Sustainable Energy supplies for Rural Communities in Sri Lanka

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Abstract

Energy supply in Sri Lanka is mainly based on three primary sources, namely hydroelectricity, biomass and petroleum. With no proven reserves of fossil fuel, hydropower and biomass, including fuelwood, are the only indigenous resources available. All of the country's fossil fuel requirements are imported.

All three major sectors of consumers, households, industries, and the commercial sectors, use the two major commercial sources of energy, petroleum and electricity. But biomass usage is largely confined to the in the rural domestic sector as a source of energy for cooking activity.

This paper reviews the current energy supply and usage patterns in the rural areas and examines its future direction based on the sustainable development agenda. It is concluded that the energy from biomass constitutes an important part of the total energy supply in Sri Lanka and that it is the sustainable solution for the current and predicted future energy requirements in the rural communities.

Apart from biomass, other renewable energy sources such as small-hydro, solar, wind and biogas also have their own applications in the rural communities, though in a small scale. It is important that the technologies associated with these sources are disseminated in the rural areas so that the communities have a choice among different sources, which fit into their individual requirements in the locality rather than force one source or another on them.

1. Introduction

Energy supply in Sri Lanka is mainly based on three primary sources, namely hydroelectricity, biomass and petroleum. With no proven reserves of fossil fuel, hydropower and biomass, including fuel wood, are the only indigenous resources available. All of the country's fossil fuel requirements are imported.

In the year 2002 hydro electricity and biomass accounted for approximately 646 thousand tones of oil equivalent (TOE) and 4310 thousand TOE respectively. Approximately 3652 thousand TOE came from petroleum giving an aggregate primary energy supply of approximately 8612 thousand TOE in 2002. These correspond to 8% from hydro electricity 50% from biomass and 42% from petroleum oil [2]

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 drying. Draught and manpower used in transporting goods, agriculture and timber harvesting have also been completely excluded. These activities, though unaccounted, amount to a significant component of the energy usage within the country. 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.

All three major sectors of consumers, households, industries, and the commercial sectors, use the two major commercial sources of energy, petroleum and electricity. But biomass usage is largely confined to the in the rural domestic sector as a source of energy for cooking activity.

The characteristics of rural energy systems, supply sources, energy mix patterns, problems and potentials for development, vary from place to place, depending on numerous factors such as availability, accessibility, affordability, alternatives, income level, socio-cultural practices and climate. Therefore, it is difficult to generalize the form of rural energy systems purely in terms of explaining only one of the different traditional energy sources that are commonly used in rural areas, or purely from the point of view of wood energy alone. The same may apply also from the point of view of identifying

strategies for its development. The specific aspects of rural energy development, planning, policy and strategy formulation, programme design, implementation, and valuation, must be based on the specific needs of a particular geographical area and vary from the simple to the more complex type depending on the characteristics of such an area.

Moreover, as the prevailing level of socio-economic development in any rural area is also reflected by the area's energy consumption/requirement, this must be taken into account when considering any efforts at further socio-economic development. This visible linkage of rural energy systems with the activities of other sectors of the national economy, local culture and use patterns clearly point out the need for integration of policies, plans and programmes of various sectors in rural areas with the programmes of the energy sector. Integration is necessary right up to the implementation stage. This emphasises the need for integrated rural development plans and programmes incorporating rural energy [5,9].

2.0 OVERALL ENERGY SUPPLY PICTURE IN RURAL HOUSEHOLDS

In Sri Lanka, by the year 2003 about 65% of the country's households had access to grid electricity. Electrification has largely benefited the urban population, which enjoy electrification rates well above the national average. However, approximately 65% of Sri Lanka's population of 19 million lives in rural areas, and it may be a while before they are connected to the national electricity grid because it is not financially viable for the utility at present to extend the grid to many of these areas. Sri Lanka being a small country has been following centralised planning in the major conventional energy supply sectors with the Ceylon Electricity Board (CEB) in the electricity sector and the Ceylon Petroleum Corporation (CPC) in the petroleum sector, both government owned utilities responsible for this activity in their respective areas. The development of the non-conventional sources such as small-hydro, wind, biomass and solar has been carried out both by the government sector through the CEB and by the non-governmental sector where many institutions are involved in promoting these sources [3]

Kerosene Oil

Rural households in Sri Lanka are more dependent on traditional renewable energy sources such as biomass rather than fossil fuels. Out of the fossil fuels use of kerosene is predominant in the rural sector as majority of these households depend on kerosene for lighting. Domestic accidents resulting from its use, a common phenomenon in rural areas has been the subject of several studies. Kerosene accounts for the highest expenditure in the household energy budget [1, 3].

Liquefied Petroleum Gas (LPG)

During the last few decades LPG consumption which is mainly for cooking purposes in households, has been rapidly increasing, particularly in urban and suburban households but it has not significantly penetrated into the rural sector.

Rechargeable and Dry Batteries

People without electricity supply use car batteries for operating televisions and radio cassette recorders and dry batteries are used for torches and radios. On a national average, the proportion of income spent on household energy rises with decreasing incomes [1].

Biomass

More than 90% of the entire population of Sri Lanka uses fuelwood, primarily for domestic cooking. The majority of rural people obtain their fuelwood requirements from non-commercial sources such as home gardens, sparsely cultivated croplands and natural forests. In rural areas, fuelwood is often gathered from home gardens or nearby forests without incurring any cost. Biomass is the main thermal energy source for many industries as well. Of this, fuel wood made the largest contribution [1, 3].

The biomass fuel used by domestic and industrial consumers comes from a wide range of sources. These can be divided into three broad categories.

- Those which are exportable, that is of a sufficient physical density, and found in sufficient species concentration for it to be

economically feasible for them to be transported beyond the boundaries of the districts from which they derive. This includes the wood products of the natural forests of the Dry Zone and of the Wet Zone rubber and coconut plantations.

- "Other fuel wood" includes wood, which is either smaller or not found in larger concentrations. These fuels have not been commercialized to any great extent.

- "Other fuel" comprises crop wastes, and is made up largely of coconut by-products from plantations and home gardens. In addition, tea wastes are important in the hills.

The significance of the three major types of fuel varies by zone. The rubber plantations in the Wet Zone produce a substantial amount of exportable fuel wood, but coconut wastes predominate, and relatively little other fuel wood is found. The Hill Country produces hardly any exportable wood and only modest quantities of other fuels. In the Dry Zone, the situation is reversed, with large amounts of exportable but only insignificant amounts of other fuels being produced [5,6].

Biogas

Biogas is a source of energy which is mainly used for domestic purposes, such as lighting and cooking. With biogas running a generator 12V batteries can be charged and then used for lighting fluorescent tubes with an inverter circuit also developed by the National Engineering Research and Development (NERD) Centre [4].

Village-hydro systems

Small hydropower is another renewable source of energy, the development of which is associated with only insignificant adverse environmental consequences. It is especially suited for areas where large installations or grid extensions are possible due to their remoteness to the grid and high capital expenditure. The energy generated through the village hydro unit is used for domestic lighting or to power small, local industries in the rural sector [7,8]. By 2002 the number of off-grid small-hydro systems was around 140.

Solar Photovoltaics (Solar PV)

Though solar home systems had been introduced to the country almost 25 years ago it had not penetrated properly into the rural areas until recently mainly due to their heavy capital expenditure which is beyond the reach of many rural households. But with the implementation of the Energy Services Delivery Project (ESD) and its successor Renewable Energy for Rural Economic Development project (RERED) of the World Bank where there is a grant component for solar PV systems and associated government subsidy in some provinces, solar home systems have already begun to play a visible role in some rural areas in the country [1, 2]. The total number of solar home systems in the country has now exceeded 50,000.

3.0 RENEWABLE ENERGY AND ENERGY EFFICIENCY IN RURAL HOUSEHOLDS

3.1 Biomass Based Cooking

In the early ages, cooking was done over an open-fire with fuel wood arranged in a pyramid configuration. The simplest and most common form of shield-fire was the three-stone stove. Subsequently, the three-stone configuration was changed to a U-shaped semi-enclosed mud stove (or mud/stone stove) with an opening in the front for fuel feeding and combustion air entry. Later, number of modifications was made by the users in light of their own experiences.

In 1950s, improved cook-stoves (ICS) development programmes started in number of developing countries. These programmes involved technical improvements in cook-stoves such as introduction of multi-pot stoves, chimney, adjustable dampers, etc., and measurements of cook-stove efficiencies. The second phase of the improved cook stove programmes (ICPs) started in 1970s when the oil crisis brought energy issues and related environmental concerns to the forefront.

Most of the Sri Lankan households use either three-stone stove or semi-enclosed mud stove (similar to U-Chulah in India) for their daily cooking. Stoves are placed sometimes on the floor level and sometimes on a platform of up to a meter in height. These conventional stoves are usually built by the users themselves. In general, two (or some time

three) units are placed side by side with a shared wall between each of them.

In Sri Lanka, as in the other parts of the world, the current interest in cook stove development activities started in early 1950s. During 1950s to 1970s a number of government institutes, non-government agencies and private individuals were attempted to introduce new stove designs. By late 1970s, the deforestation in the country became a severe problem and within two decades forests cover reduced by 50%. In consequence environmental changes and fuel wood scarcity were beginning to take place, and prices of fuel wood were increasing in the urban areas. These critical situations had led "Sarvodaya", a leading non-governmental community development organization, to start the Sarvodaya Wood Stove Project in 1979. This programme had a tremendous impact on the improved cookstove developments in Sri Lanka, due to its broad objectives. The improved cookstove model developed by Sarvodaya was first disseminated in Kandy District and thousands of stoves were installed. National Fuel wood Conservation Programme (NFCP) launched by the Ministry of Power and Energy in 1984 promoted these dissemination programmes. The other major impact on the improved cook stove developments in Sri Lanka was due to the collaborative programme initiated in 1987 between the CEB, Intermediate Technology Development Group (ITDG) and a few private sector tile manufacturers. This programmed aimed at the urban market and the designs were based upon modified versions of the Sarvodaya stove [1,2].

From a recent survey done, we found that the "past practice" to be the most significant barrier in the rural sector when it comes to expansion of energy efficient cook stoves. Also free and excessive availability of biomass has also contributed to the same. Since there is excess biomass the rural population not intended to think of reserving biomass for future use. Income of the family, high initial cost, risk of breaking the improved stove, transportation and also worrying about the quality of the kitchen are also considerable barriers but of less significance [1,2,3].

3.2 Solar Based Cooking

Sri Lanka does not have any significant experience in solar power based cooking though related technological developments have been prominent in India. One of the major barriers for expansion of these technologies in the rural sector would be poor awareness and inaccessibility to the technology. Further it is unlikely that these technologies would penetrate in the Sri Lanka rural sector, particularly considering the rural population's reluctance to move away forms of cooking.

3.3 Solar Lighting

The relative high cost of solar electric systems prevented the widespread use of solar power for many years after. However, as the costs are gradually decreasing, many developing countries have begun promoting solar power, especially for rural domestic use. The relatively low per capita income levels of developing countries and in their rural areas in particular, it necessary to make available systems at a low cost. Many countries have now established grant funding arrangements and easy payment schemes to make these systems more affordable to the rural population.

The CEB in recognizing the need for alternative power sources established the Alternative Energy Unit, which started introducing solar electric systems in a large scale in the rural areas. These pioneering efforts laid the foundation for other private sector institutions to embark on marketing solar home systems from late 1980s, both for small scale domestic applications and for large-scale projects. These efforts have been now further strengthened by the Energy Services Delivery Project (ESD) of the World Bank in Sri Lanka where application of solar PV systems in the rural areas has been financially supported for the last three years. It can be concluded that Solar Electricity has already begun to play a significant role in rural energy supplies in country.

The recent survey mentioned before has found that "unawareness" to be the most significant barrier to switch from kerosene to solar power based lighting in the rural sector. About 85% of the rural population was unaware of the technology available for solar power based lighting. Further, the heavy initial cost which is about US$ 500 for a typical

50Wp system has been identified as another major barrier for its expansion [3].

3.3 Wind Electricity

Sri Lanka commissioned its first pilot scale grid connected wind power plant of 3MW capacity in early 1999. But small wind turbine systems for water pumping and battery charging had been developed by the NERD Centre about twenty years before, mainly to address the rural energy needs. Later most of these systems have been abandoned due to poor technical support from the part of the original manufacturers and the inability of the local communities to maintain those systems themselves. Now there is a resurgence of the small-scale wind turbine system technology for battery charging with ITDG supporting a programme along with local expertise and entrepreneurs to install these plants in rural villages. These systems are generally meant for individual households supplying approximately 250W of capacity. It has been found that the cost these systems are almost equal to the cost of a 50Wp solar home system. The only constraint in the application of small wind turbine systems is that they generally tend to operate only about nine months during the year due to poor wind velocities in the remaining period [3].

3.4 Village Hydro Systems

Hydropower utilization 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 20 privately owned small hydro plants with a total capacity of about 25MW already connected to the national grid supply approximately delivering 40 million units of electricity annually.

Micro hydropower is a renewable source of energy, the development of which is not associated with adverse environmental consequences. It is especially suited for areas where grid extensions are not practical due to poor financial viability.

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

The energy program of the ITDG – Sri Lanka has played and continues to play a key role in promoting the establishment of rural energy systems. It promotes by demonstration decentralized energy options to communities, local government bodies, the private sector and state organizations. The energy program initiated work in this regard primarily with micro hydro units in villages. A major achievement of ITDG-Sri Lanka in this project has been the development of a village hydro model, in which the technology, cost and management components have been simplified sufficiently, so that they can be handled for the most part by the village community.

In addition to these many other NGOs have stepped into the establishment of village hydro systems with the assistance of the ESD Project of the World Bank. Under this programme over 150 villages hydro plants of capacities going up to 25kW each have been now established. Each of these plants generally supplies 100 to 200 rural households mainly for lighting in the evening and small-scale income generating activities during the day time [7, 8].

3.5 Biogas Systems

Studies carried out at the NERD Centre in Sri Lanka have resulted in the development of a unique batch-type biogas generator that eliminates the problems commonly associate with the traditional system of biogas production. Biogas is relatively high value fuel, formed during anaerobic digestion of organic matter that provide convenient source of energy. This process has been known for centuries and is being successfully employed in various applications in many parts of the world. Interest in biogas

technology has grown considerably in recent times due to the rising cost and uncertainty of future supplies of fossil fuels and the growing scarcity of fuel wood, especially in developing countries.

Traditional biogas generators based on the Chinese or Indian type design use animal wastes as feed material. Daily feeding and other maintenance such as scum breaking have prevented this technology from being adopted on a much greater scale in Sri Lanka. The technology developed at the NERD Centre has overcome these problems. Its advantages include independence from animal waste requirements, absence scum formation, and minimum requirement of water and minimal operation and maintenance costs. Feed material, which is paddy straw is easily available, especially in paddy cultivating areas, one charge produces gas for a period of six months to one year, and the digested material after the production of gas is a rich fertiliser available for agriculture. The social resistance that normally exists especially in the urban areas against handling animal and other wastes encountered in the traditional processes does not occur with use of the this local technology.

A biogas generator with 1000kgs feed capacity produces gas sufficient for cooking requirements of a family of five and produces approximately 1000kgs of fertiliser. For the rural households, the biogas generator eliminates the need for fuelwood and chemical fertiliser. Biogas fertiliser costs approximately half that of chemical fertiliser. The technology developed by the NERD Centre also provides a substitute for LPG for the urban user, thereby reducing the need for energy imports [4].

The survey has shown that most of the rural communities have very poor awareness with regard to the use biogas systems. Further freely and easily available biomass kept them away from focusing on biogas systems. A small percentage households expressed their reservations to this concept as they were under the impression that the technology was not clean and the local environment can be badly affected by these systems [1,2,3].

4.0 FUTURE

4.1 Biomass: The Way Forward

Sri Lanka continues to consider biomass energy as a non-commercial form of energy though it has been the main primary energy source in the country up to now. It is therefore important to explore possibilities of treating biomass as a commercial fuel. For this purpose it is necessary to produce and utilize biomass in a sustainable manner. In order to have a sustainable supply of biomass it is necessary to have dedicated energy plantations supplying fuel wood. Since biomass is the only source of primary energy found locally in large-scale it is necessary to concentrate in developing this source to suit the local needs.

Biomass for Cooking

The majority of rural people obtain their fuel wood requirements from non-commercial sources such as home gardens, sparsely cultivated croplands and natural forests. In rural areas, fuel wood is often gathered from home gardens or nearby forests without incurring any cost. It has been revealed from a recent survey that 86% of rural population is having free access to bio-mass. An interesting factor to be noted here is that the higher proportion of the rest 14% incurring a cost consists of households who have to bear only the transportation cost for biomass [1,2,3].

Charcoal is used for domestic cooking and other applications. Because of diminishing fuel wood supplies, charcoal making, from residues, which often cause environmental problems if left unutilized, is becoming more attractive. A wide range of devices, developed for carbonizing agricultural and other residues, have found limited acceptance so far. Recent developments in biomass carbonization include producing energy from the waste gases produced during batch carbonization. The process improves both the overall process energy efficiency and the environment.

Another development is torrefaction, a low temperature carbonization process that produces a substitute product for conventional charcoal in some applications.

Biomass for Electricity Generation

Further development of hydropower resources is becoming relatively more expensive. Moreover, the rainfall pattern in any year in Sri Lanka is uneven. During the first 6 months of the year little rain falls, while during the second six months substantially

more rain falls. Some form of thermal energy based generation is necessary to improve the reliability of the power supply. In any event, to meet the increasing demand for electrical energy an additional 100 to 150 MW of capacity needs to be added to the system annually. Therefore biomass based thermal power stations has a great potential to fill these generation capacity gap in the Sri Lankan electricity grid.

Practically all biomass based electricity generation plants employ steam turbine systems. Such electricity generation is established in developed countries, where relatively cheap/ waste bio mass is available. Most systems are based on low-pressure boilers with overall efficiencies around 20%. Modern biomass powered high-pressure boiler-turbine systems can potentially produce electricity with efficiencies approaching 32% [10].

Thermal energy, produced by burning biomass and other low grade fuels, can be used for small-scale power generation using an external combustion engine, such as the sterling engine. This may be of great interest for rural applications, since there is potential for higher efficiencies than those using gasifier-engine or steam-based power plants of similar capacity.

Cogeneration process is also practiced in sugar mills world-wide to meet in-house demand for steam and electricity, typically by using low pressure boiler-steam turbine systems. By the use of high pressure systems, mills can produce substantial quantity of surplus electricity which can be sold locally or to the national grid. This technology can be implemented in the sugar industry in Sri Lanka, which has not so far generated any surplus electricity to be injected to the system or to the surrounding community.

Over the last 8-10 years, interest in large-scale biomass gasification for power generation has been growing. Efficiencies of over 40% are predicted for such plants. For capacities lower than 5-10 MW, catalytic gas cleaning and low-tar gasifier designs may make a new generation of such gasifiers feasible. In rural areas there is an adequate potential for implementing gasification systems operated on paddy husk, other crop residues and sawdust, even this method is not efficient than the fuel wood gasification.

In Sri Lanka, a prototype gasifier was designed by the National Engineering Research and Development Centre (NERD) during 1980-81. This research has subsequently been developed for both stationary down-draught and fluidized bed gasification. Water pumps, generators and vehicles running on this gas have been already demonstrated. This local technology can be now implemented in rural communities for improved flexibility in biomass use, particularly to implement decentralized biomass based electricity generation systems

4.2 Community based energy plantations

The sustained development of the forest cover is the main objective of the forestry sector of Sri Lanka. Since its establishment in 1887, the Forest Department has undertaken this responsibility. Other agencies, which undertake fuelwood planting, are the tea estate sector and the Ceylon Tobacco Company. Securing the participation of people in forest management has been a key objective of these programmes for the last two decades.

The Forest Department's current reforestation programmes are mainly under the Forestry Sector Development and Participatory Forestry Project. The main objective of these two programmes is to produce timber and fuel wood [6]

Currently there is an increased volume of activities at field level and there is evidence of increased participation of the local communities in forestry activities. Although the main concern of participants is to obtain higher incomes from timber production, a considerable amount of fuel wood has been produced as a by-product. In order to encourage them in the production of fuel wood, studies on fuel wood marketing and research on the economics of fuel wood species are highly recommended. But consideration should also be given to biomass based power generation in a sustainable manner.

Moreover the rural poor which heavily rely on state subsidies under the Samurdhi Programme can be encouraged to participate in community based energy plantations feeding electricity generation plants. Samurdhi Authority, which owns a large volume of under-utilised finances, has a great potential to be an investor in such a programme on behalf of the rural poor.

4.3 Renewable Energy Authority

Though the conventional energy sub sectors such as petroleum and electricity have some form of policy directions emanating from the state run CEB and CPC respectively, Sri Lanka has no policy directives or plans to encourage the sustainable use of biomass or a policy dealing with the renewable energy sector. If the renewable energy sector including biomass sector is to be developed to maximise its benefits in the country it is of utmost importance that this sector is organised properly under state patronage as it has been done in countries like India. It is unlikely the authorities dealing with conventional energy sources would take a lead in renewable energy sector development to level which makes those sources competitive with their own preference. Therefore the solution is to have separate authority for renewable energy development in the country.

5.0 CONCLUSION

Energy from biomass constitutes an important part of the total energy supply in Sri Lanka and it is the sustainable solution for the current and predicted future energy requirements. The manner in which biomass is currently utilized for energy is however far from ideal and is characterized by gross inefficiency and pollution of the environment. Biomass fuels could provide a much more extensive energy service than at present such as electricity generation if these were used efficiently.

The participation of the rural community can play an important role in the proposed energy plantation programmes effectively not only as a solution to the energy crisis but also to address the problems associated with rural poverty.

Apart from biomass, other renewable energy sources such as solar, wind and biogas also have their own applications in the rural communities, though in a small scale. It is important that the technologies associated with these sources are disseminated in the rural areas so that the communities have a choice among different sources, which fit into their individual requirements in the locality rather than force one source or another on them. This emphasises the need to have a renewable energy authority to look after the renewable energy sector, especially to co-ordinate the rural energy supplies.

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