ART GOLD Sri Lanka

Research on Renewable Energy in Sri Lanka

(August - October 2007)

Realized by: Davide Ceretti

Index:

1 Object of research

- Identification and evaluation of technical and social effectiveness of existing project on energy sector in Sri Lanka, with particular attention on Southern Province territory;
- identification of develop potentiality of renewable energy on the ART GOLD program zone (solar power, wind mill, biomasses, biogas).

2 Situation Analysis

Sri Lanka energy sector is dominated by conventional energy sources with more than 50% of the total consumption coming from biomass, 11.4% from hydro 31.6% from petroleum and rest from renewable like solar and wind. Only around 70% of the house holds in Sri Lanka have been electrified with the figure varying from 90% in Colombo, Galle and Matara to less than 40% in Monaragala district.
There are also 150,000 households that are near the grid, but the economics condition doesn't allowed family to have a contract of electric supply.

Uplift by the economic growth, Sri Lanka's energy consummation grow by 8% per year, and it expected to continue grow between 7-8 % per year over the next fifteen years.
The system reserve margin will drop at 9.5% in the 2007, and to the 2 % in 2008. An energy crisis is near.

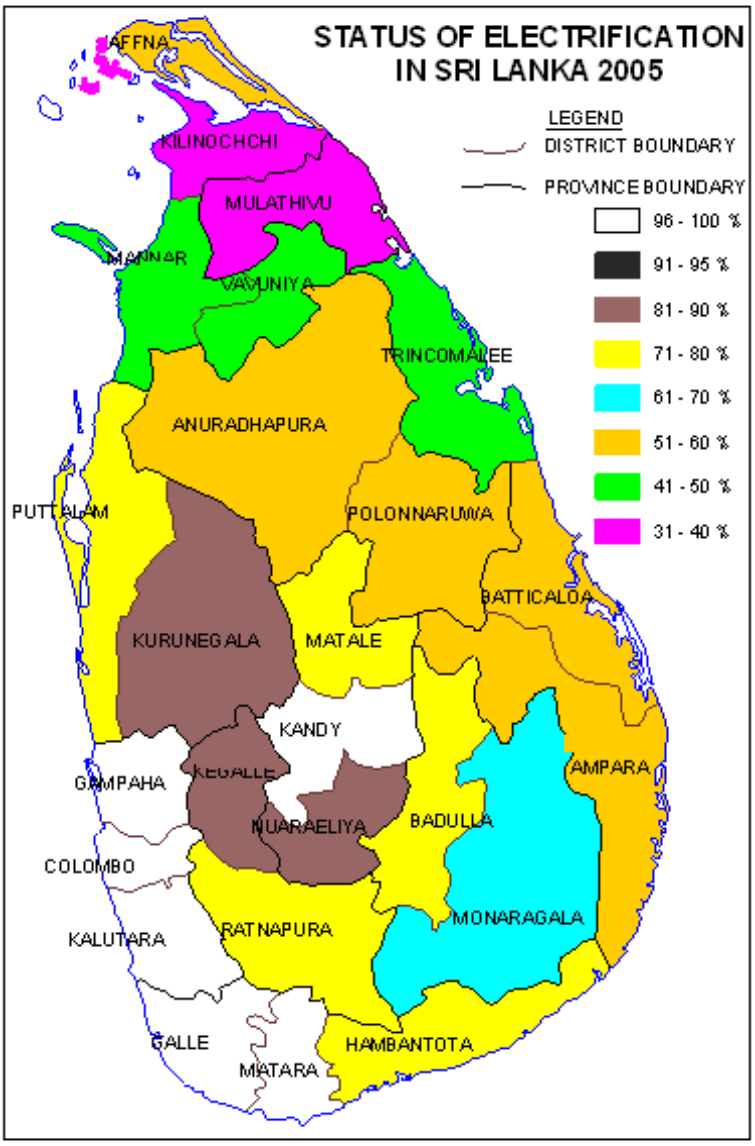
The overall strategy is to diversify energy source, restrict the addition of any further oil-based power units, instead has set out program to encourage the use of coal and renewable energy and to improve the efficiency of the system.
The coal will be totally imported, no mines or oilfield are existing on country territory. This means an expense on foreign value.

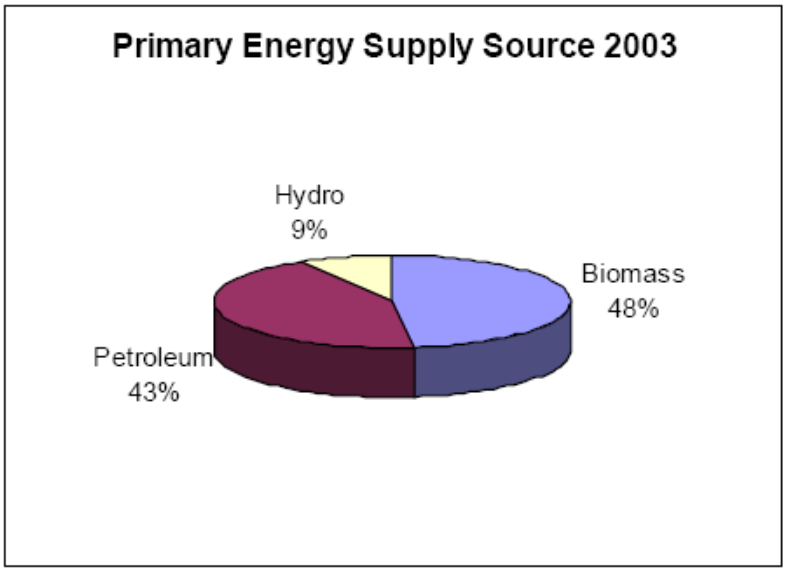
The Government of Sri Lanka, with the assistance of the World Bank and the Global Environment Facility (GEF) has established the Renewable Energy for Rural Economic Development (RERED) Project, which aims to expand the commercial provision and utilisation of renewable energy resources, with a focus on improving the quality of life and economic development in rural areas by providing access to electricity, generated from this resources. The Project, which is being implemented over the period 2002-2007, will be extended for other 3 years.
The World Bank guide lines for the next 3 years are to give more attention to Wind Mill and BioMass Project.
The develop strategy had 2 focal point:

- Loan and grant from the World Bank credit line managed from DFCC Bank, for the develop of rural area
- Special tariff for each of the renewable source, that could help the pay-back time of power plant

Some NGOs (like Energy Forum, Practical Action, Bio-Energy Association) provide support and assistance for the rising of village cooperatives, called Electricity Consumers

Society, to ensures that this society has sufficient organizational capacity and funding mechanisms to take responsibility for the plant operations on a sustainable basis.





3 Renewable Source

3.1 Hydro

The hidro power generation cover about the 45% of the electric needing.
This production is divide between On-grid and Off Grid power plant. There are 31 mycro hidro plant connected to the grid and about 200 schemes (9000 family) of Off-grid Village Hydro.
In table 1 are showed the progression of plant's number financed by RERED project, and table 2 shown the installed power *(*Source: Project Progress Reports, DFCC AU*)*:

Table 1: *Cumulative Position of Grid-connected Mini-hydro Sub-projects*

Quarter Ending	Grid-connected Mini		% Completed
	Approved	Completed	
31/12/02	**3**		**0**
31/03/03	**9**		**0**
30/09/03	**11**		**0**
31/03/04	**16**	**7**	**43.8**
30/09/04	**23**	**13**	**56.5**
31/03/05	**37**	**16**	**43.2**
30/09/05	**43**	**18**	**41.9**
31/03/06	**41**	**22**	**53.7**
30/09/06	**41**	**24**	**58.5**
31/03/07	**45**	**31**	**68.9**

Table 2: *Approved Mini Hydro Projects*

Quarter ending	Projects		Capacity		Increase %	
	No.	Increase	MW	Increase	Projects	Capacity
31/09/04	**23**		**58.5**			
31/03/05	**37**	**14**	**97.5**	**39.0**	**60.87**	**66.67**
30/09/05	**43**	**6**	**120.0**	**22.5**	**16.22**	**23.08**
31/03/06	**41**	**-2**	**108.5**	**-11.5**	**-4.65**	**-9.58**
30/09/06	**41**	**0**	**108.5**	**0.0**	**0.00**	**0.00**
31/03/07	**45**	**4**	**110.5**	**2.0**	**9.76**	**1.84**

The Off Grid power plant are community owned micro hydro schemes that are set up by Electricity Consumer Societies (ECS) to generate, distribute and consume the electricity produced by members of the Society. A typical village hydro of 10kW capacity provides a 230V, 50Hz supply to about 40 rural homes within a 2km radius (no transformers are used). Each home would thus have a limit of about 250W, which is sufficient for energy efficient lighting (standard fluorescent lamps or CFLs) and the operation of basic appliances such as TV, radio/cassette player and in some cases refrigerators and irons.

These schemes are set up by 'project preparation consultants' who mobilise the community, prepare a feasibility report including detailed engineering calculations in

accordance with technical standards specified by the RERED Project, assist the ECS in obtaining all required environmental and statutory clearances, negotiate a bank loan for the ECS and provide technical assistance in implementing the project up to successful operations.
The program requires the verification of technical compliance at the design stage and again upon project completion, as these safeguards provide comfort to lenders in respect of safety, reliability and longevity of the scheme. The *project preparation consultants* are registered and are paid a staggered fee for their services at standard rates based on pre-determined milestones.
The average cost of a village hydro is about US$2,000/kW excluding the project preparation fee paid to the consultant.
This cost is reduce by the social work of future beneficiary and by the RERED program that provides a capital subsidy in the form of a cofinancing grant amounting to US$400/kW (with an upper limit of US$20,000), while Provincial Councils also provide subsidies independently.
Banks providing loans that are usually secured on project assets and personal guarantees of ECS office bearers/members.
Many research shows that repayment is excellent as long as the scheme is well designed and operates as planned giving the rated power output.

As to be expected, the peak power demand for village hydros occurs during the first few hours of the night. Being run-of-the river projects, most of the generating capacity is therefore unutilised and wasted by day.
There are some program that, through technical assistance, supports the setting up of income generating activities by encouraging the productive use of electricity generated during daylight hours. Typical productive applications set up so far include communication centres, refrigerators/freezers in shops, carpentry, food processing and packaging, sewing machines/tailoring, computer education centres, hair dressing salons and battery charging.
Following are presented two example of plant, realised on the Galle district:

Micro Hidro Village 1:

Total Cost of Power plant	1.3 mil SLR
Provide by the village family	5000 SLR
Beneficiary Households	80
Cost of electricity	5 SLR/kWh + 100 SRL/month
Generator power	7.5 kW
Total Production	5.5 MWh/y

Micro Hidro Village 2:

Total Cost of Power plant	1.05 mil SLR
Provide by the village family	3500 SLR
Beneficiary Households	25
Cost of electricity	5 SLR/kWh + 100 SRL/month
Generator power	4 kW
Total Production	2 MWh/y

Tipical dam for Mycro Hidro Plant

Dispels of electricity

A DFCC bank research on 88 projects show that the capacity that were in operation at 31/03/07 was 914 kW as against the planned capacity of 912 kW.
The actual capacity of these projects varied from less than 55.0% of the planned capacity to over 145.0% (Fig.1). Only in 23.9% of the sub-projects was the actual capacity the same as the planned capacity. 34.1% exceeded the planned capacity while 37 sub-projects (42.1%) were below the planned capacity. However, 48.6% of them were less than 15.0% below the planned capacity.

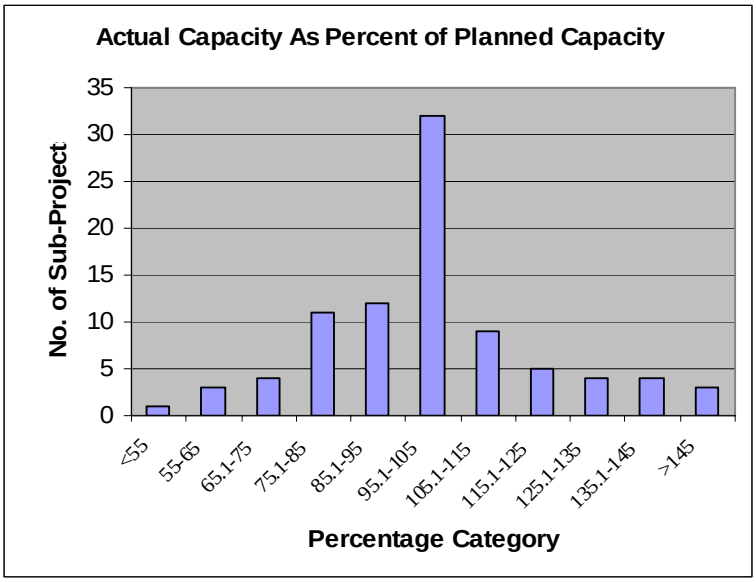


Fig.1: *Performance of Micro-hydro Projects*

In table 3 is showed the main use of electricity and is changing.
Although VECSs do not permit to use some home appliance during night time; their use has caused an overload in many projects resulting in poor quality lighting due to low voltage. This is a frequent complaint made by HHs in several projects. **Hence the projects had to introduce rules and regulations with penalties to prevent such malpractices.**

Table 3: *Use of Appliances in HHs in Micro-hydro Projects*

Appliance	Per cent of HHs		
	Nov 2004	Dec 2005	Dec 2006
TVs	**58.1**	**95.0**	**87.3**
Electric irons	**68.6**	**73.3**	**73.6**
Fans	**1.7**	**38.3**	**44.5**
Kettles	**23.3**	**36.7**	**37.3**
Rice cookers	**0.6**	**3.3**	**30.9**
Refrigerators	**0.6**	**1.7**	**6.4**

3.2 Photovoltaic Panels

The solar PV industry is making an increasingly important contribution towards rural electrification. Under the program mere than 90,000 homes (about 2% of homes in Sri Lanka) were using solar home systems.
Nearly the totally of this households systems are be installed under the RERED project, but there are also some other NGO's project that are contribute to the electrification of a thousand HHs. For this reason the systems are required to meet global quality standards specified by the program, and are sold and serviced by registered solar companies who provide warranties (minimum 10 years for the solar panel and 1 year for balance of system components) and after sales service. After the project launch, the were 2-3 small solar companies selling about 20-30 systems/month in 1998 through one micro finance institution. Some solar companies also attempted direct consumer financing, but it was found to be impractical. The program presently has countrywide coverage with average sales of over 1,500 systems/month through 11 registered solar companies and about six micro credit providers, each competing for business. The average system price including installation is around US$10/Wp today.
The solar companies are primarily responsible for marketing and service. They work closely with providers of consumer finance that include specialised micro finance institutions, leasing companies, finance companies and a few banks. A cofinancing grant, based on the capacity of solar home systems installed, is provided to solar companies to help them set up rural infrastructure. The grant is limited to small systems, and is presently US$40 for systems in the 10 to < 20Wp range and US$70 for those in the 20 to 40Wp range. Poor service by the solar company can lead to a dissatisfied customer and a breakdown in loan repayment.
For this reasons the micro credit provider establish a memorandum of understanding with the solar companies, typically covering aspects such as minimum service levels, repossession of the solar panel on foreclosure and buyback in the event of a grid expansion.
In addition to the cofinancing grant and technical assistance that are funded by GEF, the Government presently provides a solar subsidy to householders resident in three provinces (Uva, Sabaragamuwa and North East) that have the lowest grid penetration in the country. The subsidy amounts to Rs7,500 (approx. US$75) per householder who purchases a system up to 60Wp capacity. The Government solar subsidy is also managed by the Administrative Unit at DFCC Bank, and is used to reimburse solar companies who provide an up-front discount equal to the subsidy amount.
Loans and leases are secured on the solar home systems themselves, as solar panels have an economic life of 20 years or more and are therefore marketable assets even after repossession. In addition, counter guarantees by family members or neighbours are also obtained, mainly to effect peer pressure. Repayment has been found to be excellent as long as debt collection is regular, after sales service is responsive and the consumer is properly educated on system capabilities and limitations
The loans and finance leases typically carry tenures of 3 to 4 years. There is no grace period, and the consumer makes an initial down payment of around 10% of the purchase price, followed by monthly instalments. Payments are sometimes structured to suit the cash flow pattern of the consumer, as in the case of rice farmers with seasonal incomes.

The capacity of SHSs installed depends to a large extent on the income of the HH. It varied from 3 light systems to 9 light systems. Most (74.0%) have installed systems with more than 5 lights. Only 24.0% have installed 3 - 4 light systems. This indicates both the priority HHs have given to better lighting and their ability to afford systems of different

capacities. According to the Nielsen report (*Off-Grid Consumer Satisfaction, ACNielsen Lanka (Pvt) Ltd., September 2006*), 51.0% of the HHs that installed smaller SHSs (20 - 40 Wp) had a monthly income of Rs.6,000 or less while 65.0% of HHs that installed larger SHSs (41 - 60 Wp) had a monthly income of over Rs.6,000. However, the fact that 35.0% of the poorer HHs installed SHSs of higher capacity indicates the priority they place on better lighting and ability to use TV.

Unfortunately the electricity from SHSs is not a lot, and can be used just for lighting, watching TV, listening to the radio and charging mobile phone batteries.

According whit report of impact survey, showed that HHs used electricity mainly for TV (70.0%) and radio (68.0%) other than lighting. Only 33.0% of the HHs in this sample stated that they used TVs before receiving electricity.

Distribution of SHSs as at 30/09/06 and 31/03/07 and SHSs Used for Enterprises & Institutions as at 31/03/07 According to Districts

RERED Project Progress Report, Quarter Ended 31/03/07

District	No. of Houses receiving electricity			No. of Enterprises receiving electricity
	30/09/06	31/03/07	% Inc	
Colombo	51	55	7.84	0
Gampaha	40	45	12.50	0
Kalutara	623	839	34.67	6
Kandy	753	965	28.15	0
Matale	2,512	2,985	18.83	35
Nuwara Eliya	559	652	16.64	20
Galle	1,324	1,479	11.71	0
Matara	1,008	1,095	8.63	0
Hambantota	791	986	24.65	38+9*
Jaffna	268	290	8.21	0
Mannar	588	633	7.65	0
Vavuniya	328	344	4.88	0
Mullaitivu	1,762	2,573	46.03	0
Kilinochchi	3,603	4,379	21.54	0
Batticaloa	1,365	1,721	26.08	0
Ampara	5,958	6,563	10.15	57
Trincomalee	2,236	2,422	8.32	0
Kurunegala	7,490	8,903	18.87	115
Puttalam	4,015	4,438	10.54	65
Anuradhapura	4,717	5,900	25.08	44+1*
Polonnaruwa	3,116	3,392	8.86	60+1*
Badulla	4,451	4,706	5.73	55
Moneragala	10,328	11,129	7.76	47

Ratnapura	12,804	13,916	8.68	91
Kegalle	2,914	3,397	16.58	21
Total	73,604	83,807	13.86	654+11*

* The first figure refers to the number of enterprises and the second figure to the number of institutions

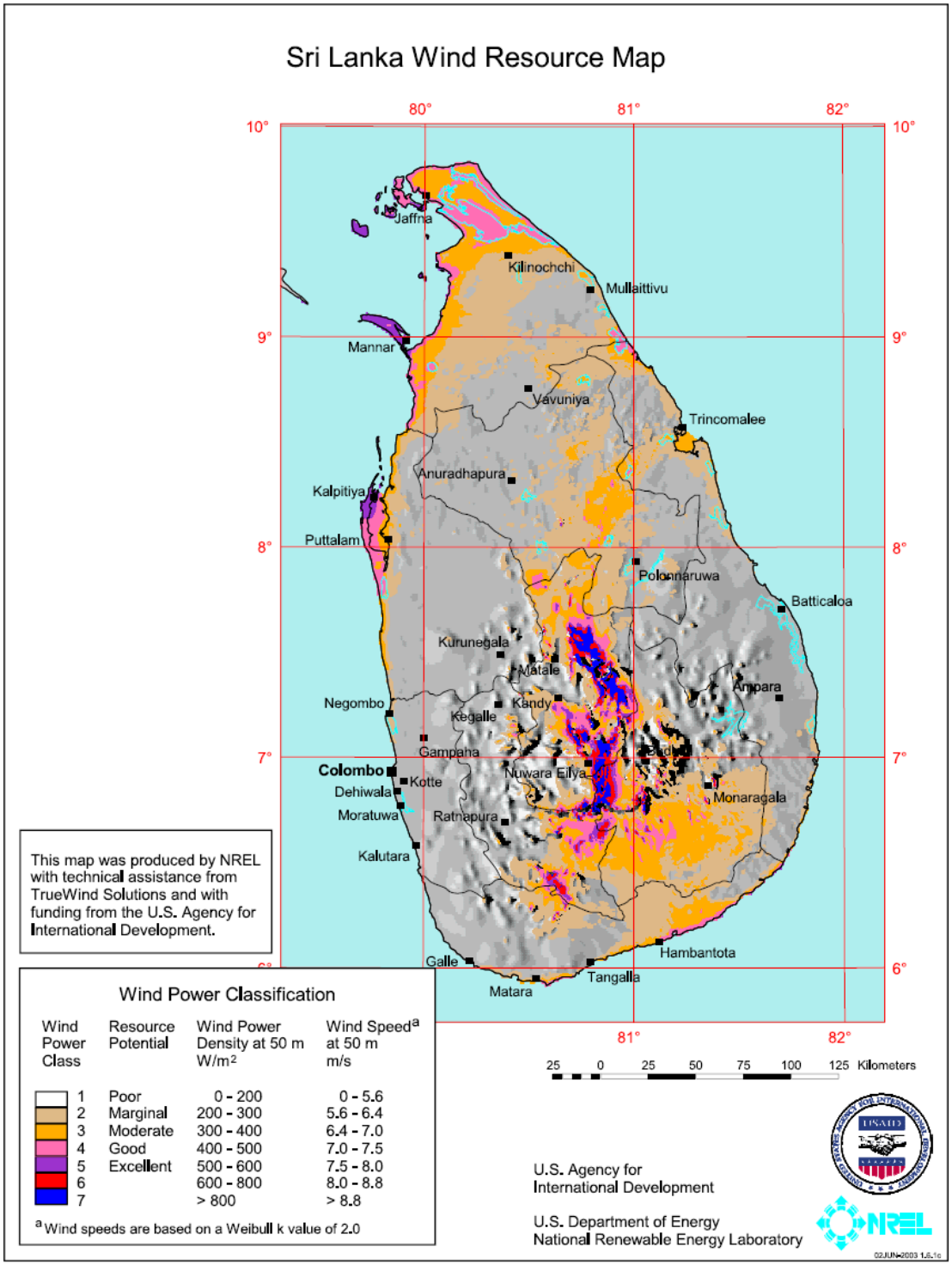
3.3 Wind Mill

In the Hambatntota district there is a 3 MW demonstration wind farm comprising five 600 kW turbines designed to supply a total annual capacity of about 4.5 GWh was commissioned by CEB in 1999 at a cost of about US$1,175/kW. The wind farm is interconnected to the CEB grid and operates at an average plant utilisation factor of 14%, which is lower than the projected value of 17%. The operation of the pilot wind farm created interest among private developers looking to develop wind power projects, and a Request for Proposals for a larger wind farm was solicited by the Government/CEB in 2003. However, the procurement was cancelled for unclear reasons, thus undermining the interest of private investors in this sector.

Despite of this, the USAID had financed the realisation of wind resource map that are edited by NREL whit technical assistance of TrueWind Solution.

According whit this map the Hambantota coast have a good potential on this field, and whit the new guide line of the RERED project the situation could be change.

In the first part of RERED Project solar and mycro-hidro was the two R.E. sources financed but for the next three years, the attention will be diverting on Bio-masses plant and Micro wind mill. Unfortunately the pilot project started (about 40 wind mills) show that these power plant need some technical improvements.



3.3.1 Pilot wind power plant

In some areas of the Hambantota district are installed some pilot plan, to test the real capacity of the wind generation. The existing power plant are divided in two categories: for house old and for small communities.
The first type of wind mill have a nominal power of 300 W and a diameter of 2.5 m and cost about 160.000 SLR; the second are little bigger, whit a diameter of 3.7 m and a power

of 2 kW. Whit this wind mill are generally electrified a dozen of household, with a 220 V tension.
Both of type give enough power for 5 bulbs and TV use for some hours.

characteristic of household wind mill:

Nominal Power	300 W
Height of pole	6 m
diameter of wind mill	2.5 m
Star wind velocity	3 m/s
Optimal wind velocity	7 m/s

characteristic of comunity wind mill:

Nominal Power	2 kW
Height of pole	9 m
diameter of wind mill	3.7 m
Star wind velocity	3 m/s
Optimal wind velocity	9 m/s

Alas, this kind of power wind generator have several problem that prejudice the system's performance, and cause the users unsatisfaction.

3.4 Biogas

Biogas is produced by anaerobic digestion. It is a process whereby organic matter is broken down by microbiological activity and, as the name suggests, it is a process which takes place in the absence of air. It is a phenomenon that occurs naturally at the bottom of ponds and marshes and gives rise to a combustible gas.

There are two common man-made technologies for obtaining biogas, the first (which is more widespread) is the fermentation of human and/or animal waste in specially designed digesters. The second is a more recently developed technology for capturing methane from waste landfill sites. The scale of simple biogas plants can vary from a small household system to large commercial plants of several thousand cubic metres.

The digestion of animal and human waste yields several benefits:

- the production of methane for use as a fuel.
- the waste is reduced to slurry which has a high nutrient content which makes an ideal fertiliser; in some cases this fertiliser is the main product from the digester and the biogas is merely a by-product.
- during the digestion process bacteria in the manure are killed, which is a great benefit to environmental health.

Two popular simple designs of digester have been developed; the Chinese fixed dome digester (fig. 1) and the Indian floating cover biogas digester (fig. 2). The digestion process is the same in both digesters but the gas collection method is different in each. In the floating cover type, the water sealed cover of the digester is capable of rising as gas is produced and acting as a storage chamber, whereas the fixed dome type has a lower gas storage capacity and requires good sealing if gas leakage is to be prevented. Both have been designed for use with animal waste or dung.

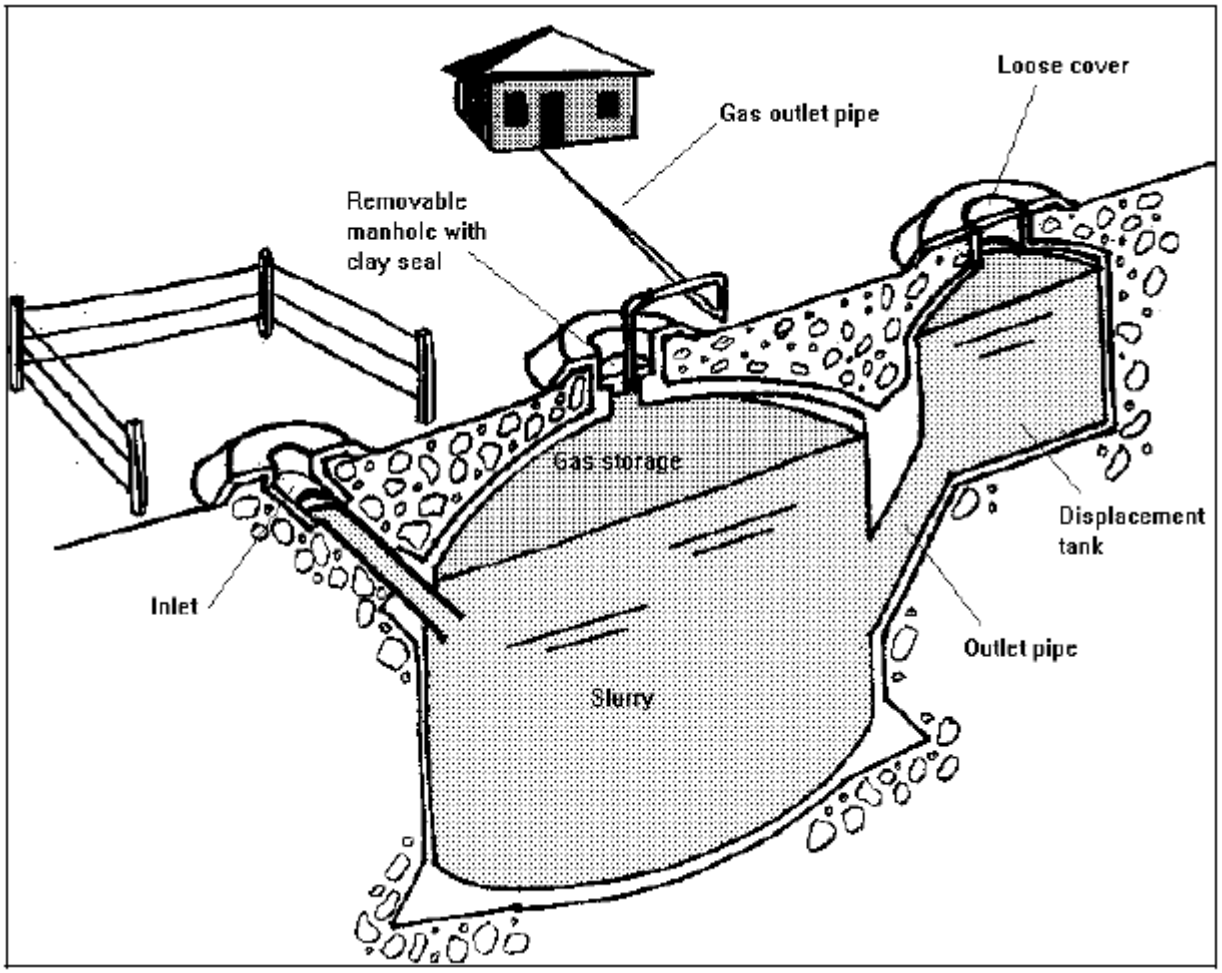


Figure 1: Chinese's type digester

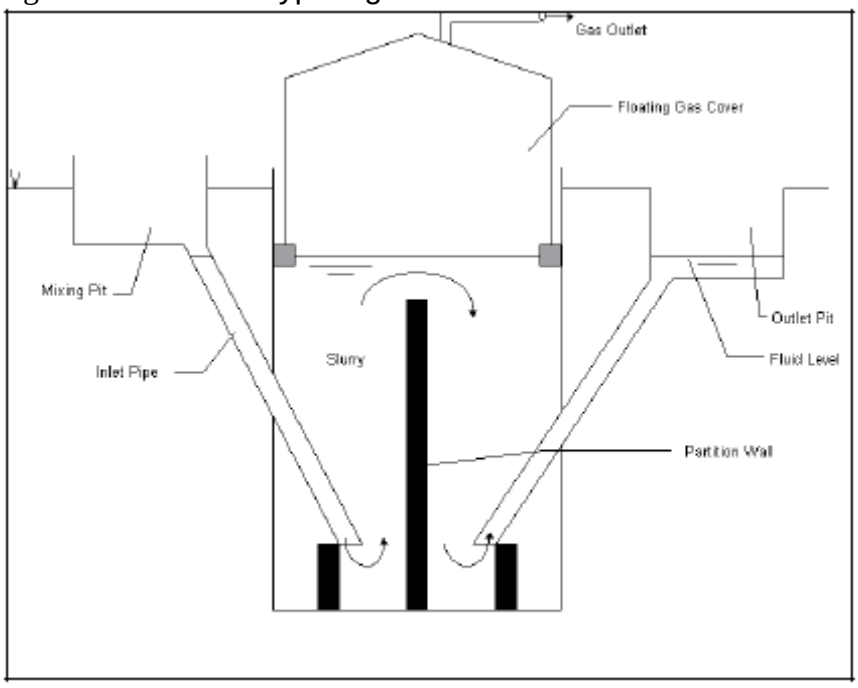


Figure 2: Floating cover digester

The waste is fed into the digester via the inlet pipe and undergoes digestion in the digestion chamber. The temperature of the process is quite critical - methane producing bacteria operate most efficiently at temperatures between 30 - 40°C or 50 - 60°C - and in colder climates heat may have to be added to the chamber but here in Sri Lanka the

situation could be optimal. The product is a combination of methane and carbon dioxide, typically in the ratio of 6:4. Digestion time ranges from a couple of weeks to a couple of months depending on the feedstock and the digestion temperature. The residual slurry is removed at the outlet and can be used as a fertiliser.
Small-scale biogas digesters usually provide fuel for domestic lighting and cooking.

Comparison of biogas whit other energetic source:

Application	$1m^3$ biogas equivalent
Lighting	equal to 60 -100 watt bulb for 6 hours
Cooking	can cook 3 meals for a family of 5 - 6
Fuel replacement	0.7 kg of petrol
Shaft power	can run a one horse power motor for 2 hours
Electricity generation	can generate 1.25 kilowatt hours of electricity

The widely used is Chinese type whit 1 or 2 ton capacity, but for its characteristics is not the most efficient for Sri Lanka.
The main problem is that needs a daily feeding, but cows (that have to feed the plant) are not in stalls, but are leave around. The consequence is that the collection of dung is not easy, and discourage the farmer.
To overcome this issue, a new type had be developed and called Dry Batch type.
The principal raw used for the digester is straw, that is easy available in the paddy cultivations.
The main difference is that type of plants needs a separate gas holder to store the generate biogas.

Chinese and Dry batch types are installed in more than 1200 house, only 2 of them produce electricity, and usually provide to the family needing of combustible for cook and in same case also for light, whit gas lamps.
Sri Lanka government had a program for sustain the diffusion of biogas plant, that provide at the 50% of the total cost (50,000 SLR),. Unfortunately the program is now stopped for the absence of found, and is not know were will be refinanced.

3.5 Biomass

Sri Lanka's energy research community has invested considerable resources to evaluate the potential of deriving electricity from biomass power (burning fuel wood, also called dendro).
The Ministry of Science and Technology, the Ministry of Environment, ITDG, and the ngo Energy Forum had carried out pre-feasibility studies, which indicate strong dendro power potential. The next step was to implement some pilot-scale dendro power plant for off-grid community electrification and on grid for feeding the national power grid.
Now the situation could change very fast under the influence of the World Bank programs, that want to encourage this form of electricity generation.
In the southern province, a pilot power plant is started near Mathara, but for some technical problem at the moment is not working.

Also the power plant that was completed at Badalkumbura had to shut down due to internal problems, and it will be relocated.
Despite this problem, The Ministry of Science and Technology has successfully completed a programme to demonstrate the feasibility of Sustainable Short Rotation Coppice plantations, and one of the plantations is situated on the Hambantota district.

3.5.1 Gassifier Technology

Processed and partly dried fuel wood, which is subjected to burn under controlled conditions, produces a specific gas. This gas, activates an internal combustion engine to turn an alternator, which is coupled to the engine. Engines that are designed to run on diesel and liquefied natural gas (LNG) are capable of running on dendro producer gas.
For the power station to operate it requires access to water, storage facilities for fuel wood to be kept in a proper dry state and access to roads to bring fuel wood.

3.5.2 Type of Combustible material

This type of plant could work whit various type of biomass, starting from agricultural waste to the wood. Most of the biomass supply in the country is derived at the moment from non-forest resources in comparison to other countries in the region. Less than 10% of biomass supply originates from forest in Sri Lanka.
Baggage resulting from sugar production is almost completely utilized at the present moment for electricity generation within the sugar factories. Rice husk is being increasingly used in rice mills and in tobacco barns as a major energy.
Biomass energy plays an important role in energy sector since it is specifically referred to *Sustainable Grown Fuel Wood (SGF)* of *Short Rotation Coppicing (SRC)* species and not of the use of forest wood or other non-sustainable resources.
In Hambantota district is still existing a project farm for the cultivation of SRC.

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

Biomass availability in MT per year (from Bio-Energy Association)

3.5.3 Existing experience

- Haycarb Limited has ventured into a DENDRO Thermal application at their Activated Carbon project at Badalgama and the Coir Fibre Industry at Madampe. In both locations Haycarb have installed DENDRO Gasifiers fuelled by SGF Biomass - Ginisiriya giving them more than 50% reduction in fossil fuel use.
- The Lanka Transformers Limited successfully tested a 35kW Dendro electricity-generation plant at Sapugaskanda and it was re-installed by the Energy Forum (a local NGO) at the Wadagahakilua off-grid village in Moneragala District. It's providing electricity to 100 households.
- A 3kW dendro power plant for electricity generation is established at a Coconut estate in Madampe.
- Lanka Transformers Limited along with Ceylon Tobacco Company Limited had completed 1MW Dendro power plant to provide electricity to the National Grid at Walapane.
- Practical Action run two project on the Thanamalvila division of Uva Province.

Following it will be reported some example of on-going project:

3.5.3.1Wadagahakiwla power plant:

Wadagahakiwla is a village in Moneragala District. Villagers of Wadagahakiwla showed a high level of enthusiasm and support for a dendro power project and formed the Wadagahakilua Dendro Power Electricity Consumer Society to establish and operate the first ever off-grid dendro power plant in Sri Lanka.
Community members contributed information and assistance to the feasibility study team during the study period and participated and contributed in civil works during the construction period. Once the power plant is operational the running cost will be paid directly by the consumers.

Project details:

Power plant capacity	40 kW
Net out put	35 kW
Transmission losses	15%
Net Power	29.75 kW
Per h/h power allocation	250 W
No of house holds	100
Total h/h requirements	25 kW
Excess power to future use	4.75 kW
Annually fuel wood requirement	160 MT
Available annual fuel wood out put	280 MT

This power plant use the Gliricediya Sepium, and it work for about 6 hours a day.
The fuel wood required is provide by the are served by the service (2 km), and on project analysis is considerate that the medium expense for electricity is SLR 412.00, and the revenue from fuel wood per h/h SLR 238.33.
Wadagahakiwla is in the dry zone of the country, that is the characteristic of Hambantota district. The experience and the lessons learned could be adapted to other areas in the same climatic zone.
The found for this project was provide by GEF, Ministry of Science and Technology and RERED Project.

4 Economic Value of the Power Generated

For the year 2006 the amount of energy generated by the small grid-connected hydro power plants was estimated as 322 GWh. The average avoided cost as calculated by CEB for this year was Rs.7.12 per kWh. Hence the economic value of energy generated by grid-connected power plants for the year 2006 is Rs.2,293 million. This is much higher than in 2004 (Rs.1,059 million) and in 2005 (Rs.1,537 million).
From next year situation will still improve. Whit the new source base tariff the income will have a sensibility growth.

One of the most significant economic value to this is the amount of imported petroleum saved in the CEB's oil based thermal power plants. Based on the same value of US$ 0.081/kWh as the fuel cost of electricity generation, the value of foreign exchange saved for the year 2006 by the energy generated from small grid-connected hydro power plant is estimated at US$ 26.08.
To this, it must be added the amount of carbon emission reduction.
For the year 2006 the saves resulted from the generation of grid-connected small hydro power plants amounts to 257,600 tonnes of CO_2 (@ 0.8 kg CO_2/ kWh).

5 Social Impact of Renewable Energy

Having electricity for lighting and to watch TV has made a significant impact on the quality of their life and changed the behaviour of HH members in a positive manner.

Main benefit gained continues to be an improvement of hygienic condition becoming from the substitution of kerosene lamps (poor lighting, inhaling smoke, time spent to bring kerosene and the danger of accidents as key problems) and a better quality lighting, which has enabled children to study longer hours. That will benefit their education.
Women also find it more convenient to attend to their housework and adults, particularly male members of HHs, have more time in the evening to spend at home, enjoy watching TV or attend to some work. Such change improves family relations and increases their interest in family matters, their children's education, condition of their houses and their economic condition.

Saving on kerosene has increased their real income which will be a continuing and increasing benefit given the rising price of kerosene. It has also opened a door to entertainment via the TV. Many HHs in micro-hydro projects are also using electric irons, fans and rice cookers. Convenience, improved security and psychological satisfaction have led to a "reawakening of life".

In case of power plant connected to the national grid, the project will allows the born of local cooperative for the manage of power plant. Whit the new source based tariff, the income of the cooperative could be high.
The energetic plant could became an important complementary money-making revenue for communities living in depressed economic dry areas.
This cooperative could be private or public-private partnership, formed by farmers that provide the biomass but also village based institutes, private organizations, business

community, NGOs and community-based organizations including local government authority.

5.1 Capacity Building

Federation of Electricity Consumer Societies was contracted to conduct a second round of 10 training courses in 2006 to strengthen the capacity of office-bearers and members from Village Electricity Consumer Society (VECSs) that had not received training earlier.
It had conducted 2 training courses for 68 office-bearers from 14 VECSs during the 2007, completing 7 training courses for 229 office-bearers from 48 VECSs up to now.
The investigations confirm that all the VECSs considered the training are useful and 89.0% of them said it was very useful. Most VECSs had gained knowledge on managing their VECSs, maintaining their accounts properly and maintaining and operating their power houses.
From an investigation commissioned by DFCC bank, results that topics identified as most useful were:

- Holding General Assembly meetings at the proper time.
- Maintaining minutes of Executive Committee and General Assembly meetings properly.
- Maintaining accounts properly.

The specific topics that were found to be least useful were:

- Holding Executive Committee meetings regularly.
- Presenting audit reports to the General Assembly.
- Payment to the Power House Caretaker.
- Supplying electricity without interruption.

5.2 Activities of Energy Service Companies During 2006

There are 12 Energy Service Companies (ESCOs) registered with the Energy Conservation Fund. These are:

- NERD Centre - Energy & Environmental Management Centre
- Hayleys Industrial Solutions Energy Solutions Division
- Industrial Services Bureau
- Metropolitan Agencies (Pvt) Ltd., Power Systems Engineering Division
- Professional MET Consultancy Services
- Small& Medium Enterprise Developers
- VIS-CON Enterprise
- Energysolve International (Pvt) Ltd
- Enexe (Private) Ltd
- Environment & Management Lanka (Pvt) Ltd.
- LTL Energy (Pvt) Ltd
- Access Energy Solutions (Pvt) Ltd

5.3 Rule of Energy Conservation Fund

The Energy conservation found (www.energy.gov.lk) could provide to facilitate the implementation of projects whit is experiences. The following were identified as the capacity building / training / other intervention which the ECF could provide:

1. Expedite arranging and finalising low interest facilities for projects.
2. Publicise implemented projects under ECF's recommendations.
3. Strengthen capacity of the ESCOs on new technologies.
4. Circulate among bulk energy consumers, a quarterly report on developments and achievements of ESCOs
5. Obtain from Secretary, Ministry of Finance a duty waiver or concessionary duty rate for energy conservation products on the basis of supporting documents and recommendation given by ECF.
6. Have quarterly meetings with ESCOs for progress and achievements.

6 Source Based Tariffs

As say, the new strategy of Sri Lanka's government count on the introduction of specific tariffs. Unlike flat tariffs or tariffs based on avoided costs that fluctuate with international fuel prices, these cost-based tariffs could provide profits to developers from the first year of operation. This provides the maximum tax-free returns to developers as almost all projects enjoy at least a five-year tax holiday under Board of Investment concessions.
The Small Power Purchase Agreements (SPPAs) could become the real impulse factor for the diffusion of renewable energy.
This agreement will be limited to power plants with installed capacity under to 10 MW.
At this moment the tariffs for biomass power plants will be confined only to those power plants using grown fuelwood. For biomass like saw-dust, paddy husk and municipal waste will be study a specific tariff.
Following are relate the two possible tariff proposed. The selection between the two options have to be made at the time of signing the SPPA.

6.1 Option 1: Three-tier Tariff

This will consist of a fixed rate, an operations and maintenance (O&M) rate and a fuel rate. All prices are in LKR/kWh.

Technology	Escalable Base O&M rate	Escalable Base Fuel rate	Non-escalable fixed rate		Escalable Year 16+	Royalty to Govt, paid direct by Sri Lanka Energy Fund Year 16+
			Year 1-6	Year 7-15	Base rate	
Mini-hydro	0.96	none	8.28	3.07	1.00	10% of total tariff
Wind	1.69	none	14.52	5.39	1.00	10% of total tariff
Biomass	0.84	5.00	5.40	2.01	1.00	No royalty
Escalation rate for year 2007	7.43%	4.95%	None	None	4.95%	

Note 1: Escalation of O&M rate and fuel rate shall commence from the 1st day of the month of January immediately after the commercial operation date.
Note 2: The applicable escalation rate for each year shall be the rate announced for that particular year.
Note 3: For biomass, the maintenance base rate increases from year 16. The year 16 rate will be the actual rate paid in year 15 multiplied by 1.25, and escalated at the rate announced for year 16.
Note 4: To compensate for the higher tariffs in tier 1, developers will be required to deliver in tier 2, an average amount of energy at least equal to that delivered in tier 1. This obligation will be stipulated in the agreement, with corresponding penalties for non-delivery in tier 2.
Note 5: Biomass means sustainably grown firewood.

6.2 Option 2: Flat Tariff

Technology	All inclusive rate (LKR/kWh) for years 1-20
Mini-hydro	7.76
Wind	13.52
Biomass	12.06

Note 1: The flat tariff will not be escalated for any reason over the entire 20-year period.
Note 2: Extensions after the 20th year will be at the same rate as for an option 1 project.

6.3 Exaple of Application:

In the following tabs it is relate of development of the three-tier tariffs, based on the escalations rates applicable for year 2007. It should be noted that the following is only an example to demonstrate the application of escalation rates, where the escalation rates for year 2007 (4.95% and 7.43%) have been applied every year throughout the 20-year period of the SPPA. The actual escalation rate will be calculated and announced every year.

Tier 1

		All inclusive Tariff for SPPAs signed in year 2007 (LKR/kWh)					
Year of operation		1	2	3	4	5	6
Small-hydro	Non-escalable	8.28	8.28	8.28	8.28	8.28	8.28
	Escalated O&M	0.96	1.04	1.11	1.19	1.28	1.38
	Total	9.24	9.31	9.39	9.47	9.56	9.65
Wind	Non-escalable	14.52	14.52	14.52	14.52	14.52	14.52
	Escalated O&M	1.69	1.82	1.95	2.10	2.25	2.42
	Total	16.21	16.34	16.47	16.62	16.77	16.94
Biomass	Non-escalable	5.40	5.40	5.40	5.40	5.40	5.40
	Escalated Fuel	5.00	5.25	5.51	5.78	6.07	6.37
	Escalated O&M	0.84	0.90	0.97	1.04	1.12	1.20
	Total	11.24	11.55	11.88	12.22	12.59	12.97

Tier 2

		All inclusive Tariff for SPPAs signed in year 2007 (LKR/kWh)								
Year of operation		7	8	9	10	11	12	13	14	15
Small-hydro	Non-escalable	3.07	3.07	3.07	3.07	3.07	3.07	3.07	3.07	3.07
	Escalated O&M	1.48	1.59	1.71	1.84	1.97	2.12	2.28	2.45	2.63
	Total	4.55	4.66	4.78	4.91	5.05	5.19	5.35	5.52	5.70
Wind	Non-escalable	5.39	5.39	5.39	5.39	5.39	5.39	5.39	5.39	5.39
	Escalated O&M	2.60	2.79	3.00	3.22	3.46	3.72	4.00	4.29	4.61
	Total	7.99	8.18	8.39	8.61	8.85	9.11	9.39	9.68	10.00
Biomass	Non-escalable	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
	Escalated Fuel	6.68	7.01	7.36	7.73	8.11	8.51	8.93	9.37	9.84
	Escalated O&M	1.29	1.39	1.49	1.60	1.72	1.85	1.98	2.13	2.29
	Total	9.98	10.41	10.86	11.33	11.83	12.36	12.92	13.51	14.13

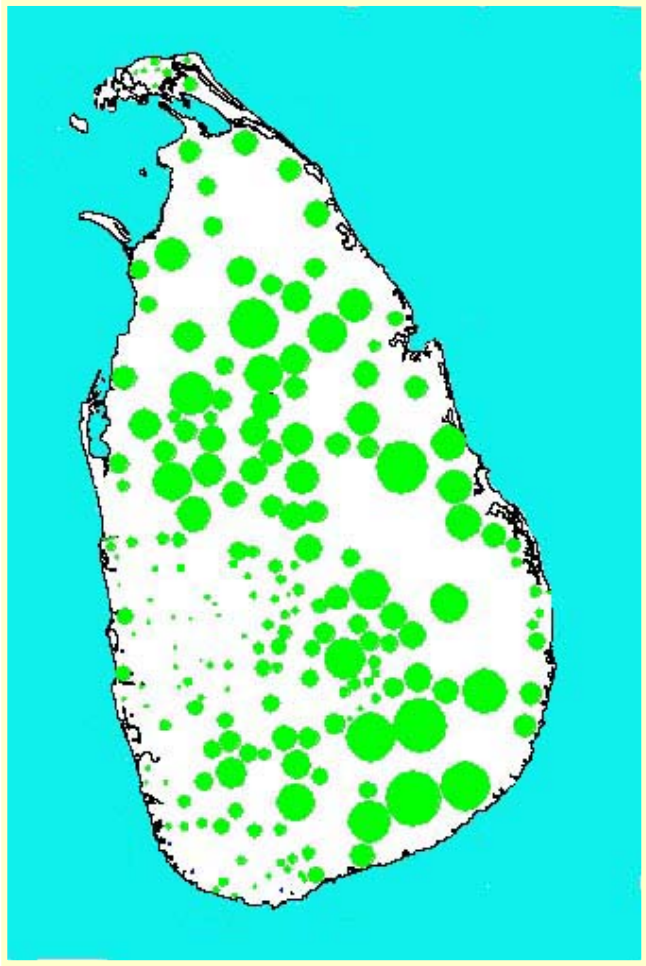
Tier 3

		All inclusive Tariff for SPPAs signed in year 2007 (LKR/kWh)				
Year of operation		16	17	18	19	20
Small-hydro	Escalated Fee	2.06	2.17	2.27	2.39	2.51
	Escalated O&M	2.82	3.03	3.26	3.50	3.76
	Total	4.89	5.20	5.53	5.89	6.27
Wind	Escalated Fee	2.06	2.17	2.27	2.39	2.51
	Escalated O&M	4.95	5.32	5.72	6.14	6.60
	Total	7.02	7.49	7.99	8.53	9.10
Biomass	Escalated Fee	2.06	2.17	2.27	2.39	2.51
	Escalated Fuel	10.32	10.84	11.37	11.94	12.53
	Escalated O&M	3.07	3.30	3.55	3.81	4.09
	Total	15.46	16.30	17.19	18.13	19.12

Other two important measure that could help the project managing are:

1. Non-delivery of energy will not carry any penalty (except non-delivery in years 7-15 for those opting to the three-tier tariff). SPPAs will have a mandatory period of 20 years. If the energy delivered in any month is zero or if CEB is of the view that the power plant has not operated within a given billing period (usually one month), the SPPA will be extended by the same number of months. However if at any time during the 20 year SPPA the cumulative number of billing period (months) of non-operation reaches 12 months, the power plant will lose the escalation on O&M and fuel costs (in case of biomass) for that year. Similarly, the escalation provided for the third-tier will also be reduced by one year.
2. Extensions will be by mutual agreement, and will be at the same rate as in the 20th year in the three-tier tariff, escalated similarly.

6.4 Map of Sri Lanka's marginal land



6.5 Biomass Availability in the country

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

7 Art Gold Programme area

The ART GOLD project is engaged on the Southern Province territories. The area of Hambantota district is the less electrified of the province, with only 70% of electrified households, and could be the benefit place were start new energy project.

- Wind Mill Project:

According whit the wind resource map, edited by NREL whit technical assistance of TrueWind Solution, the Hambantota coast have a good potential on this field.
These power plants are use for the electrification of single or few household. Unfortunately the pilot project started show that these small wind mills need some technical improvements.

- BioMass Project:

The sparse and degraded forests, as showed on the following tabs, cover 55,077 ha of the district. Whit a biomass power plant, this land could be converted to Gliricidia plantation, which could provide the biomass needing of the power plant and becoming at the same time an important income for the families. Also Government and VIDATHA program are encouraging the plantation of Gliricidia for his characteristic.

Un –utilized State owned Lands:

District	*Extention (Ha.)*
Galle	169
Matara	55
Hambantota	5927

Alienated State owned Lands:

District	*No. of Major Settlement Schemes*	*Highland Extent (Ha.)*	*No. of Allotments*
Hambantota	03	376	1626

Forests with Sparsely Vegetated:

District	*Total Spares (Ha)*	*Total Dense (Ha.)*
Galle	1584	18953
Hambantota	59630	23197
Matara	1773	18468

8 Project Proposal

In comparison with other electricity generation technologies available, the small-scale fuel wood fired gasification IC engine based electricity generation plant requires major involvement from local resources. Participation of the local community, not only in plantation establishment but also in harvesting, transport, and fuel preparation can create useful work and high involvement.
Small-scale stand-alone power plants are very suitable for electrification of rural villages and tend to attract funding support from a range of sources including the villagers themselves.
With the medium sized plants (1MW+), the fuel wood requirement can be considerable (around 50 tonnes/day) and reliability of supply is critical. The dendro-power plant established at Walapane has provided some valuable lessons that can affect the success of such projects.
The study that has been made on that project, has indicated the importance of careful assessment of the needs of the communities and attention to the arrangement for collection of biomass and setting an acceptable payment.
This experience advise to move in the direction of very small plant, under 100 kWe.

8.1 Public Private Partnership Initiative

The focal point of this project proposal must be the promotions of public-private partnership on an experimental basis among farmer groups, village based institutes, private organizations, business community, NGOs and community-based organizations including local government authority, to coordinate and link the resources available in the private and public sectors and to strengthen the community level institutions by harnessing the potentials existing in the divisions.
These partnerships focus on promoting rural investment and economic opportunities by tapping into the production capabilities of the rural communities, linking them to existing capital resources of the private sector and by exploiting existing market potentials.

8.2 Groups Organization and Community Company

The Project will aim to promote self-governance core groups at the community level through the formation of People Company as partners in economic development.
The ART Gold work group could mobilizes the business and rural communities to form institutions and cooperative organizations for the formation of social capital and partnership and assists the partnership with the management of necessary technical support and credit.

8.3 Why Biomass Energy?

Sri Lanka locally available energy resources such as hydro, biomass, solar and wind have to be developed to meet the increasing demand. But the potential for commercially viable wind and solar photovoltaic energy is very small in Sri Lanka. Hydropower sector has already made a noteworthy contribution to the national requirement of energy. However, this potential is limited to a further 200 – 250 MW from all identified locations.

Therefore, biomass energy plays an important role in energy sector since it is specifically referred to *Sustainably Grown Fuel Wood (SGF)* of *Short Rotation Coppicing (SRC)* species and not of the use of forest wood or other nonsustainable resources.

This sector is practically unused. Based on the yield data obtained from many independent studies a hectare of energy plantation with 5000 trees per Ha of Gliricidia, Accacia or Cassia in the dry Zone of Sri Lanka would produce a minimum of 15-20 tonnes(dry wood) per hectare per year. This would be sufficient to meet the fuel requirements of a 2.5 KW power plant operating on an annual plant factor of 70% annually generating 15 MWh of electrical energy per hectare. The total extent of degraded marginal lands suitable for energy plantation in Sri Lanka is estimated at 1.6 million hectares.

If only 10% of the fossil fuel imports are replaced by bio fuels, the benefits would result in:
• *Employment potential 50,000 farmers*
• *Contribution to Rural Economies - SLR 2000 Million/year*
• *Saving in Foreign Exchange US $ 72 Million/year*
• *Soil Enrichment 22,000 tons of Urea/year*
• *Potential carbon Credits @ US$ 4.00 per ton US $ 4,000,000/year*
• *Enhancement of Green Cover 75,000 Ha*
• *Livestock Development 32 Million Litres of Milk/year*

The total potential of this resource is more than enough for total replacement of fossil fuels currently imported for the Electricity generation and thermal use in Industry.

On the assumption that Gliricidia planting is spread in 25000 hectares and added 25MW dendro power to national grid:

(A) Economic Benefits
• Contribution to Rural Economies - SLR 700 Million/year
• Saving in Foreign Exchange - SLR. 2500 Million/year
• Livestock Development 32 Million Liters of Milk/year.
• Nearly 180 Gigawatt hour bio electricity generation and injection to the national grid annually

(B) Social Benefits
• Employment potential 50,000 farmers
• Active direct employments of 500 rural youth in remote area
• Rural infrastructure Development
• Rural community was empowered
• Rural Community capacity building

(C) Environmental Benefits
• Soil Enrichment 22,000 tons of Urea/year
• Potential carbon Credits @ US$ 4.00 per ton - SLR 150M/year
• Enhancement of Green Cover 25,000 Ha
• Cumulative Displacement of 977,000 Metric Tones of carbon from atmosphere

Dendro power projects have the largest scope of empower the rural communities whit providing employment.
Each MW of this power could provide employment for 300 rural people earning around SLR 300 per day. This has been well proven in the commercial energy plantations that supply fuel wood for thermal energy applications.

Other renewable energy projects such as wind, solar PV, solar thermal, etc. provide productive employment opportunities only for the countries manufacturing the equipment.

The proposed Dendro projects, are small and regional projects. Therefore the beneficiaries will be the growers of energy plantations. They will remain in their own areas and homes to grow fuel wood as an additional source of income, not as an alternative to growing food for sale and consumption.

The technology involved, could easily be assimilated by the Sri Lankan university and research centre and it could growth indigenous capabilities too.
Renewable energy development involves the design, fabrication, installation and commissioning of many engineering devices in many different locations in the country. This will give an opportunity to many local technical workers to improve their skills. This has been amply demonstrated in the investigation on the case of micro hydro projects and biomass energy projects already commissioned.

Farmers engaged in the traditional rice cultivation in the dry zone in Sri Lanka have employment opportunity only for peak labour periods during certain months of the year. These farmers need alternative income generating avenues in the remaining months in the year.
The introduction of energy plantations in their locality would enable these workers to productively engage themselves also during these slack months. Each worker could earn around SLR 300 per day. A family combination working 150 days in the year would bring a supplementary annual income of at least SLR 100,000 per family.

8.3.1 Organic Fertilizer Production

Experiments carried out at the Coconut Research Institute has revealed that the incorporation of 35 kg of green Gliricidia leaves to a coconut palm has the equivalent effect of applying 800 grams of urea fertilizer.
In this manner, the leaves obtained from energy plantation could replace a substantial quantity of imported chemical fertilizers, reducing the cost of production of our agricultural products.

8.3.2 Enhancement of Dairy Industry

At present over 80% of the national milk requirement is met through imports. The high cost of this item has resulted in severe malnutrition amongst the children of the poor families in Sri Lanka. A study conducted and published by the National Science Foundation reveals that rice straw and Gliricidia leaves jointly constitute an excellent feed for dairy cattle. Burning rice straw in the field annually destroys large quantities of rice straw in the country. Surplus rice straw and Gliricidia leaves from energy plantations could be processed into cattle feed.

8.4 Selection Criteria

In looking at the choice of appropriate technologies, attention has to first be made to whether the unit is to serve the community directly in an off-grid capacity or whether the intention is to establish a commercial unit capable of feeding the grid.
Than the attention must be diverted on the territory that have to provide the combustible for the plant. The major part of the cost of management being harvesting and transportation costs. An economic analysis done at the CRI showed that the transport of *Gliricidia* fuel wood within the radius of 15 km. from power generating plant is still economical.
In the following are reported some of the criteria that could be utilized in the choose of place were the start of project could be easily:

A. Exclude

1. Stream and road reservations
2. Catchments areas of tanks
3. Forest and wild life reserves
4. Land above 30% slope
5. Land above 1600 m contour
6. Land with too much rock

B. Include

1. Land with good soil
2. Land with water supply close by
3. Land less than 8% slope
4. Land between 8% and 30% slope for Agro-Forestr

8.5 Main project activities:

1. Conducting of social mobilization program.
2. Formation of people based company and public private partnership.
3. Conducting of microfinance environmental lending program.
4. Formation of community initiative Dendro power generation action plan.
5. Cultivation of *gliricidia sepium (albecia)* plant in bare land belong to farmers in the project area.
6. Introduction of land use policies including organic farming
7. Rural infra structure development process.
8. Installation of the thermal bio energy power plants.
9. Transmission line and grid connection works.
10. Organic fertilizer production process by using gliricidia leaves.
11. Project expanding and replication process.
12. Community participatory monitoring and evaluation program.

Funding and Investment Sources:

1. Government Fund/Equity
2. Private Investment
3. Local and International Donor Fund
4. Co financing from Local and International Institutions.

5. NGO Fund/Equity
6. Community Fund/Equity

8.6 Investigation on "Gliricidia sepium"

Public and private sector institutions have been demonstrated the technical economic viability of establishing and operating "Gliricidia sepium" (GS) SRC Plantation:

- Investigation have identified GS as the most promising species for SRC energy plantation in marginal degraded lands in all districts in Sri Lanka.

- Average yield of 20.0 tonnes (20% moisture) of fuelwood per hectare per year and 16 tonnes of (fresh weight) of foliage per hectare per year has been confirmed.

- An optimal spacing of 1 metre x 1 metre has been recognised.

In Hambantota district is still existing a project farm for the cultivation of SRC.

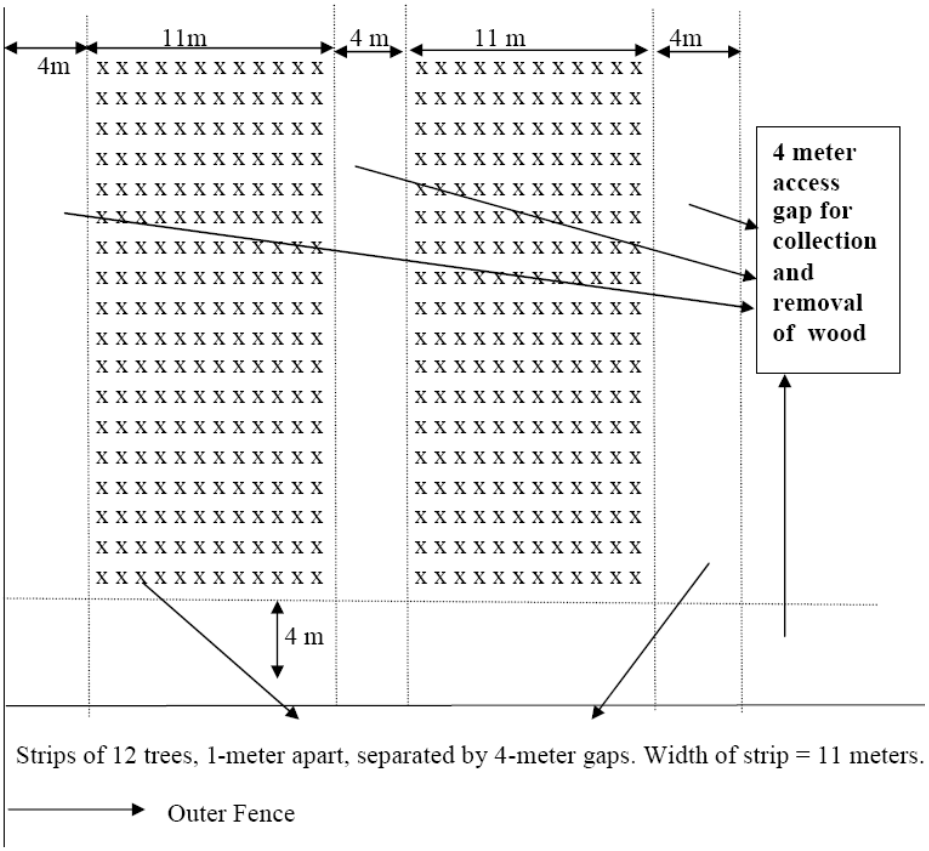
Productivity of Gliricidia (Tree/Year):

	Year 1	**Year** 2	**Year** 3	**Year** 4	**Year** 5	**Year** 6
Leaf (kg)	2.0	2.5	3.6	6.0	8.0	6.0
Wood (kg)	1.4	4.0	5.0	8.0	7.0	8.0
Value (SLR)	3.60	9.00	11.40	18.30	17.00	18.30
SLR/ha	9,500	23,760	30,000	48,000	44,800	48,700

8.6.1 Gliricidia Farming

The results of the experiments carried out at the Coconut Research Institute of Sri Lanka have indicated that either *Gliricidia* grown at 1 m x 1m (10,000 trees/ha.) maximized wood yield. Field observations also revealed that planting of these trees into 1m x l m system quickly suppressed weed growth and led to the production of small diameter sticks which could be easily harvested. In terns of plantation design, access tracks are required and the favoured design seems to be blocks of 12 rows of trees at 1x 1 m with 4 m gaps to provide harvesting access (Fig 2).
Harvesting regimes also affect the yield of wood and foliage. Results shows that annual coppicing at a height of 1.0 m from ground level produced the highest wood yield.
Complete removal of all branches showed that regrowth is fast and uniform branches also could be obtained, compared to the harvesting regime of continuous harvesting where the removal of branches is

limited to those that are over 25 mm. only. Removal of all branches at the same time would help to maintain apical dominance of the tree.
The harvesting interval may vary with climate, soil, etc. The trials at the CRI have shown that an 8-month harvesting interval is the best for *Gliricidia* in the intermediate Low Country (IL), region of Sri Lanka.



8.6.2 Advantage of Gliricidia

- **Carbon Sinks** There is a vital difference between energy production from fossil fuels and from biomass. Burning fossil fuels releases CO_2. By contrast burning biomass simply returns to the atmosphere the CO_2 that was absorbed as the plants grew and there is no net release of CO_2. If the cycle of growth and harvest is sustained. Thus the biomass option is proven to be CO_2 neutral. Energy plantations will act as carbon sinks. As such the energy producers using bio mass could benefit from the Carbon Credits under the Cleaner Development Mechanism (CDM) formulated under the Kyoto Protocol carbon credits are being traded for US $ 4-6 per MT.
- **Soil Enrichment** The establishment of SRC plantations with Nitrogen fixing trees such as Gliricidia and Leucaena in degraded lands previously used by shifting cultivators will over time upgrade the land to its original status.
- **Soil Erosion** Gliricidia has been proven to be ideal for Sloping Agricultural Land Technology (SALT). Through a method of planting along the grid lines in twin

hedgerows soil erosion can be arrested. This method has been very effectively sustained in the hill country in tobacco growing lands.

- **Prevention of Land Degradation and Desertification** Land degradation has been identified as a serious problem in dry zone in Sri Lanka. About a third of Sri Lanka land area has been degraded and is under utilized. Annually, about 0.1% of virgin forestland is encroached by shifting cultivators. Clear signs of desertification are appearing in many parts of dry zone.
  Establishment of energy plantations is an economically viable way to embank this problem.
- **Pricing** Energy efficiency wise 4 tonnes of fuel wood is equivalent to 2 tons of Coal or 1 tons of oil. At current prices for oil at around SLR 24,000 per tons the energy equivalent price of fuel wood would be around SLR 6000 per tons. Also using a delivered price of sustainable grown fuel wood (Gliricidia) of SLR 3000 per tons is two times cheaper than oil. As the price of fossil fuel continue to increase and the supply becoming volatile, domestically grown fuel wood will become increasingly attractive.
- **Employment & Growth in Rural Economy** Fuel wood farming can become an attractive employment opportunity to the rural youth. A fully grown energy plantation of 50 Ha can provide employment to around 40 persons on a sustainable basis bringing an income of around SLR 200 a day per person for manual labour. A one MW power plant would inject a sum of SLR 22 million to the rural economy. This sum will be shared between the farmers and the collecting agents. This opportunity will also prevent migration by the rural youth to urban areas.
- **Foreign Exchange** Large sums of foreign exchange will be saved from not importing fossil fuel and can be diverted to other important areas or reserves.
- **Land Use/Green Cover** Large extents of unproductive lands would now be better utilised as energy plantations. Not only will there be plantations but simultaneously the green cover in the country will be enhanced.
  If 50,000 Hectares of energy plantations are grown it can increase the forest cover from the current 19% to 25%.
- **Electricity To Inaccessible Areas** There are many areas in the country where grid electricity may not reach due to transmission difficulties. Biomass electricity is an ideal solution to such areas.
- **Economic/Social/Environmental Impact** The economic, social, and environmental impact from the above will be a tremendous boost to the country as a whole. For example the pressure for urban migration of youth could be reduced by providing employment opportunities and means of income generation in the rural areas.
- **Thermal Energy for Crop drying and processing** . The bio mass gasification as wells as waste heat form the power generation are valuable sources of energy for low grade heat requirements for crop drying and processing needs and are available practically at no cost.

Gliricidia have characteristic that could be right also in the dry land that are the characteristic of Hambantota district.
Could be grown under difference agro-climatic/soil conditions, especially poor and gravel soils, maintaining is high growth rate. Average yield of 20.0 tones (20% moisture) of fuel wood per hectare per year and 16 tones of (fresh weight) of foliage per hectare per year

has been confirmed, also in this condition. The dry climate will also facilitate the drying of wood, helping the work of farmers.

8.6.3 Risks On Biomass Project

The initial question to be answered is the total energy demand of the village and the plant generation capacity that will be required Consideration needs to be given to the cost of energy production from current resources and the cost that can be borne by the villagers.
The villagers must have a positive frame of mind about the project, since success depends upon the active attendance of all the villagers.
The major factors that determines the sustainability of the project is the continuity of the fuel wood supply, the issue of loan repayment. The risks involved in a village based off grid Dendro project stem from an over-estimate of the potential production from the plantation (possibly accentuated due to drought or other unfavourable growing conditions outside the control of the project), pressure from the need to repay the loan and mechanical breakdown of the Gasifier .

Critical factor on the fuel wood supply:

- When villagers fail to supply the fuel wood
- Fuel wood plantation damage by something
- Limitations of storage facilities
- Fuel wood transportation difficulties
- Difficulties of finding substitutes for fuel wood

Probably the first few years, there won't be any difficulties to maintain the continuity of the supply chain, but the situation could be change, for example if some interpersonal conflicts rise or for slowness of the villagers to supply fuel wood.

9 CONCLUSION

The Millennium Development Goals (MDG) announced by the United Nation requires the development of country specific plans to sustain economic independent, from much prospective, energy being a significant inclusion. The supply of reliable and affordable clean energy has been recognized the MDG Global Plan as an extremely important aspect.
In Sri Lanka, the steep rise in global oil prices has resulted a great burden to the economy in supplying of these conventional energy sources without fluctuations.

The available options are the utilization of renewable energy sources and efficiency improvement in the current use. Energy security has become an important factor in achieving the objectives articulated in the economic policy framework.
The implementation of renewable energy program has created a vibrant industry of suppliers, developers, consultants and trainers, community based organisations, NGOs and specialised industry associations. By mid-2005 there were over 40 mini hydro companies backed by about 20 active developers, 11 registered solar companies, 22 registered village hydro developers and 12 village hydro equipment suppliers as compared to 1 mini hydro developer, 4 fledgling solar PV companies and 2 village hydro developers at the start of the program in mid-1997. At village level, there are now more than 90 functioning electricity consumer societies that own and operate off-grid micro hydro schemes that meet ESD and RERED technical standards.

Commercial financing to this sector has been largely mainstreamed, with banks competing for business in some sectors such as mini hydros. At present two development banks, five commercial banks, two leasing companies and a micro finance institution provide subloans under the program, while independent credit providers include a few finance companies and rural development banks.

Active industry associations include the Grid Connected Small Power Developers Association (commercial mini hydro developers), Bio Energy Association of Sri Lanka (dendro power developers), Federation of Electricity Consumer Societies (representing owner-operators of off-grid village hydro schemes) and the Solar Industries Association (solar home system suppliers and consumer loan providers).

Annex 1

Impact of 1 MW power plant:

For feeding 1 MW power plant, the quantity of dry wood necessary is 12,000 tonnes each year. The growth of necessary Gliricidia will take about 600 ha of land, involving at least 600 families with a part-time employment. Whit a price of 3.00 SLR/kg, that means an income of 60000 SLRL/ha/year.
In a case of ON-Grid plant, the economics benefit will increase by the selling of electricity to the national power grid. At the current price of 8.50 SLR, whit a production of 7 GWh means an income of 59,5 million of SLR.
Moreover, for the end of 2007, the new tariff will become effective, and the new price for this source will be significantly increased. On this situation a cooperative, like the one born for the micro-hydro plant, could multiply the advantage and improving of life condition on population.

Added to this, there are also the foliage (about 16 t/year/ha) that could be used for fed about 4-5 cows each ha, whit the respective milk production.
The best rational scheme, will contemplate also a biogas plant that could produce gas for cocking and fertilize for the field.
Furthermore, are still present a grant for the inter plantation of Gliricidia in the coconut field.
The inter-plantation of Gliricidia in coconut field raise moisture availability over coconut alone, increase effectiveness of rains (reducing temperature of ground level) and increase soil moisture.
The implementation of project that use agricultural knowledge and social cooperative for producing energy could be an umbrella project, that for sure could generate an improvements of general condition of life but could also have a strongest social impact.

10 MW project

As example, in the following tab is explain an existing project of biomass power plant compared with a same power coal power plant. The power generation and the cost of this power plant is very high, but can demonstrate the economic feasibility of the kind of project:

	Dendro	**Coal**
TECHNICAL		
Plant Capacity MW	10.00	10.00
Dollar Parity SLR/ Us$	102.00	102.00
Cost of fuel delivered /kg dry	2,000.00	6,000.00
Interest rate	10.00%	10.00%
O D Rate	12.00%	12.00%
Capital Cost US$/KW	1,000.00	1,200.00
Tariff SLR/KWh	8.50	8.50

Internal Consumption %	10.00%	10.00%
No of Days Run/Yr	330	330
Specific Fuel Consumption kg/kwh	1.50	0.50
Calorific value Kcal/kg	3,700.00	6,000.00
Overall Efficiency	15.52	28.71

FINANCIAL

ROC (Return on Capital)	17.65%	12.43%
ROSE	93.31%	35.52%
IRR over 7 years	13.06%	7.85%
IRR over 20 years	19.42%	15.20%
Payback Period (Yrs)	5.67	8.05

A detailed breakdown of the capital and recurrent costs involved with the establishment and operation of a dendro-power unit of 10MW can be accessed here. As indicated above, the figures suggest that the IRR over 20 years is expected to be close to 19%, with a payback period of 5.7 years. Total capital costs would be of the order of $11.8 million.
The main assumptions made for this calculation are provided on the spreadsheet. It is assumed that the wood consumption of 1.5 kg/kwh. The plant would produce an output of 71,280,000 KWh on the basis of operation of 330 days/year with 10% of the power being used internally.
Total amount of wood that will be required will equal 118,800 tonnes/year at a cost of SLR2,000/tonne. Unfortunately this price is considerate to low from the farmers, however the new source based tariffs cold enable to increase it.

Cost-Benefits in the inter-planting Gliricidia whit Coconut

During the first year, establishment of 1 ha of Gliricidia cost SLR. 20,700. Of the total establishment costs, 50% was for labour. From the second year onward, maintenance cost did not exceed SLR 4,000 per ha/year. At the fifth year, the cost of harvesting increased to SLR. 18,000 per ha in addition to the transport cost of cut material which amounted to a further SLR 12,000 (Table 4).

Income from *Gliricidia* is calculated from the sale of the wood and the use of leaf biomass for fertilization of coconut. Value of wood at 20% moisture level was SLR. 2.60 per kg and this market price generated SLR. 63,000 per ha per year in addition to the value of leaf biomass. At the fifth year, leaves of *Gliricidia* utilised as a supplementary green manure was calculated as have a value equivalent to SLR. 6,200/ha/ye ar looking at the savings made in the use of urea.

The total value of leaves and wood was calculated to be SLR. 69,388 /ha in year 5. By year 5 (reaching maturity) *Gliricidia* inter-cultivation with coconut was able to generate approximately SLR. 35,000 as net profit, excluding the value of the coconut crop.

Table 4 :Expenditure and Income from inter-planting Gliricidia in 1.0 ha of coconut during the initial 5 year period (SLR.)

Activity°	Year 1	Year 2	Year 3	Year 4	Year 5
A) Materials					
Planting Materials	4500	-	-	-	-
Weedicides	6000	-	-	-	-
B) Labour					
Land clearing	2500	-	-	-	-
Planting	2800	-	-	-	-
Vacancy filling	900	-	-	-	-
Maintenance (weeding	4000	4000	4000	4000	4000
Harvesting	-	9000	13500	15000	18000
Transport	-	6000	9000	10000	12000
Total Cost	20700	19000	265000	29000	34000
C) Income					
wood	-	31720	47320	52520	63180
Leaf *	2064	2576	3278	5200	6208
Total	2064	34296	50598	57720	69388
D) Net Profit (Rs/ha.)	(-18636)	15296	24098	28720	35388

* *Value of leaf was calculated on the basis of urea equivalent with 1.0 kg of urea = SLR.16.00*
Wood price - SLR. 2.50 per kg (at 20% moisture level)

Saving on Chemical Fertilizers by using Gliricidia: (SLR.)

	APM	Gliricidia 50 kg/palm/yr
Urea	12.80	-
ERP	2.94	1.72
MOP	39.50	24.70
Dolomite	2.60	1.30
Total/palm/year	58.00	28.00

Saving - SLR. 30/palm/year
- SLR. 1,920/ac/year

Gliricidia in coconut plantations led to a significant improvement in the soil and micro climate. There was noted to be a reduction in soil temperature underneath the *Gliricidia* canopy, which may have several benefits. Among them being an increase in root activity, a reduction of soil moisture losses, and a reduction in soil carbon oxidation. Leaf litter collected from shredded *Gliricidia* leaves will also cover soil and thereby reduce soil temperature. Soil fertility improvement by *Gliricidia* is the key for development of degraded soils and agriculture. One hectare of *Gliricidia* with coconut produced approximately 24 m.t (fresh weight) of leaf biomass annually. Organic materials are considered as important resources for building soil fertility. Soil under *Gliricidia* has shown elevated levels of organic carbon. N, P over non-Gliricidia plots. These changes in soil nutrient profile are general, because *Gliricidia* could mine plant nutrients such as P, K. Ca, Mg. from deeper layers of soil. With the continuous lopping of *Gliricidia* as a renewable forestry, such plant nutrients are expected to be high in the surface layers of soil.

- Bio-Energy Association of Sri Lanka (BEASL)

Address: 465/1 Sunethradevi Road, Pepiliyana, Borelasgamuwa, SRI LANKA
Telephone: +94 (0)11 2812373
E-Mail: info@bioenergysrilanka.org
www.bioenergysrilanka.org

- Energy Forum

Address: 239 Highlevel Road, Kirulapone, Colombo 05, SRI LANKA
Telephone: +94 011 5524613
Facsimile: +94 011 2852167
Email: eforum@sltnet.lk
www.energyforum.slt.lk

- RERED Project (DFCC Bank)

DFCC Bank functions as the Administrative Unit of the RERED Project.
Administrative Unit - RERED Project - DFCC Bank
73/5, Galle Road, Colombo 3, Sri Lanka
Tel: +94 11 244 2442
Fax: +94 11 244 0376
E-mail: info@dfccbank.com

- Practical Action

5, Lionel Edirisinghe Mawatha, Kirulapone, Colombo 05, Sri Lanka
Tel: +94 11 2829 412 (... 413, 414, 415)
Fax: +94 11 2856 188
e-mail: SriLanka@practicalaction.org.lk
www.practicalaction.org

- National Engineering Research & Development Centre (NERD)

Mahinsasa Narayana - Renewable Energy Department - (e-mail: narayana@nerdc.lk)
2P/17B, IDB Industrial Estate
Ekala, Ja-ela, 11350, Sri Lanka
Tel-+94-112-236284/ 236384
Fax:- +94-112-753545/97
Email: nerdcentre@nerdc.lk
www.nerdc.lk

REFERENCES

- *DFCC Bank Administrative Unit, Sri Lanka Renewable Energy for Rural Economic Development Project, Financial Monitoring Report, Quarter Ending 31 March 2005*
- *Exel J., Sri Lanka Solar Industry Review, December 2003*
- *Nagendran J., Sri Lanka Energy Services Delivery Project Credit Program: A Case Study, for Infrastructure Forum 2001, 2001*
- *World Bank, Sustainable Energy: Less Poverty, More Profits, December 2004*
- *World Bank, Project Performance Assessment Report, Sri Lanka Energy Services Delivery Project, Report No: 29532, 25 June 2004*
- *World Bank, Implementation Completion Report, Energy Services Delivery Project, Report No: 25907, 5 June 2003*
- *World Bank, Sri Lanka Renewable Energy for Rural Economic Development, Project Appraisal Document, 24 May 2002*
- *Bio Energy Association of Sri Lanka (The Dendro Option for Future Energy Security of Sri Lanka)*
- *Energy Forum Publications'*
- *Practical Action Publications' and personal interview*
- *Ceylon Tobacco Company (2006) Presentation on Dendro Project to the Lanka Transformers Limited.*
- *Ceylon Tobacco Company (2002) Gliricidia Survey conducted by the Leaf Department.*
- *FAO, (2000) Options for Dendro Power in Asia: Report on the Expert Consultation, Regional Wood Energy Development Programme in Asia*
- *Energy Conservation Fund (2005) Report of the Inter Ministerial Working Committee on Dendro Thermal Technology*
- *Wickremasinghe, A. (2006) Gender and Energy Issues related to Sustainable Development: Sri Lanka, National Paper prepared for the UN Commission for Sustainable Development, May 2006*
- *A Socio-economic study on the Dendro Power Project at Umbalgamuwa, Walapane conducted for the Asia Pro Eco Programme by Hemanthi Ranasinghe*
- *CEB long-term generation expansion plan, Generation Planning Branch, Ceylon Electricity Board, Sri Lanka.*
- *Sustainable electricity system for Sri Lanka - Tyndall Centre for Climate Change Research*
- *Martinot, E., Chaurey, A., Lew, D., Moriera, J. and Wamokunya, N. (2002) "Renewable energy markets in developing countries", Annual Review of Energy and the Environment.*
- *SURVEY OF BATTERIES USED IN SOLAR HOME SYSTEMS IN SRI LANKA - Final Report Submitted to RERED Project, DFCC Bank*