Renewable Energy Development in Sri Lanka

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1.0 What is Renewable Energy?

Renewable energy is any form of energy, which can be used by the present generation without affecting the future generation's ability and right to use the energy resource. The basic forms of renewable energy are based on solar energy (Biomass, Hydro, Direct solar and Wind). All these renewable energy forms depend on the solar radiation, except geothermal energy, which again is a renewable energy resource, independent of solar energy. Another significant renewable energy resource is animal energy, which has been used extensively in the past to transport people and goods. Even human muscle energy, as used in cycling, rowing and in all possible agricultural activities, amount to a form of renewable energy extensively traded in the past in the form of slaves.

In contrast, non-renewable energy resources are petroleum, coal, nuclear and natural gas. These forms of energy, which are consumed by the present generation causes rapid depletion of resources denying the right of the future generation to use it.

Biomass Energy

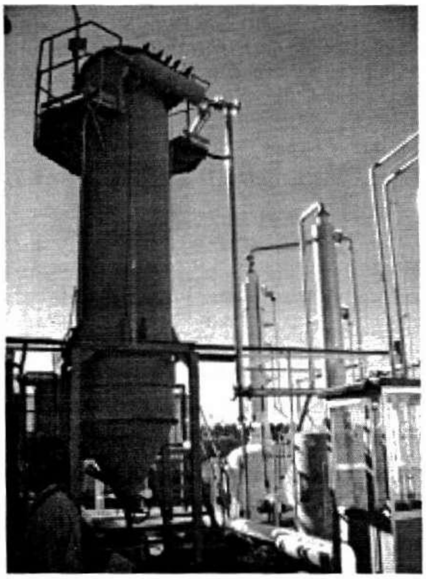
Sri Lanka has a vast potential of producing biomass from a unit area as a result of high plant growth rate due to high incidence of solar energy and rainfall. It is estimated that approximately 40 Billion kg of biomass can be generated by converting marginal land to fuel wood plantations, and improving productivity of other crop land and home gardens [Energy Conservation Fund, 2005). Total potential of this resource is estimated to be about 16 Million tonne oil equivalents (Mtoe) per annum. Most widely-used renewable energy in Sri Lanka is biomass. Biomass energy falls into three categories:

(i) Solid biomass, which are either raw fuel wood or a processed form of agro or animal waste such as fuel briquettes, paddy husk, etc. This is the most widely-used energy form in Sri Lanka, accounting for more than 50% of the total energy consumption.

(ii) Liquid biofuels, named biocarburants in an engineering perspective, which are alcohols and oils derived from either tree or animal sources. Even though these commodities are produced in large volumes, they are not utilised at present for energy purposes.

(iii) Gaseous biofuels, commonly known as biogas, which are combustible gases emanating from rotting biomass, due to a process known as anaerobic digestion. A small number of households use this energy form, converting animal droppings and agro-wastes into a valuable cooking fuel.

Figure 1
A Modern Biomass Power Plant



Biomass energy can be produced in large quantities in Sri Lanka, where a lot of rainfall, plenty of sunshine and a fertile soil, all combine to produce high biomass yield from a given area within very short time period, compared to other less favourable countries. However, countries without high biomass yields are also paying serious attention to develop bio resources other than grown fuel wood. A modern biomass power plant depicted in Figure 1 is located in Spain, and is able to generate electricity from a variety of bio resources ranging from forest derived wood chips to agro waste. Amount of solid biomass extractable on a sustainable basis is around 30,000 kg/ha per year, in contrast with most other countries, where yields are mostly around 10,000 kg/ha per year (Global Environmental Division 1998). Further, what we term as dry and arid conditions (e.g., Puttalam and Hambantota areas) are considered wet areas in notions adopted by other countries based on annual rainfall. Hence, the country can be termed as a rich country in terms of biomass resources. The government has already recognised the need to elevate biomass as both a commercial crop as well as the third fuel option for electricity generation and has declared Gliricedia Sepum (known as Weta Mara, Ladappa, Ginisiriya) as the fourth plantation crop after tea, rubber and coconut. The government is also planning to replace 20% of transport fuels by 2020, and the prospects for biomass energy in Sri Lanka would be bright.

Hydro Energy

Due to the geographical configuration having a rain-fed central hills, Sri Lanka enjoys a good hydro-power potential. Hydro-power potential is defined by two aspects of the water resource which is either moving or flowing body of water, i.e., the amount of water that passes through a point during a given period and the vertical drop through which the body of water passes through. Hence, large volumes of water and sudden drops (e.g., water falls) are termed good hydropower resources. The country has used this resource for conveyance of irrigation water for many millennia, and for electricity generation during the last two centuries. Early days of grid electricity generation saw hydro as the major component in electricity generation, accounting for more than 65% of the total. Recently, this component has been reduced to 35% mainly due to the exponential load growth, which cannot be met by this limited resource (Energy Conservation Fund 2005)

Figure 2
A Locally Manufactured Hydro Turbine

Major hydropower potential will be fully developed with the commissioning Upper Kothmale Hydropower Project in 2010, totalling an installed capacity of 1355 MW.

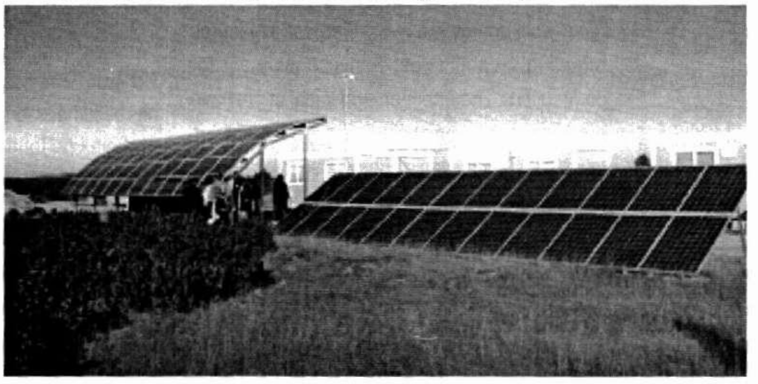
However, significant portion of small hydro potential remains to be developed. Potential sites have capacities ranging from a few hundred kW to 40 MW, and the total potential is estimated to be around 500MW. Of this total, private sector developers have developed 133 MW and almost all the remaining capacity has been identified by the Ceylon Electricity Board (CEB) and private sector developers. Thus, total energy potential that can be realised by developing this portion stands at 1,500 GWh (360 Thousand toe) per annum [Energy Conservation Fund]. Apart from these medium and large scale projects, micro hydro or community investment projects which uses hydropower to electrify isolated rural villages too dot the central highlands of Sri Lanka. A significant aspect of these projects is the use of local plant and equipment in almost all projects, opening the doors for a whole new industry of manufacture of hydropower turbines as shown in Figure 2 in p. 16.

Solar Energy

Located near the equator, Sri Lanka is blessed with an impressive solar energy resource. From the earliest times, this resource had been utilised for drying purposes such as crops, clothes, etc., and has remained largely a non-commercial energy resource.

Two thirds of the country's lowland area receives a radiation of 4-5.5 kWh/m^2 per day, whilst the remaining area in the central hills receives a lower radiation of 2-3.5 kWh/m^2 per day, due to persistent cloud cover in those areas. It is interesting to compare these energy yields with daily electricity consumption of a typical household as both are in the same range of 4-5kWh per day [National Renewable Energy Laboratory of the United State of America 2003). However, it is dangerous to assume that all houses can be provided with a solar panel of 1m^2, as conversion losses and energy storage requirement of such a system is well beyond the reach of a typical family. Cost of a solar solution comparable with a CEB grid electricity connection is about 4 million rupees, and a unit of energy thus produced will be more than 10 times as expensive as a unit of energy supplied by CEB.

Figure 3
An Array of Solar PV panels Generating Electricity for a Central Grid



Solar photovoltaic technology has come forward to provide basic electricity to isolated and sparsely-populated areas of the country, with successful initiatives by both the CEB and the National Engineering Research and Development (NERD) Centre. Presently, the technology has reached a high level of commercialisation, with installed capacity reaching a 2.5MW level, with approximately 90,000 solar home systems, and a 35kW pilot-scale grid-connected plant. However, in most European countries, grid connected solar PV arrays are now becoming a common sight as depicted above in Figure 3.

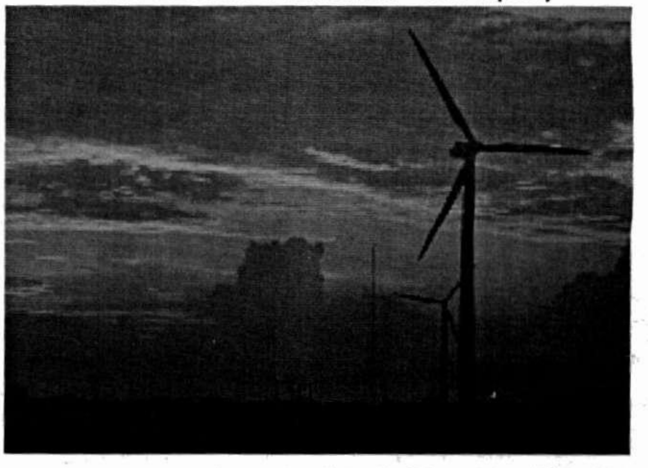
The potential of this resource is usually not quantified, because the only limiting factor is land area. However, a significant amount of energy can be harnessed using solar thermal technologies for commercial heating applications as well as for power generation. The size of the resource can be approximately estimated to be around 100 Million GWh (8,600 Mtoe) [Energy Conservation Fund 2005)

Wind Energy

Sri Lanka is located in the Indian Ocean facing a vast swath of uninterrupted ocean, providing solid wind energy potential. The country experiences two main wind climates, namely the South-Western monsoon (May-August) and the North-Eastern monsoon (October-December). Archaeologists have proven that iron smelting using South-Western monsoon without the use of a bellow to pump air to smelting furnaces had been widely-used technology during the period of 300-200 B.C. in the Balangoda area, making Sri Lanka the earliest country to utilise wind energy for productive work(Gill Juleff 2003)

As in the case of hydropower, wind energy is derived from a moving body of wind, by transferring the kinetic energy of the moving body of wind to a turbine rotor. Due to the very low density of wind, (water is nearly thousand times denser than air) the devices needed to harness wind energy are enormous structures, usually having rotating components with diameters exceeding 100m.

Figure 4
Wind Power Plant of Hambantota – 3MW Capacity



The wind resources, estimated after a meso-scale study by the National Renewable Energy Laboratory of the United States of America (USA), with the CEB under a technical assistance programme of United States Agency for International Development (USAID), stands at 25,000 MW. Only 3 MW of capacity of this vast, indigenous resource is presently exploited. The first wind power plant of Sri Lanka is in operation for the last decade in Hambantota as shown in Figure 4. The most promising area identified in the above study is the west coast, and a further ground wind assessments are underway, to develop this resource to a commercial level. The total potential of this resource is estimated to be around 40,000 GWh (3,440 Thousand toe). Only a portion of this capacity may be developed, if Sri Lankan grid remains isolated from a stronger regional power grid.

Other Renewable Energy Sources

In addition to the four resources mentioned above, there are other forms of renewable energy such as wave energy, ocean current energy, geothermal energy and (Ocean Thermal Energy Conversion (OTEC) energy which could be useful for Sri Lanka in the distant future. Presently, these resources are evaluated and technologies being developed for energy conversion, and early breakthroughs are eagerly awaited by the research communities worldwide. Hence, no attempt will be made to describe these forms of energy.

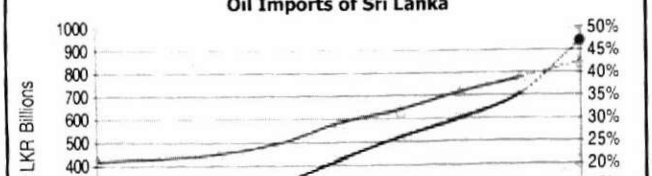
2.0 Why Develop Renewable Energy?

In the latest energy policy development effort by the Ministry of Power and Energy, a strong emphasis is made on energy security, from both the national level strategic sense and from an individual's perspective. The policy envisions a situation where reliable, affordable and clean energy is available to all the citizens of the country. This requires an energy resource base, or resources, available aplenty, at all times. However, almost all energy resources fail to meet this criteria and the need for several resources or an energy mix arises.

Although renewable energy, in the form of major hydro schemes had contributed heavily to the development of Sri Lanka, present focus is on non-conventional renewable energy sources i.e., excluding the well-known major hydropower projects. This is the direct result of the exhaustion of all major hydro resources, as shown in the Figure 5 below. From this graph, it can be clearly visualised that no major hydro capacity addition has taken place since mid 1990s. Continuing increase in level of electrification and, industrial and commercial development is increasing the demand for electricity, whilst the exploitable major hydropower resources remain static.

This phenomenon, coupled with the steep rise in world oil prices has adversely affected the country's economy and the energy sector in particular (Figure 6).

Figure 6
Impact of Oil Imports on National Economy



All over the world, the deepening energy crisis is being dealt with by the two-prong strategy of renewable energy development and energy efficiency improvement. Renewable energy often fails to appeal to financial analysts because renewable energy is a thinly-dispersed resource requiring unfamiliar/expensive equipment for conversion. The effect of high initial costs have prevented many renewable energy projects from taking-off, as renewable energy resources appear to be unattractive investments in a financial sense. However, almost all renewable energy resources have a strong contribution to national economic development, by way of providing long term price stability in electricity prices particularly in the case of countries without petroleum resources. A case in point is Sri Lanka, where the pioneering efforts of Eng.Wimalasurendra which gifted Sri Lanka a series of hydropower plants which are still insulating the electricity user from market upheavals after half a century of existence. This is due to the fact that cost of renewable energy can be fixed, as it depends almost entirely on the capital cost, as the fuel required to operate these plants are available at no cost or at a fixed cost determined by royalties rather than vagaries of international markets.

Unlike non-renewable energy conversion plants, which are characterised by a relatively low initial investment and a substantial operational cost, renewable energy conversion plants have negligible operational costs. This offsets the high capital cost and contributes significantly to maintaining lower, long-term energy costs. Renewable energy production facilities are not subject to fuel-price volatility, therefore, renewable energy should be considered to be the ultimate strategy for stabilising energy prices in the long term. For an example, a mini-hydropower plant commissioned today will be able to provide a unit of electricity at a constant price of LKR12.77 during the next twenty years, giving robust returns to financiers and investors. Such a level of comfort and certainty are impossible to expect from a fossil fuel burning power plant, as the volatile fuel prices pay the dominant role in the price structure of those projects.

Renewable energy also contributes to retaining national wealth within the country. This is seen as an important aspect as in year 2004, the oil import bill amounted to 22% of all export earnings. This level of drain was avoided during the last two decades thanks to the pioneering efforts of Wimalasurendra and the accelerated Mahaweli Scheme. The need to develop renewable energy has become a high priority, as year 2006 is expected to drain one fourth of our export earnings on oil [Energy Conservation Fund 2005).

The acceleration of renewable energy development in Sri Lanka needs to become a major strategy in a broad-based energy mix to provide quality, affordable energy to its citizens, whilst contributing heavily to minimise adverse effects on the environment by lowering greenhouse gas emissions. The vast untapped potential of renewable energy and the diversity of the array of possibilities allow Sri Lanka to benefit and to veer away from an economic calamity, stimulated by the oil crisis. In this respect, the promise of biomass energy, with its capability to deliver firm power stemming from the storage characteristic and the promise of wind energy, with its sheer vastness should receive high priority in the development plan. The national energy demand, encompassing all sectors from domestic cooking hearth to mega-scale industries, expressed in toe per annum terms for a five year period, and the annual potential of each resource are shown in Tables 1 and 2.

Table 1
Primary energy requirement of Sri Lanka from 2006 to 2010

Year	2006	2007	2008	2009	2010
Primary energy requirement (Thousand toe/year)	9,313	9,639	9,976	10,326	10,687

Source: Corporate Plan 2008-2010, Sri Lanka Sustainable Energy Authority

Table 2
Annual energy potential of resources in Sri Lanka

Resource	Potential Thousand toe/year
Biomass	16,000
Hydro	360
Solar	8,600,000
Wind	3,440

Source: Corporate Plan 2008-2010, Sri Lanka Sustainable Energy Authority

3.0 Renewable Energy Development as an Economic Opportunity

Renewable energy provides sound economic opportunities, especially for local enterprises since all renewable energy resources are available within the country with a thin dispersion.

Table 3
Investment opportunities in electricity generation in Sri Lanka from 2007 to 2016

Year	Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Electricity Generation	Biomass										
Cumulative Capacity MW	Mini Hydro	1	3	20	31	42	53	64	75	80	91
	Wind	112	130	134	151	168	186	203	220	250	267
		3	3	30	54	78	102	125	149	170	194
Investment Opportunity LKR Millions		1667	4367	5724	5724	5724	5724	5724	5724	5724	4057
Industrial Thermal Energy Generation Cumulative Capacity MW	Petroleum to Biomass	5	11	35	67	123	190	270	360	460	570
Investment Opportunity LKR Millions		45	54	216	288	504	603	720	810	900	990

Source: Corporate Plan 2008-2010, Sri Lanka Sustainable Energy Authority

Unlike petroleum and other fossil fuel resources which are confined within the boundaries of very few countries, renewable energy occur almost in all countries, and is considered a very *democratic* resource. A 60% of known oil resources are located in three countries. The wide dispersion of renewable energy resources means, unlike a highly concentrated form of energy, the harnessing will essentially be confined to the local area of occurrence of the renewable energy resource, resulting in local involvement and creation of room for local investments. Further, the thin dispersion means wide distribution of harnessing activities, resulting in quite a large number of energy conversion facilities (e.g., large number of mini hydropower stations dotting the hill country) rather than a single central plant (e.g., the sole petroleum refinery of Sri Lanka located in Sapugaskanda).

However, these same characteristics make it difficult for harnessing the renewable energy, as the occurrence of the resource and consumption of the converted energy happen to be on two geographical locations. The issue of transportation or transmission crops up due to this fact. Further, renewable energy is considered a non-firm energy, as most forms of renewable energy tend to vary in magnitude with time. For an example, our hydro resources display a substantial seasonal variation, whilst wind energy also follows a seasonal variation and an hourly variation as well. These characteristics of renewable energy limit our ability to fully exploit these resources. Another complexity is the difficulty of storing energy. Other than biomass energy, nóne of the renewable energy sources available to us can be economically stored, for release on demand.

Considering the above characteristics and limitations, the government has envisaged developing the renewable energy resources to reach 10% of total electricity demand by 2016. Further, industrial thermal energy requirement will be met by expanding the present utilisation by another 10% by 2020. Biofuels as an important constituent of the transport energy will be developed to take a 20% share by 2020. The investment opportunities available in these areas are given below (Table 3).

Biomass energy features prominently in the programme, mainly because of its unique characteristic of ability to store energy for release on demand and ability to act as a conduit of wealth from urban consumers to rural farmer/producer of energy crops. In this light, it is worthwhile to consider the benefits accruing from a typical 10MW Dendro power plant (Table 4).

Table 4
Benefits of 10Mw Dendro power plant

Outcome	Quantity
Energy Generation GWh / year	701
Fuel Saving Million Litres	140
Foreign Exchange Saving US$ Million / year	70
Addition to Forest Cover ha	40,000
Contribution to Agricultural Output	1.7%
Direct rural income LKR Million / year	1,667
Indirect rural income LKR Million / year	5,513
Total rural income LKR Million / year	7,181
Direct Employment persons	15,600
Indirect Employment persons	80,000
Total Employment persons	95,600

Source: Report of the Inter Ministerial Working Committee on Dendro Thermal Technology

Similarly, other renewable energy technologies also provide varying degrees of economic benefits, and equal amounts of environmental benefits whilst contributing towards the national energy security. It is an absolute necessary to look beyond the available portfolio of renewable energy and develop technologies for newer types of technologies such as solar concentration systems and wave power systems, as Sri Lanka is blessed with both these resources.

4.0 How this will be achieved

Renewable energy in general, and biomass in particular, has been recognised by the government as a means of achieving long-term stability of energy prices and a tool for income distribution. Accordingly, a proposal to establish a dedicated agency for renewable energy development and energy efficiency by the name of Sri Lanka Sustainable Energy Authority (SEA) and an Energy Development Fund, by the name of Sri Lanka Sustainable Energy Fund (SLSEF) and a host of other integrative measures have been already achieved by the Government of Sri Lanka.

As a first step in the direction of developing the full potential of renewable energy, the government is contemplating to offer a cost-based generation tariff to project developers, thereby eliminating the present discriminatory treatment of all but one technology i.e., mini hydropower. With the new system, all other technologies such as wind, biomass and even hitherto undeveloped low-head hydropower will receive investor interest, and a hive of activity in the sector is expected. The cost-based tariff will initially require additional financial resources, as the CEB will pay only a portion of the cost of the new cost-based tariff. SLEF is expected to act as a cushion between the project developer and CEB, by providing additional financial support by way of government funds. It is envisaged to progressively reduce dependence on treasury funds by several methods mentioned below:

(a) Attracting a portion of carbon credits received for energy sector projects.

(b) Levying a cess on energy sales (e.g., 1US$ per toe of commercial energy use) from importer/producer/developer entities.

(c) Charging an energy resource royalty from renewable energy power plants operating under standardised power purchase agreement (SPPA) on expiration of agreement after 15 years.

(d) Channelling a portion of savings from energy efficiency improvement/fuel switching projects.

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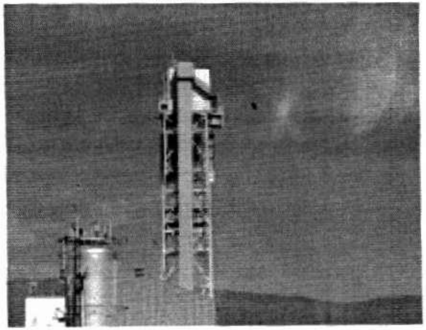
The finances will be also utilised to carry out resource development activities, which include carrying out long term studies to quantify the resource, and providing assurance to project financiers about the ability of the resource to generate electricity so that a bankable project can be developed for a particular resource. Similarly, auxiliary costs such as network strengthening for renewable energy absorption could be met with the finances available from the SLSEF.

Other than a good price for energy generated from renewable energy resources, there are many other measures that are required to drive a successful development programme such as providing a conducive policy and regulatory framework, mobilisation of investment capital, speedy approvals, development of suitable technologies such as concentrated solar thermal power plants as shown in the Figure 7 below and infrastructure and development of knowledge bases to create *investor confidence. These measures will be* combined to form a package of measures and will be the first task of the renewable energy development plan produced by the Sri Lanka Sustainable Energy Authority of the Ministry of Power and Energy.

Figure 7
Future of Energy could be in Solar Thermal Technology A Concentrating Solar Thermal Power Station in Almeria, Spain – 10mw Capacity



Conclusion

With the vast renewable energy resource base, Sri Lanka can look forward to achieving energy security better than most other countries. The pivotal role of the renewable energy development programme will be developing indigenous knowledge and technology and capacity building to contribute to achieving this goal. As a nation, our primary focus ought to be in this area, as economic development of any nation is still very much the child of the marriage between the Engineering industry and Energy industry.

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