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Renewable Energy Supply Options for Sri Lanka

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Abstract

Sri Lanka energy sector is dominated by conventional energy sources such as biomass, hydropower and petroleum. The electricity sector is dominated by hydropower supplying approximately while a small component is supplied by oil fired thermal plants. Sri Lanka has a relatively low household electrification level with major variations among urban, suburban and rural areas of the country. Main renewable energy sources capable of offering a substantial contribution to the Sri Lanka electricity generation sector are micro-hydro, wind, biomass and solar. Penetration of RE in the electricity generation sector has been extremely limited by the constraints in financing mechanisms and financial viability. The only exception has been the micro/mini-hydro sector due to its relatively low capital investment and recent opportunities for grid connection. Also the recent World Bank funded Energy Services Delivery (ESD) project has helped the resurgence of MH sector during the last few years. This paper examines the feasibility of the use of these renewable sources particularly for electricity generation in Sri Lanka along the incentives and barriers to their expansion.

Key words: Renewable energy supply options

General energy scenario: Energy supply in Sri Lanka is mainly based on three primary sources, namely hydroelectricity, biomass and petroleum. In 1997, Hydro-electricity and biomass accounted for approximately 827 thousand Tonnes of Oil Equivalent (TOE) and 4030 thousand TOE respectively. Approximately 2,539 thousand TOE came from petroleum crude and oil products giving an aggregate primary energy supply of approximately 7396 thousand TOE. These correspond to 11percent from hydroelectricity 55 percent from biomass and 34 percent from petroleum oil products. The energy accounted here does not include direct solar energy usage in many day-to-day activities in different parts of the country particularly in crop drying. Draught and manpower used in transporting goods, agricultural practices and timber harvesting have also been completely excluded. Also the use of other renewable energy sources such as wind power and solar electricity is estimated to be insignificant in comparison to energy from the three major sources while the use of coal is also insignificant at present.

The energy supply is expected to increase approximately to 11.500 million TOE by the year 2010 at an annual growth rate of 4 percent to 8 percent in different sub sectors. Hydro power and biomass based energy supplies which are considered to be the only large scale indigenous primary energy sources available in Sri Lanka, are expected to remain virtually fixed during this period. Petroleum oil, gas and coal, all imported fossil fuels, will gradually increase their share in the national energy picture (Ministry of Irrigation Power and Energy 1997).

As can be seen in Table 1, the per capita energy consumption in Sri Lanka is considerably low compared to the average consumption level in the low income country group. The growth of the consumption is also relatively low in comparison to other countries in the region (World Development Report, 1998/99). Fuel-wood and other biomass such as coconut residues, paddy husk and saw dust are largely used for domestic cooking. The total fuelwood consumption in domestic cooking amounts to 8.7 million tonnes which is about 85% of the total annual biomass consumption in different sectors.

Small manufacturing industries such as bakeries and tile and brick making also use fuel-wood as their source of energy supply consuming approximately 1.2 million tonnes annually. Baggase resulting from sugar production is almost completely utilized for electricity generation within the sugar factories themselves. Rice husk is being increasingly used in rice mills and in tobacco barns as a major energy source during processing (Perera, 1992).

Around 10% of fuelwood supply originates from forests in Sri Lanka. Home-gardens provide a major component of the fuelwood supply. By regulation villagers within a radius of 3 miles of a forest are allowed to collect dead wood for their own use. In addition, the Department of Forests issues permits to individuals for dead wood collection and transport though it is not encouraged presently due to possible misuse of these permits to cut down trees in the forests and transport timber. At present, permits are required for felling of trees even in home gardens and transport of timber except in the case of about 15 species not generally grown in forests. Currently the Forest Conservation Act is being amended to provide provision for more species grown in home-gardens to be excluded from requiring permits for felling and transport. Although biomass accounts for about 57 percent of the total energy supply in the country, the biomass sector operates without adequate policy support from the government.

Petroleum: Petroleum oil products with an annual supply of approximately 2 million TOE, contributed to 31.5 percent (1996) of the primary energy supply in Sri Lanka at a cost of Rs 18.3 billion. This is supplied either through the output of the local refinery at Sapugaskanda with an annual refining capacity of 2.2 million tonnes of crude oil and from direct importation of refined products. Imported crude oil is processed at the Sapugaskanda refinery into petrol (gasoline), kerosene, diesel fuel, aviation fuel and Liquid Petroleum Gas and sold through a well-established distribution network. Shortfall of refinery capacity is met through direct import of finished products.

Of particular significance is the importation of kerosene oil and liquid petroleum gas. The major user of petroleum products is the transport sector (59%) followed by industrial (22%) and electricity sectors (15%).

During the period 1988 to 1997, the consumption of all petroleum products have been on the increase with liquid petroleum gas (LPG) and auto diesel showing a faster consumption growth rate compared to others. The

Table 1: Per capita energy consumption in selected countries and groups of countries by income

Country or Country Group	Commercial Energy Consupmtion (Kg of oil equivalent per capita) 1980	1995
Bangladesh	32	67
India	137	260
Nepal	12	33
Pakistan	139	243
Sri Lanka	96	136
Thailand	259	878
Low income country group	133	198

Table 2: Fuelwood Supply Demand Balance

Year	Potential Supply '000 tonnes	Estimated Consumption '000 tones
1994	8963	5681
2010	9044	6769

demand for heavy diesel and fuel oil shows a marked increase whenever there is a heavy demand on thermal electricity usually resulting from dry years where hydro generation capability is at its minimum.

The present (1998) annual consumption of 2 million TOE of petroleum is expected to grow up to 4.9 million TOE by the year 2010 mainly as a result of increased direct consumption in transport and industrial sectors, recording an average annual growth rate of 7 percent in this sector.

Biomass: Biomass, the most widely used source of primary energy in Sri Lanka had a consumption equivalent to approximately at 10 million metric tonnes in the year 1996 shared between domestic, commercial and industrial sectors. Most of the biomass supply in the country is derived from non-forest resources in comparison to other countries in the region.

Hydro power: Hydropower utilisation in the country is mainly confined to the electricity generation sector consisting of large hydro plants in three river systems and mini/micro-hydro plants scattered mainly in the highlands.

Large hydro reservoirs operating a total generation capacity of 1135MW at present contribute around 4000 million units of electricity annually. In addition, there are about 14 privately owned small hydro plants with a total capacity of about 7MW already connected to the national grid supply approximately delivering 12 million units of electricity annually (Generation Planning Brnch, 1996).

Future hydropower supply is expected remain fixed at present levels with thermal based generation system expanding to fulfil future electricity generation needs in the country.

Renewable energy sources: The major renewable energy sources available for Sri Lanka are micro/mini-hydro biomass, wind power and solar power. Other sources such as wave energy and ocean thermal energy are unlikely to make a significant impact in the Sri Lanka renewable energy sector in the near future.

Biomass: The annual biomass availability in Sri Lanka is estimated to be between 10,900 to 16,500 kilo tonnes corresponding to 4142 thousand TOE and 6270 thousand TOE. Although the biomass supply over demand for the whole country is positive, there are some regional deficits. If forest -fuel-wood management programmes are carefully carried out, it is possible to obtain an excess of supply over demand at least until the year 2020.

A recent study (Daranagama *et al.* 1999) has identified 1.2 million hectares of scrub land and chena land, where energy plantations can be introduced. If one third of this available land is used for an energy plantation, it will produce around 8 million tons of fuelwood annually. This quantity of fuelwood, if used for electricity generation, it can produce 8,000 MWh of energy ewquivalent to 3 million tonnes of oil. This energy generation level is almost twice the exploitable hydropower potential in Sri Lanka. In addition, it is estimated that such an energy plantation covering 400,000 hectares will provide employment opportunities for 120,000 rural families giving an average monthly income of Rs 10,000 to each family (Wijewradena *et al.* 1997).

Presently there are few pilot energy plantations established in different parts of the country mainly for the purpose of determining optimum parameters such as species types, planting distances and harvesting cycle. Increase in fuel-wood production and lowering production cost result in creation of employment opportunities and possible voluntary substitution of imported fuels such as fuel oil and LPG in certain applications. Private sector participation can be readily obtained in establishing energy plantations in the present marginal lands if commercial fuelwood production is encouraged by creating a conducive environment.

Biomass generally implies fuel-wood, agro-waste through forest and non-forest sectors including twigs, branches and roots.

Micro/Mini-Hydro: The central hills of Sri Lanka experience nine months of rain during a typical year. This has resulted in a large number of small water streams radiating from this area finally forming into large rivers at lower elevations. While two major large scale hydropower complexes are based on two of these rivers, another large hydro-plant is located on a third river.

In the early part of the twentieth century many of the small water streams flowing through the tea gardens in the central hills had been used for micro-scale power generation mainly to fulfil the electricity requirement of individual tea factories situated in this area. Most of these micro-hydro plants were abandoned when grid electricity penetrated into the tea estates in the early nineteen sixties. The records reveal that there had been around 500 micro-hydro plants with capacities varying between 10 kW to 250 kW giving total combined capacity around 20MW, during this period. The exploitable capacity at these sites was estimated to be as high as 40MW. It is estimated that the total exploitable small hydro potential in Sri Lanka, mainly confined to these central hills is around 100 MW to 120 MW giving an annual energy output of around 350GWh (Danapala et al. 998; Darangama, 1999 and Fernando *et al.*, 1996).

In mid 1990s the Ceylon Electricity Board (CEB), the government owned institution responsible of generation, transmission and large part of distribution devised a scheme to allow grid connection of small hydro plants. CEB has been purchasing all the electrical energy injected to the grid by such plants at a pre-published power purchase tariff meant only for small power producers. This has attracted a considerable interest among private developers on investing on these small hydro plants. Presently, there are about seven plants already connected to the national grid under this scheme supplying a total of about 12GWh annually.

Also, the Intermediate Technology Development Group (ITDG) and other non-governmental organisations (NGOs) have been involved in developing stand-alone small hydro plants in remote villages with no access to grid electricity. These plants are in the order of 1kW to 25kW capacities. The villagers themselves along with technical and financial assistance from sponsoring institutions generally carry out implementation and management of these schemes. With the introduction of the Energy Services Delivery Project (ESD) of the World Bank, more of these stand-alone village hydro systems are encouraged with grant funding made available for technical support and to cover part of the investment cost.

Solar Power: Solar insolation in Sri Lanka is considerably high at an annual rate of 1.86 TWh per square km on average. Traditionally solar power has been directly used in day to day activities mainly involved in drying processes. Solar drying of various agricultural products such as rice, chilli and many others has the largest single contribution in this area. In recent times, solar hot water systems designed to capture direct solar radiation for water heating, has been used by a few affluent households and tourist hotels in the country, mainly motivated by increasing electricity costs. Also, there are on going research and development activities addressing the use of solar thermal systems in the industrial sector as a means of cheaper and cleaner energy supply.

In early 1980s Sri Lanka started promoting the use of solar photovoltaic (PV) systems for rural domestic use. Since then many private sector has been involved in assembling and marketing solar PV systems in the country. However, the solar photovoltaic cells are completely imported.

The main solar PV applications identified for Sri Lanka are in domestic lighting, operating radios and television sets in remote rural areas where there is no access to the national power grid within the foreseable future. The records reveal that there are approximately 8000 solar home systems installed around the country while there are around 20 solar PV based water-pumping schemes in Monaragala and Badulla districts, established with grant funding from the Australian Government (Gunaranratne, 1994).

A typical 40W solar PV system in Sri Lanka costs around US$ 400 including all the accessories for internal wiring and a local battery. If this is financed through a commercial loan the monthly repayment is such that the rural poor find it hard to honour debt repayment unless such an energy supply is coupled with an income generation opportunity. In general, solar photovoltaics are not economically viable for large or moderate power applications in Sri Lanka.

Wind Energy: In Sri Lanka the systematic studies involving the development of wind energy commenced in 1988 by the CEB. These studies revealed that the coastal belt from Hambantota to Kirinda in the southern part of Sri Lanka offers an exploitable total wind turbine capacity of 200 MW with an annual yield of 350 million units. It is further known that a significant wind energy potential is available on the coastal belts from Putlam to Jaffna and from Jaffna to Trincomalee in the north-western and north-eastern areas. These have not been systematically studied for economic and technical feasibility (Fernando, 1996). In addition, certain areas of central hills such as Ambewela and Uva-basin experience strong wind speeds and some wind measurement studies are being presently carried out by the CEB with financial and technical assistance from the UNDP and the Global Environmental Facility (GEF).

One of the major drawbacks of wind power in Sri Lanka is that in most locations of the southern coastal belt, only an annual average wind speed of around 6m/s to 6.5 m/s is experienced. Further, there is a mismatch between the wind speed variation and the system electricity demand. These two factors will result in very low annual plant factors associated with possible future large-scale wind plants raising the unit cost of electricity from these plants. In early 1999, CEB commissioned a pilot wind farm of 3MW capacity consisting of five 600kW turbines in Hambantota. The recorded annual average plant factor of these wind plants in the first year of operation is around 17%. Some private sector institutions also have expressed their interests in establishing grid-connected wind turbine plants in the southern coastal belt.

Even with high unit costs at present, wind power is still an option to be considered in the long-term future power development in Sri Lanka due to gradually decreasing turbine costs resulting from technological advances.

Barriers to sector expansion: There are many barriers to the development of the RE sector in Sri Lanka in the areas of policy making, marketing and technical capability.

Input primary energy sources: In terms of water supply, greater variation of weather patterns may result in unpredictable variations in water inflows to the small hydro schemes leading to non-optimal use of these sources in certain locations. Such unpredictable water inflows also may lead to poor financial evaluation thereby some times making the schemes financially not viable after establishment. This is also equally applicable to the wind energy, solar energy and biomass sectors where input resource availability is generally uncertain.

Also procedures to follow to obtain permission for land use rights with regard to renewable energy development is extremely cumbersome making them unattractive to investors.

Poverty: The majority of the poor population in Sri Lanka lives in rural areas where potential renewable energy sites are located. Inability of most of the local population to contribute financially towards development of renewable energy systems is a major barrier for sector expansion. If initial investment costs come in the form of a grant or easy payment scheme it is likely that most of the rural inhabitants are capable of covering operating costs considering their avoided costs of alternative energy sources such as kerosene oil. Also, limited household incomes in the rural sector mean that expenditure on "luxuries" such as electricity are more likely to be lower in priority to more basic needs.

General Financing: Although there were small-scale programmes to finance renewable energy sector development before the ESD project came into existence, most of the finance institutions didn't have a separately identified credit line for the energy sector. Limited period of existence of financing institutions in funding of renewable energy schemes has resulted in long delays in approving loans and reluctance to finance these projects in general. Also, the ESD project, which was expected to give an impetus to renewable energy sector development, has been in operation just under two years and therefore the financing institutions has had only a limited exposure in handling financing mechanisms in the renewable energy sector.

This situation is further worsened with villagers not being able to have a large equity participation apart from their physical labour input which is only around 30% to 40% of the total project capital cost. Inability of the lending institutions to monitor the construction and operation of the schemes due to lack of technical expertise has also handicapped the financing mechanisms of the RE sector.

Risks and Uncertainties: Ability of the project to pay back loans from the lending institutions entirely depends of the level of income the project generates. When considering renewable energy systems, particularly the stand alone electricity generation systems, the income from the scheme depends on annual energy generation which is highly correlated to the uncertain input energy pattern such as rain fall and wind pattern in the site area regular maintenance introducing an element of uncertainty into the operation of the scheme with the absence of local expertise and necessary components possibility of national grid extended to the geographical areas in the vicinity of the project, thereby affecting its customer base in decentralised systems while not having convenient procedures in place for grid connection of these plants. variation and uncertainty in income level of the customers in these decentralised schemes as a result of the nature of income generating activities they are involved in. e.g. agricultural activities.

social dynamics and cohesion in rural village communities and their ability to organise and operate decentralised systems.

The risk associated in the event of developers failing to pay back the loan due to the project is the sale of land (leasehold rights) and buildings of the project. In reality, it is very unlikely that the bank will be able to recover all its dues by doing this.

Enabling Environment and competition from other sources: According to the electricity sector regulations, at present, only the CEB has the licence 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. Currently, these distribution rights are not given formal clearance and growth of the renewable energy sector in the future will require a clear process and institutional mandates.

This situation acts as a disincentive for private developers of stand-alone generation systems unless they are community owned. Larger projects classed as Small Scale & Large Scale Infrastructure projects are given separate incentives and status under the Board of Investment (BOI). These may operate grid-connected schemes or stand alone units generating for their own consumption. Taxes are levied on all the imported components as well as local components and services of renewable based plants sold in the local market. But at present developers of any large conventional generation plant enjoy tax benefits involving their investment and operation of the plant. This gives a competitive advantage to conventional generation over its competitors in the renwable energy sector.

Lighting in rural communities in Sri Lanka is usually based on kerosene oil lamps and kerosene oil is a subsidised commodity across the country. Electricity from decentralised generating schemes is also mainly used for lighting and therefore the cost comparison is always with kerosene oil. Consequently, subsidised kerosene oil acts as an unfair competitor to electricity based on RE schemes in the rural sector.

Since fuelwood is freely available in rural areas in Sri Lanka, it has become the most widely used source of fuel for heating purposes. Therefore, any small-scale end-uses in renewable energy schemes involving heating cannot ever compete with fuelwood on financial grounds though it may be possible on the level of convenience in usage.

Technical Know-how: Lack of technical expertise in carrying out pre-feasibility studies at the community level is a major hindrance in identification of possible sites for renewable energy schemes. Also, limited experience and exposure of the rural inhabitants in community development activities have contributed to poor organisational skills in initiating and implementing such schemes. This is further worsened with inadequate information on how and where to approach for such advice on technical and financial matters.

Technology: Local manufacturing capability of different components of renewable energy sector, such as turbines, generators, induction generator controllers (IGC) and electronic load controllers (ELC), gassifiers for biomass based plants and solar cells, is not widely available in Sri Lanka. This has led to complicated procedures and relatively high expenditure for rural communities in acquiring these components since they need to be either imported from other countries or some of these technologies are almost a monopoly of certain local manufacturers. Also this can result in delays and high expenditure in attending to urgent repairs and required regular maintenance.

End-use: Many case studies on village hydro schemes clearly show that the use of electricity in Sri Lanka is mainly to primarily satisfy household lighting requirements rather than income generating activities. This characteristic limits entrepreneurs in terms of market sizes and access for their products. Also, the poverty within these communities has led to limited capacity to invest in manufacturing as well as to buy these local products further weakening the market for them. Consequently, end-use other than for each household requirement is limited to small-scale enterprises such as battery charging, ice making, bicycle repairs with facility for vulcanising and small scale rice milling.

Conclusions and Recommendations: It can be seen that addressing the policy issues and concerns associated with the renewable energy sector is most important for the sustainable development of the Sri Lanka energy sector. Considering the many issues that have been discussed following conclusions can be arrived at and corresponding recommendations can be made.

The most cost effective of the renewable energy technologies is micro/mini-hydro followed by biomass and wind while solar PV is relatively expensive and unaffordable for rural communities in general

Use of renewable energy for electricity generation need to be broadly identified into two categories; large-scale grid connected systems and small-scale decentralised systems. Policies applied to the renewable energy sector should clearly differentiate these two groups and they need to be treated separately.

Solar PV systems can be promoted in rural communities at a considerable distance away from the existing national grid and to areas which will not have the grid in the foreseeable future.

A level playing feel need to be created for both conventional energy sources and the renewable energy applying financial and other incentives uniformly while giving due consideration to the environmental benefits associated with RE based generation.

Project similar to ESD project where technical and financial support is extended on concessionary rate need continue until such time that a reasonable market for renewable energy technologies and local expertise are established.

A comprehensive resource assessment needs to be carried out to establish the availability of water, wind and land resources in different regions of the country to facilitate development of the renewable energy sector at decentralised levels.

Centralised generation expansion planning process now handled by the CEB needs to be modified and extended to accommodate the renewable energy systems and environmental concerns on conventional generation system facilities which are absent at present planning models used by the CEB. This will create a level playing field for renewable energy in competing with conventional sources.

Technical co-operation between countries in the region where many cost effective technological advances have been made in the renewable energy sector, need to be encouraged in order to improve the economic viability of renewable energy schemes.

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