays in project implementation. Therefore, it is very essential to build the capacities of officers involved in project approvals.

□ **Community level training & education.**

Mostly the communities in rural areas will benefit from RE projects. They themselves have to manage, operate and maintain such projects for which they need to be properly trained and educated. Some NGOs are giving high priority for training but such efforts need to be broad based especially in areas where high potential for RE exists.

□ **Formal education system.**

If we are to assign the national importance and priority for RE promotion, brining it under the formal education system at all levels (Primary, secondary and tertiary) is a must. Especially, cultivating the right attitude, learning to appreciate and understanding the importance at the very tender age would go a long way in embracing RE as part of our day to day living.

□ **Public awareness.**

Lack of awareness among thegeneral public has resulted in a negative sentiment towards RE. In general, RE is perceived as inferior in terms of convenience, flexibility, etc. compared to other forms of conventional energy sources. If we are to assign national importance to RE, lack of awareness needs to be attacked from all fronts. The general public needs to be made aware of the importance of RE through all means. Both print and electronic media have a distinct role to play in such awareness.

11.2.5 Strategies to Remove Institutional Barriers

□ **Execution of powers vested in SLSEA.**

As described in Chapter 4, SLSEA is vested with enormous powers but it is yet to execute such powers in full scale. Most of the issues dealt in Chapter 10 under barriers could be overcome by the executing powers of SLSEA.

□ **Dedicated organization for the promotion of RETs**

This should be considered in line with one of the strategies suggested for technology testing under the removal of technical barriers. A dedicated organization proposed for the said task could also act as the promoter of RETs.

□ **Need driven projects**

It has been a common occurrence that some projects are donor driven rather than national need driven whether they are implemented by State sector or NGOs. This is possible when the organizational needs are not aligned with national needs. Such incongruence could lead to a waste of funds and have negative repercussions for genuine efforts.

□ **Capacity building of approving bodies.**

What is said for local authorities is true for national level approving bodies too. Some officers involved in project assessments, evaluations and approvals lack necessary competence and skills in handling such tasks. The end result is the undue delay in project implementation. Therefore, it is very essential to build the capacities of such officers.

□ **Making state entities accountable.**

In addition to the competency and skills issues, lack of accountability on the part of some officials involved in approval process has resulted in undue delay delays in project approvals.

11.3 Specific Strategies

11.3.1 Biomass for Dendro Power

□ **Support mechanism for biomass suppliers.**

A steady supply of biomass is a crucial factor for the promotion of Dendro power and for industrial and commercial sector thermal energy generation. Fair amount of investment and effort is required for commercial scale fuel plantation. Lead time of about 18 months is required for the first harvest in case of Gliricedia – that has been identified as the most suitable Short Rotation Coppice for local conditions. It took a considerable period of time and effort of the promoters of bio-energy to attract entrepreneurs and investors into the business of commercial firewood plantations. High fossil fuel price is the decisive factor for the energy users to switch over to biomass. As the demand for biomass increases, the price goes up and that is the driving force behind the propagation of commercial plantations. However, drop of fossil fuel prices reverses this trend. It happened in Sri Lanka recently with the global economic slow down. Many individuals and entities invested on commercial plantations are badly affected. Some are still struggling to survive while others have given up. The danger is that, they will never comeback and also it gives negative signals to prospective new entrants. Therefore, a state sponsored support mechanism is needed to protect the suppliers against the effect of fossil fuel price fluctuations.

□ **Relaxing transport restrictions for commercially grown firewood.**

Wood and timber transport is restricted in Sri Lanka to prevent illegal felling of jungle trees and other trees having food or 'Aurvedic' values. Law imposing authorities with a lack of understanding of the difference, apply the same restrictions to the transportation of commercially grown firewood causing a lot of inconvenience to the industry. Therefore, either reinterpretation of the law or some relaxation for commercially grown firewood is required.

□ **Technologies for fuel processing.**

It appears that the focus is on the development and improvements of conversion technologies but little is being done to improve fuelwood processing technologies that would bring down cost of transportation and enhance conversion efficiencies as well as keeping quality of firewood.

□ **Energy entrepreneurs – A new business model**

Sri Lanka could learn from the "Tea Factory Model" when promoting energy entrepreneurs. The tea factory model consists of a tea manufacturing unit, a nucleus tea plantation to ensure a minimum supply of green tea leaves to operate the manufacturing unit, out-grower system surrounding its nucleus to buy extra green tea leaves to run the manufacturing unit at its full capacity and a trading arrangement through brokers to sell its finished product which is the 'tea' to final consumers. A similar model could be applied to promote Energy Entrepreneurs. In place of 'tea', the final product to be sold will be the 'energy' or 'electricity'. Energy Entrepreneurs could run a Dendro power plant with the capacity of around 250 to 500 kW with its Gliricedia nucleus plantation of around 100 to 200 acres and with surrounding out-growers to cover an extent of around 300 to 400 acres. In this case, the broker is the CEB to which electricity is sold through a power purchasing agreement. This model could be tried out in areas where marginal lands are available with grid accessibility.

11.3.1 Wind

- **Maintenance capabilities.**

Special skills are required for the maintenance of wind turbines and towers owing to the complexities of systems and unsafe conditions under which maintenance have to be carried out.

11.3.1 Biogas

- **Appliance bank.**

Reliable appliances such as lamps, cookers, burners, compressors, IC engines, etc. need to be made available for prospective users with performance guarantees under reasonable prices. This could be another task for the already suggested dedicated organization for the promotion of RETs.

Chapter 12

CONCLUSION

Sri Lanka is endowed with ample resources of renewable energy. Nearly 50% of the country's electricity generation is from renewable hydro resources, though its share is coming down as the hydro power potential is fully harnessed. The balance requirement is being met by imported fossil fuel making Sri Lanka more vulnerable to external forces. The energy demand of Sri Lanka is on the increase for industrial and commercial uses as well as for rural electrification. It is undoubtedly a big challenge for every one; planners, policy makers and even the energy users. However, the share of electricity generation from non-conventional renewable energy resource is as low as 4%. The target is to achieve 10% by 2015.

Sri Lanka now has a supportive frame work of energy policy and also an institutional mechanism with a fully empowered organization (SLSEA) to give a real boost to the development and promotion of renewable energy.

Sri Lanka could also boast of its profound success in promoting SHS for rural electrification which is quoted by many as unique. This is a typical case where public and private participation works very well. A conducive environment was created with policy supports, financing mechanisms, technological supports, incentives, capacity building, etc.

Sri Lanka could learn from this success and venture into more challenging but high potential renewable energy options such as Wind, Biomass and Solar to meet its growing energy needs.

There are still many shortcomings that ought to be overcome to get the best use of this abundant renewable resource. First and foremost is the technological base that needs to be consolidated. Technology has to be reliable and cost effective. Then the economics have got to be right for which there must be RE friendly credit facilities supplemented by prudent incentives. Capacity building at all level is paramount to have a persistent and sustained effort.

Above all what is crucial is the national priority assigned to the cause. It appears that some influential stakeholders are still half hearted; many divisions, divergent opinions, self agendas, etc. An open mind approach by seeing things in the right perspective would take Sri Lanka to the threshold of the renewable energy era.

Annex 1

REFERENCES

[1] Abeygunawardana, A., **The role of community organizations and NGOs in the energy sector**, Energy Forum (Power Point Presentation).

[2] Boyagoda, M., **Evaluation of Capital Market Constraints to Financing Renewable Power Projects in Sri Lanka**, Prepared for the DFCC Bank on behalf of the Ministry of Finance, Government of Sri Lanka under the Renewable Energy for Rural Economic Development Project, 2007.

[3] Finucane, J.R., **Solar Industry Growth Analysis, Sri Lanka,** under RERED project (Renewable Energy for Rural Economic Development), DFCC Bank, Sri Lanka, 2005

[4] **National Energy Policy and Strategies of Sri Lanka**, Ministry of Power And Energy Government of Sri Lanka, 2006.

[5] Siemens Power Technologies International Ltd, **Technical Assessment of Sri Lanka's Renewable Resource Based Electricity Generation - Technical Assessment of the Generation Absorption Capacity of the Sri Lanka Power System** under RERED project (Renewable Energy for Rural Economic Development), DFCC Bank, Sri Lanka, 2005

[6] Siemens Power Technologies International Ltd, **Technical Assessment of Sri Lanka's Renewable Resource Based Electricity Generation - Overview of Technical Requirements, Connection and Management of Embedded Generation** under RERED project (Renewable Energy for Rural Economic Development), DFCC Bank, Sri Lanka, 2005

[7] Sri Lanka Business Development Centre, **Survey of Batteries Used in Solar Home Systems in Sri Lanka** Submitted to RERED Project, DFCC Bank, 2005

[8] The Energy and Resources Institute (TERI), New Delhi, **Development of Policy Framework for Renewable Energy Resources Based Electricity Generation Project** under RERED project (Renewable Energy for Rural Economic Development), DFCC Bank, Sri Lanka, 2005

[9] ACNielsen Lanka (Pvt) Ltd., **Sri Lanka Solar Industry Market Survey** under RERED project (Renewable Energy for Rural Economic Development), DFCC Bank, Sri Lanka, 2005

[10] Energy Forum - Sri Lanka, **Establishing National and Regional Standards & Code of Practices for Micro-hydro Sector**, 2006

[11] Sugathapala, A.G.T., **Lecture notes on Wind Energy**, Thermo-Fluids & Energy Group, Department of Mechanical Engineering, University of Moratuwa.

[12] Munasinghe, S., **Biogas Technology and Integrated Development, Experiences from Sri Lanka**, Practical Action (formerly ITDG), 2000

[13] Interview with Mr Namiz Musafer, Country Manager, Practical Action Consultancy & Mr Rohitha Ananda, Project Manager (Enhancing Renewable Energy Option) – **Practical Action**

[14] Interview with Mr H.A.Wimal Nadeera, Head, Renewable Energy Resource Allocation – **Sri Lanka Sustainable Energy Authority**

[15] Interview with Mr Kapila S. Abeygunawardana, Assistant Director, Civil Engineering – **Sri Lanka Standard Institution**

[16] Interview with Mr T.A.Wickramasinghe, Head of the Department of Renewable Energy, Mr J.A.Ajith D.Jayasuriya, Senior Research Engineer, Renewable Energy Department, Mr Nandana Edirisinghe, Senior Research Engineer, Renewable Energy Department, Ms Nayana Edirisinghe, Senior Research Engineer, Electrical & Electronics Department, Mr M.V.S.A. Kumara Perera, Head of the Department, Techno Marketing Department – **National Engineering Research & Development Centre**

[17] **http://www.jbic.go.jp**
[18] **http://www.energyservices.lk**
[19] **http://www.sundayobserver.lk/2009/06/07/fin01.asp**
[20] **http://www.ifc.org/southasia**
[21] **http://www.export.gov.il**
[22] http://www.fmo.nl
[23] Sugathapala, A.G.T., **Policy analysis to identify the barriers to the promotion of bioenergy technologies in Sri Lanka**, Energy for Sustainable Development, Volume VI No. 3, September 2002.
[24] http://www.island.lk/2009/01/14/features1.html
[25] http://www.lankabusinessonline.com/fullstory.php?nid=356106394
[26] Elliott, D., Schwartz, M., Scott, G., Haymes, S., Heimiller, D., George, R., **Wind Energy Resource Atlas of Sri Lanka and the Maldives**, National Renewable Energy Laboratory, 2003
[27] Renné, D., George, R., Marion, B., Heimiller, D., Gueymard, C., **Solar Resource Assessment for Sri Lanka and the Maldives**, National Renewable Energy Laboratory & Solar Consulting Services, 2003
[28] http://www.eai.in
[29] http://www.lbo.lk/fullstory.php?nid=621727118
[30] http://ipsnews.net
[31] Proceeding of the Conference, **Achieving Sustainability and Equity in Energy: Policy Choices for the Future**, Sri Lanka Sustainable Energy Authority and Practical Action, 2008.
[32] Proceeding of the Conference, **International Conference on Issues for Sustainable Use of Biomass Resources for Energy**, Asia Pro-Eco Programme, Colombo, Sri Lanka, 2005.
[33] Proceeding of the Conference, **Non Conventional Renewable Energy Tariff Announcement**, Sri Lanka Sustainable Energy Authority, 2009.
[34] Fernando, S., **An Assessment of the Small Hydro Potential in Sri Lanka**, 2002.
[35] **Sri Lanka Energy Balance 2006**.
[36] **Sri Lanka Energy Balance 2007**.
[37] **Our Renewable Energy Future**, Sri Lanka Energy Managers Association, Annual Session Report, 2005.
[38] Dhanapala, K., Wijayatunga, C., **Best Practices for Micro-Hydro Development**, Practical Action South Asia Programme, 2006.
[39] **Code of Practices for Design & Construction of Micro-Hydro Power System**, Sri Lanka Standard Institution, 2007.
[40] Gunawardena, S., **Liquid Biofuel for Transportation in Sri Lanka**, e-net (energy network), 1/2009.
[41 **Code of Practices for Design & Construction of Biogas System, Part 1 – Domestic Biogas Systems** , Sri Lanka Standard Institution, 2006.
[42] Wijayatunga, P. D. C., Siriwardena, K., Fernando, W. J. L. S., Shrestha, R. M. and Attalage, R. A. **Strategies to overcome barriers for cleaner generation technologies in small developing power systems: Sri Lanka case study,** Energy Conversion & Management, Vol. 47, No. 9-10, June 2006, pp. 1179-1191.
[43] Beck, F., Martinot, E., **Renewable Energy Policies and Barriers,** Academic Press/Elsevier Science, 2003-2004.
[44] **Energy for Sustainable Development Sri Lanka - A Brief Report with Focus on Renewable Energy & Poverty Reduction,** Integrated Development Association (IDEA)
[45] **Green Technological Interventions in Sri Lankan Industries, Promotion of Eco-efficient Productivity (PEP) Project,** An initiation of the Ceylon Chamber of Commerce with financial Assistance from the Royal Netherlands Embassy, 2009.

[46] **http://sundaytimes.lk/071223/FinancialTimes/ft338.html**
[47] **http://www.jica.go.jp/english/news/press/2009/090420.html**
[48] **http://www.serd.ait.ac.th/smi_vol2no2.pdf**
[49] http://www.windenergy.com/aboutsmallwind/wind-power-case-study-sri-lanka.htm
[50] Abeygunawardana, A., **A world without oil or coal – A solution to Sri Lanka's electricity crisis in the post fossil fuel era,** 2008.
[51] Draft Report - **Reducing Greenhouse Gas (GHG) Emissions by Promoting Bio-energy Technologies for Heat Applications**, (FAO-UNEP-GEF Project No: EP/RAS/106/GEF), Energy Conservation Fund Ministry of Power & Energy, 2005.
[52] **Sri Lanka Sustainable Energy Authority Act No 35 of 2007**, Parliament of the Democratic Socialist Republic of Sri Lanka.
[53] **Annual Report – Central Bank of Sri Lanka**, 2008.
[54] http://www.gov.lk/info/index.asp?mi=19&xp=0&xi=62&o=0&t=0
[55] Interview with Mr Indika Gallage, Managing Director, – **EnerFab (Pvt) Ltd**
[56] Interview with Mr Parakrama Jayasinghe, President – **The Bio-energy Association of Sri Lanka**
[57] Interview with Mr Lalith Seneviratne, President – **Lanka Gasifiers Private Ltd.**
[58] Interview with Mr Asoka Abeyginawardane, Executive Director – **Energy Forum**
[59] Interview with Dr Thusitha Sugathapala, Senior Lecturer, **University of Moratuwa**

Annex 2

LIST OF INTERVIEWEES
(SOME KEY STAKE HOLDERS)

1. Mr Namiz Musafer, Country Manager, Practical Action Consultancy & Mr Rohitha Ananda, Project Manager (Enhancing Renewable Energy Option) – **Practical Action**
2. Mr H.A.Wimal Nadeera, Head, Renewable Energy Resource Allocation – **Sri Lanka Sustainable Energy Authority**
3. Mr Kapila S. Abeygunawardana, Assistant Director, Civil Engineering – **Sri Lanka Standard Institution**
4. Mr T.A.Wickramasinghe, Head of the Department of Renewable Energy, Mr J.A.Ajith D.Jayasuriya, Senior Research Engineer, Renewable Energy Department, Mr Nandana Edirisinghe, Senior Research Engineer, Renewable Energy Department, Ms Nayana Edirisinghe, Senior Research Engineer, Electrical & Electronics Department, Mr M.V.S.A. Kumara Perera, Head of the Department, Techno Marketing Department – **National Engineering Research & Development Centre**
5. Mr Indika Gallage, Managing Director, – **EnerFab (Pvt) Ltd**
6. Mr Parakrama Jayasinghe, President – **The Bio-energy Association of Sri Lanka**
7. Mr Lalith Seneviratne, President – **Lanka Gasifiers Private Ltd.**
8. Mr Asoka Abeyginawardane, Executive Director – **Energy Forum**
9. Dr Thusitha Sugathapala, Senior Lecturer, **University of Moratuwa**

Annex 3

PUBLICATIONS COLLECTED

Practical Action

1. Video **- Electricity from Wind** (Introduction to community owned small wind systems and explanation as to why it is suitable option for rural electrification).
2. **Best Practices for Micro-Hydro Development** by Kiran Dhanapala & Priyantha D.C. wijethunga (Provide a thorough analysis of each stage of evolution of Micro Hydro in Sri Lanka and captures important lessons that are useful for planning and implementing of development programmes), 2000.
3. **Directory of Bio Gas Service Providers** (Institutions, Field Officers, Masons and Implement Manufacturers) – Bilingual (English & Sinhala).
4. Proceeding of the Conference – **Achieving Sustainability and Equity in Energy: Policy Choice for the Future** conducted by Sri Lanka Sustainable Energy Authority and Practical Action on 30th January 2008, Colombo, Sri Lanka.
5. **Community Based Micro-Hydro Village Electrification Schemes – Technology & Approach**.
6. **Community Based Micro-Hydro Village Electrification Schemes – Operation & Maintenance**.
7. **Is a Community Based Micro-Hydro Electrification Scheme Suitable for Your Village**?
8. **E-net** (Energy Network) magazine, 1/2008
9. **E-net** (Energy Network) magazine, 2/2008
10. **E-net** (Energy Network) magazine, 1/2009
11. **"Sulan Viduli Yanthrayaka Varshika Nadaththuwa"** (Annual Maintenance of a Wind Generator) – Sinhala publication
12. **"Gruhastha Geewa Wayu Paddathi – Pariharanayata ha Nadaththuwata Upades"** (Domestic Biogas Systems – Operation & Maintenance Manual) – Sinhala publication.
13. **"……………………………."** (Annual Maintenance of a Wind Generator) – Tamil publication
14. **"Jana Thaksana Puwath"** (Appropriate Technology News), 2007-3-4, – Sinhala publication
15. **"Sulagin Apata Lite"** (Light from Wind), May 2004, – Sinhala publication

Sri Lanka Standards Institution

1. **Code of Practice for Design & Construction of Biogas Systems** – Part 1 – Domestic Biogas Systems, Sri Lanka Standard 1292 : 2006, UDC 662.767.2
2. **Code of Practice for Design & Construction of Micro Hydropower Systems**, Sri Lanka Standard 1311 : 2007, UDC 621.221.3

Sri Lanka Sustainable Energy Authority

1. **Sri Lanka Energy Balance 2006** (An analysis of energy sector performance)
2. **Sri Lanka Energy Balance 2007** (An analysis of energy sector performance)
3. **Sri Lanka Sustainable Energy Authority Act,** No 35 of 2007

4. **On-Grid Renewable Energy Development - A Guide to the Project Approval Process**, (A GUIDE TO POLICIES AND PROCEDURES TO SECURE APPROVALS TO DEVELOP A RENEWABLE ENERGY PROJECT TO SUPPLY ELECTRICITY TO THE NATIONAL GRID), 2009
5. Video – **Fuel Wood Technology As an Alternative Source of Energy**.
6. Video – **"Kuda Jala Widuli Balagara Thakshanaya"** (Micro-hydro Technology) – Sinhala.

National Engineering Research & Development Centre

1. Brochure, **Solar PV and Solar Home System Testing**, Department of Electrical & Electronic Engineering
2. **"Thakshanayan Saha Sevavan"** (Technology & Services), May 2004, – Sinhala publication
3. Brochure, **Batch Type Lankan Biogas Generator**
4. Brochure, **Saw Dust Fired Vegetable & Fruit Dehydration Machine** – Bilingual (English & Sinhala) publication
5. Brochure, **Saw Dust Fired Bakery Oven** – Bilingual (English & Sinhala) publication
6. Brochure, **Bio-mass Rice Cooker** – Bilingual (English & Sinhala) publication
7. **"Lanka Jeewa Wayu Jankaya"** (Lanka Biogas Generator) – Sinhala publication
8. Brochure, **Lanka Shakthi Wood Gas Stove** – Bilingual (English & Sinhala) publication
9. Brochure, **Integrated Solar Water Heater**

Energy Forum

1. **A world without oil or coal – A solution to Sri Lanka's electricity crisis in the post fossil fuel era**, By Asoka Abeygunawardana, 2008.
2. **"Meeting the electricity demand in Sri Lanka by 2020 – A way Forward",** Energy Forum & World Alliance for Decentralized Energy, 2006

Bio-energy Association, Sri Lanka

1. **"Biomass Energy Toolbox – The way forward for the use of wood and agricultural waste for energy production in S.Asia"**, Asia Pro Eco Programme.
2. **"Deya Negumata Wawamu Gliricedia" (Growing Gliricedia for Nation Building),** Ministry of Science & Technology and Bio-energy Association, Sri Lanka– Sinhala publication