

**GOVERNMENT OF SRI LANKA**

**UNITED NATIONS DEVELOPMENT PROGRAMME**

**Biomass Energy Development Project**

**Report of the Final Evaluation**

**January 2006**

**P. Balachandra  
Anoja Wickramasinghe**

## Table of Contents

Executive Summary	3
Introduction	10
Approach and Methodology	11
Project Concept and Design	11
Brief Descriptions of Sub-projects	13
Project Implementation	15
Project Milestones	17
Project Documentation	18
Project Expectations and Actual Outcomes	18
Findings	23
Recommendations	31
Lessons Learned	32
Annexure 1: Terms of Reference	34
Annexure 2: Persons Interviewed and Consulted	38
Annexure 3: Referred Documents	39

## **EXECUTIVE SUMMARY**

The final evaluation was carried out during 19<sup>th</sup> to 28 January 2006 (10 days) by a team of one international consultant and one national consultant. The evaluation was carried out in a participatory and consultative way. Review of documents, field visits, consultative meetings and interviews were made part of the evaluation process.

The present project on “Biomass Energy Development” funded by the United Nations Development Programme (UNDP) under Thematic Trust Fund (TTF) and implemented by the Ministry of Power and Energy (MOPE). This can be considered as a logical continuation of the earlier initiative on promoting biomass energy utilization through the GEF/UNDP funded project on Renewable Energy and Energy Capacity Building (REECB), which identified that further R&D is needed to challenge some of the prevailing misconceptions among stakeholders in the energy sector. Commonly, it has been considered that biomass energy is less cost effective, less efficient and of poor quality. Such misconceptions are also due to inadequate number of demonstrations carried out in Sri Lanka and very little awareness created among the investors and policy makers to move the concept forward as an economically viable enterprise and energy source. The present project was conceived to bridge this gap.

### **SUMMARY OF FINDINGS**

The project on “Biomass Energy Development” was funded under Thematic Trust Funds (TTF) on Energy for Sustainable Development. For this particular project, the funds provided by the government of Norway were used. Four thematic areas – (i) Thermal applications of biomass, (ii) Municipal waste gasification, (iii) Connecting private biomass plants to the national grid, and (iv) Information dissemination, were selected for implementation. Under these four themes, a total of nine sub-projects have been contracted to three agencies – Energy Conservation Fund, National Engineering Research and Development Centre and Energy Forum. The first two are government agencies and the third one is an NGO. Project implementation was planned, coordinated and controlled by the Project Management Committee (PMC). The PMC was headed by the national project director (secretary, MOPE). The national project manager (NPM) was responsible for all the implementation activities. The members of PMC included in addition to NPD and NPM, representatives from UNDP, all the participating agencies, a biomass specialist and some experts. The PMC had to put significant efforts to bring back the project into streamline and actually start the implementation. With all efforts, the project could begin only in September 2004. Participating agencies were identified, proposals for sub-projects were invited and contracts were awarded to in quick time.

It appears that the implementation of the project suffered because of long delay (17 months) in actual starting of the project from the date of approval. The project duration was in fact only one year. Further, there appears to be an attempt to complete as much as possible during the short period of three months before the deadline. This was because of uncertainty in getting the extension. One can expect serious implication of these on the quality of final outcomes of the project.

From an overall perspective, the deviation from the target outputs setout in the project proposal document by the revised targets and actual outcomes are not very significant. However, one may observe significant deviations in terms of indicative activities, scope of

the work, indicators of success and targeted stakeholders. It could be said that this deviation has resulted in dilution of the original intention of proposed project. Also, in terms of possible impact on the sustainability of biomass programme by the project in its present form is likely to be significantly less than if it had retained the original deliverables. The deviations are more visible with respect to the projects related to feasibility studies and information dissemination. The information dissemination efforts could not cover all the stakeholders as expected in the original proposal. Seminars alone could not become effective dissemination strategies. The feasibility studies focused on only some of the stakeholders.

## **PROJECT MANAGEMENT AND IMPLEMENTATION**

All the stakeholders performed their duties effectively and contributed to the success of the project.

### **MOPE's role**

- Actual implementation of the project got delayed significantly because of some happenings, which were beyond the control of both MOPE and UNDP. Change of government and resulting change of secretaries, partially contributed to the delay.
- Importance attached to this project by the secretary, MOPE can be gauged from his initiatives with regard to the recruitment of national project manager and biomass specialist. Realizing the possible delays in using government mechanism to appoint people for these positions, he requested the UNDP to take care of this responsibility. This resulted in at least partial make-up of the lost time.
- Secretary, MOPE was always available for guiding the project team.
- Even the current secretary of MOPE is very positive about the biomass energy programme. According to him, proposed power sector reforms in Sri Lanka can enhance demand for power from biomass, specially, as off-grid applications.

### **UNDP's role**

- Regularly participated in the project management meetings and contributed constructively to the completion of the project.
- Accepted additional responsibilities of recruiting national project manager and biomass specialist.
- Facilitated speedy awarding of the contracts for the sub-projects by actively involving in it.
- Involvement in continuous monitoring of the projects resulted in reasonable success in terms achieving the desired deliverables.
- Managing and coordinating such a project with so many sub-projects (many sub-activities) and many partners (and sub-partners) could pose a major challenge.

### **Project Management**

- Project management team was efficient and willing to spend significant amount of time for the project.
- According to the Ex. Secretary, MOPE, the NPM took significantly less amount as honorarium in relation to the sanctioned amount.
- The PMC meetings were frequent (fortnightly) during the crisis time.
- Project management team's attempts/efforts to complete all the projects in a short period of three months seems to be unrealistic. Project of this size cannot be completed in such a short time. It appears that these attempts have resulted in the

need for revising the original objectives significantly. This might have been the reason for deviations in actual outcomes and proposed deliverables.

### **Project implementation**

- It appears that the project implementers never planned for possibility of project getting the extension. Though they were aware of the fact that both MOPE and UNDP were putting serious efforts in getting the extension.
- Based on discussions with some of the implementing agencies, it seems that every one tried to finish the assignment somehow in time (before the deadline of November 2004).
- Finally, the project got extended till August 2005. The original plan of action and the need for revision might have resulted in some confusion.
- This has not affected the technology demonstration projects significantly. However, the feasibility studies have suffered because of this.
- Specially, the biomass supply feasibility study suffered because of this. Methodology and approach for a three months study will be entirely different from a one year study.
- The technology demonstration projects had installed the necessary equipments by the original deadline and used the extended period for demonstration, training, dissemination and documentation.
- Installation and demonstration of gasifier technologies for thermal applications in selected industries are the most important implementation outcomes.
- Efficient biomass feeder, wood chipper and biomass driers could be considered as the second most important outcomes.
- Feasibility studies on biomass supply for dendro power plant and for connecting a gasifier power plant to the grid formed third most important outcome.
- Other than these physical indicators, the project reports presented the details of implementation process.

### **RECOMMENDATIONS**

The project as a whole could be termed as a reasonably successful project considering the actual outcomes. Though one could observe deviations from the originally proposed deliverables and the actual outputs, the reasons for this were beyond the control of project management committee and the implementation agencies. Sub-projects carried out under the main project could demonstrate technological capabilities of biomass energy technologies (gasifiers, dryers) for thermal applications quite successfully. This was the most important expected deliverable of the project. Second set of technologies demonstrated successfully was related to biomass preparation (wood chipper for preparing properly sized wood pieces for gasifiers) and feeding system (an innovative screw feeder to regulate biomass feeding to the furnace) to improve the efficiency of biomass utilization. Now the most important question would be what is next? How these technologies could be spread to fellow industries? How to disseminate the knowledge thus gained? How to move forward from mere demonstration to replication? How biomass energy can make significant contribution to the energy system in a sustainable manner? The following are some of the recommendations, which might provide solutions to the above challenges if implemented.

- Biomass energy is not just a solution for the energy problems. Whole supply chain of biomass energy can provide livelihood options to many? Biomass energy plantations could earn additional income to the farmers and villagers, cutting and transportation can provide additional employment opportunities, biomass chipping

can provide entrepreneurship and employment opportunities, biomass gasifier plants could again provide entrepreneurship and employment avenues, increased access to modern energy carriers can result in many productive livelihood alternatives. These multiple benefits of biomass energy need to be emphasized, assessed and disseminated;

- Considering the above, biomass energy development need to be integrated into the mainstream national development goal;
- Integration of biomass energy development into other sectors such as agriculture/land management, rural development to enhance and to ensure the regular supply of raw materials for energy plants;
- Involving private sector and financial institutions are very important for sustainable replication of biomass energy technologies. There may be a danger of grant based free technology demonstration ending with demonstration itself. Implementations with end-user contributions, soft loans and performance related incentives could result in more diffusion.
- Target oriented training programmes to build local skills in installing and operating biomass energy plants (barefoot engineers).
- Information dissemination and awareness creation programmes need to be focused and capable of delivering the message that biomass alternatives are affordable, modern, easy to handle and saves money.
- Coordination mechanism to involve all parties interested in designing, developing, establishing and promoting technologies;
- Close linkages among stakeholders – industry/consumer, private sector, finance institutions, facilitators and end-users;
- Promotion of small and medium scale industry and means to recover the investment on technology should be introduced as integrated elements;
- Technology transfer/extension need to be accommodated as the second phase of the project by allocating financial resources for integration and scaling up with a full evaluation of the socio-economic impacts of biomass energy development.

Now more as observations rather than recommendations, some issues with respect to the project implementation.

- Implementation of the project activities started with substantial delay and the dead line for completion was just three away. At this stage, the best strategy could have been to continue to implement activities as a one year project rather than attempting to complete every thing in three months. It could be observed that this has resulted in the dilution of expected deliverables in most of the projects.
- Out of the nine sub-projects, seven have been awarded to the government agencies and two to an NGO. Since sustainable deployment of bioenergy technologies needs private sector involvement, awarding couple of projects to the private sector agencies could have resulted in additional learnings.

## **LESSONS LEARNED**

- Proactive and committed leadership is required to sail through difficult situations. Even with inordinate delays, uncertainty with regard to extension and too many participating agencies, the project was able to deliver most of the targeted outputs.

- UNDP's willingness to lend a helping hand at testing times contributed to the success of the project. This has helped greatly in appointing project management team, monitoring and evaluation and getting the desired extension.
- The need for technology development and demonstration has been justified based on assessed needs for promoting technology from the perspectives of state agency – the energy suppliers, and quality of output and energy/environmental benefits.
- Committed, progressive, innovative and risk taking entrepreneurs are required for installing and testing the new technologies. The implementing agencies have been fortunate to identify such willing partners for the technology demonstration.
- The institutions engaged in technology development have successfully completed their tasks and proved their capacity in producing technology and demonstrating them.
- Opportunities are needed for replicating the acquired institutional capacity. Demand for technology could be realized through an extension and this could provide an enabling opportunity for further addressing the drawbacks. Success of these developments is limited to piloting. Many of them provide practical demonstration for modern biomass technology options.
- As a follow up, a promotional strategy should be introduced. There is wide range of potential benefits in using biomass energy technology in agro-processing/drying. For example, the unit installed for drying pepper, with further improvements, could be promoted as a multi-functional unit, enabling the end user to use it for cooking, drying vegetables, fruit, and other spices like cloves, cardamom, cocoa etc.
- The outcomes could be taken as nine completed cases for demonstration, further work is needed for promotion, exploring the possible end users, social acceptability, contribution to economic advancement, financing arrangements to realize the ultimate goal of promoting biomass energy for enhancing efficiency and productivity.

In conclusion, we would like to state that there is a strong need for developing a national level strategy for sustainable exploitation of biomass energy resources, development and deployment of biomass energy technologies, and creation of an effective mechanism for technology diffusion and information dissemination. The framework of implementation needs to involve all the stakeholders from government, NGOs, private sector, academic institutions, community organizations, financial institutions, etc.

## Acronyms

AED	Alternative Energy Division
CEB	Ceylon Electricity Board
CO	Country Office
ECF	Energy Conservation Fund
GEF	Global Environment Facility
ITI	Industrial Technology Institute
MOPE	Ministry of Power and Energy
MOST	Ministry of Science and Technology
NERD Centre	National Engineering Research and Development Centre
NEX	National Execution
NGO	Non-Governmental Organization
NPD	National Project Director
NPM	National Project Manager
PMC	Project Management Committee
R&D	Research and Development
REECB	Renewable Energy & Energy Capacity Building
RERED	Renewable Energy for Rural Energy Development
TA	Technical Assistance

## **Acknowledgement**

We are happy to state that we have completed successfully the evaluation of the project on Biomass Energy Development. Though we claim to be the authors of this evaluation report, the contributors are many. We have received contributions in the form of ideas, suggestions, information and consultations. We would like to place on record our heartfelt gratitude to all of them.

First, we would like to thank the management of UNDP and particularly Ms. Darshani De Silva who was responsible for every thing, for all the support extended towards us. Also, we express our thanks to Ms. Judith Vannithamby for all the help.

Mr. M.M.C. Ferdinando, Secretary, Ministry of Power and Energy, and Mr. P. Weerahandi Secretary, Ministry of Housing Development, despite their busy schedules spent considerable time discussing with us. We express our gratefulness to them.

We acknowledge the inputs provided by both Mr. Liyanaratchchi and Mr. P.G. Joseph and we thank them for that.

The evaluation report has greatly benefited from the inputs provided by the representatives of various implementing agencies, namely, Mr. Harsha Wickramasinghe, Ms. Irosha S. Kalugalage, Mr. Athula Jayathunga, Mr. H.A. Vimal Nadeera and Ms. Chamila Jayasekera from ECF; Mr. Asoka Abeygunawardana from Energy Forum and Mr. Munasinghe from NERDC. We thank all of them. The new insights gained during our field visits were immensely useful in developing the report. We thank Mr. Suriya Bandara, Mr. Tissa De Silva, Mr. Gayan, Mr. Azam, Mr. Tiwanka Wickramasinghe and Ms. Inoka Manthilaka for those inputs.

P. Balachandra  
Anoja Wickramasinghe

## **Evaluation Report of the Biomass Energy Development Project**

### **INTRODUCTION**

Sri Lanka depends on Biomass for most of its energy needs. As per the recent estimates, biomass accounts for 52% of the primary energy supplied. Household cooking is the major end-use accounting for about 76% of the biomass and the remaining 24% is used for thermal applications in industries. Further about 76% of the population depends on biomass for meeting most of its energy needs.

The energy consumption pattern indicates the importance of biomass in Sri Lanka (Table 1). However, this biomass is mostly used in a conventional and most inefficient way. Electricity generation in the country is heavily dependent on imported fossil fuel, which has put severe strain on export earnings. It has been estimated that the demand for electricity is growing at 9-10% rate annually. Strategically, Sri Lanka cannot expand power generation capacities relying heavily on imported fuel. It has to look for indigenous resources. In summary, two issues emerge:

- i. Improve efficiency of biomass use
- ii. Produce electricity through indigenous resources

Technologically, it has been proved beyond doubt that both are possible with using biomass. Technologies are available to convert biomass into modern energy carriers like electricity and gas as well as utilise it efficiently. Further, availability of biomass resources can be enhanced significantly in a sustainable manner by promoting fast growing energy plantations.

Table 1: National Final Energy Consumption

<b>Energy Carrier</b>	<b>Consumption (%)</b>
Biomass	56.8
Oil	34.3
LPG	2.2
Electricity	6.9

(Source: Sri Lanka Energy Balance 2003, ECF)

The present project on “Biomass Energy Development” funded by the United Nations Development Programme (UNDP) and implemented by the Ministry of Power and Energy (MOPE) is an important event in that direction. UNDP’s earlier initiative on promoting biomass energy utilization through the GEF/UNDP funded project on Renewable Energy and Energy Capacity Building (REECB) identified that further R&D is needed to challenge some of the prevailing misconceptions among stakeholders in the energy sector. Commonly, It has been considered that biomass energy is less cost effective, less efficient and of poor quality. Such misconceptions are also due to inadequate number of demonstrations carried out in Sri Lanka and very little awareness created among the investors and policy makers to move the concept forward as an economically viable enterprise and energy source. The present project has been conceived to bridge this gap.

The project has been completed successfully. This report presents in detail an attempt made to evaluate the project outcomes.

## **APPROACH AND METHODOLOGY**

The evaluation was carried out in 10 days by two consultants (one international and one national) hired by the UNDP, Colombo. The methodology of evaluation was arrived collaboratively by the UNDP and the consultants. Following methodology was used:

- A detailed review of relevant project documents (project reports, interim project documents with amendments made, project reviews (mid-term/final/TPR, donor-specific, etc);
- Brief discussions with the Senior Management and programme staff of UNDP;
- Interviews with representatives of participating organizations and stakeholders;
- Field visits to select key projects and interviewing concerned people; and
- Consultation meetings with MOPE officials and heads of participating organizations.

## **PROJECT CONCEPT AND DESIGN**

The project on “Biomass Energy Development” was funded under Thematic Trust Funds (TTF) on Energy for Sustainable Development. For this particular project, the funds provided by the government of Norway were used.

An earlier initiative of the UNDP, the REECB project had identified that the following areas need further research and development to move forward the biomass resources development activities in Sri Lanka.

- Assess the indigenous biomass thermal application technologies used in the process of drying of agricultural, industrial and consumer items in rural Sri Lanka and to improve their energy efficiency in order to reduce the pressure on forests and other biomass resources.
- Study the potential of indigenous biomass energy conversion technologies that can be used in Sri Lanka through a process of applied research aimed at achieving greater efficiency.
- Undertake selected pilot projects involving the industry to demonstrate the efficiency of the developed processes for potential industrial applications and thereafter commercialising the technologies.

To address these issues, the Government of Sri Lanka and UNDP Sri Lanka undertook this project under Thematic Trust Fund on Energy during 2003-2005. As a whole, the objectives of the project was to facilitate reduction of greenhouse gas emissions by expanding the use of efficient technologies in the utilization of biomass energy in public and private sectors, improve the understanding and feasibility of biomass development in isolated locations and provide training in new skills to potential biomass developers, encourage R&D by applying gasification technologies customised to Sri Lankan conditions to promote biomass energy as an engine for economic development. Considering these, four thematic areas were identified for implementation:

### *i. Thermal application of biomass*

The main objective of this component was to improve thermal efficiency of existing biomass energy conversion technologies in tea, brick, spice, and tile-drying industry. These industries had been identified as the leading consumers of fuel wood for energy in the country.

In practice, residues from agriculture and forestry are the resources most frequently exploited. This is due to other biomass resources usually having alternative uses offering

higher added value and residues may often be found in large amounts at some particular place. It is noteworthy to mention that agricultural wastes in Sri Lanka at present are creating environmental hazards. Waste products from saw mills and rice processing mills are dumped in local neighbourhoods with no accepted procedures of disposal. By strengthening R&D, the project is expected to contribute to cleaning of the environment, and at the same time, derive energy available in such waste material for power generation and thermal applications. The project is expected to support R&D on kilns in the brick & tile and lime industries to allow utilization of agricultural waste such as paddy husks and saw dust as fuel. This component focuses the promotion of chipped wood manufacturing and distribution at commercial level.

*ii. Municipal waste gasification*

There is scope for disposing municipal wastes through recycling and gasification. Dispose of solid wastes in sanitary landfills and recovery of gaseous fuel is already utilized in rural communities, although not generated at an industrial scale. The project will be studying the feasibility of using smaller and medium size biomass gasifier systems for efficient thermal applications for municipal waste as apposed to biogas generation. Large gasification equipment will be made available soon from REECB project installed in NERD Centre for initial testing.

*iii. Connecting private biomass plants to the national grid*

A study is proposed to identify the institutional, financial and technological possibilities and implications of connecting private biomass plants to the national grid feeding into the Governments' renewable energy strategy. The study would focus on institutional and financial requirements for allowing and supporting sale of biomass resource-generated electricity to the grid.

In order to guarantee operation of a biomass power plant, biomass supply needs to be stable and predictable. A problem that is prevailing in Sri Lanka is that the market for biomass energy is not yet developed; therefore competitive uses still play an important role. While energy plantations are known to be feasible, so far they have not been demonstrated successfully on a large scale. This has mainly been attributed to the reluctance of interested parties to take any risks of piloting such plantations. However, dendro-energy plantations can provide an interesting option for reclamation of degraded land, and seeking the possibility of obtaining revenue from Certified Emission Reductions (CERs) of GHGs may help to make energy plantations viable in the near future. Under the policy of providing basic human energy needs, the development of commercialized fuel wood plantations and associated industry has been identified. A pilot activity to study the feasibility of developing dedicated plantations to grow and harvest fuel-wood plant; *Gliricidia sepium* in a degraded land to feed into a proposed grid-connected biomass plant will be carried out.

*iv. Information dissemination*

The project was expected to promote extensive partnership strategy for an effective implementation of project activities. It was supposed to work in close collaboration with various government agencies, research institutions, NGOs, etc., including CEB, NERD Centre, ECF and Energy Forum to achieve the main outcome. It would also give opportunities for interested individuals and other organizations in the sector to incorporate their inputs into this project during the implementing stage of the project, especially in the

---

<sup>b</sup> *Gliricidia sepium* has been identified as the best species for fuel wood production for biomass plants.

promotional activities. Involvement of the private sector in adopting the technology and promoting it as an income generating activity was to be encouraged and supported through the project.

Under these four themes, a total of nine sub-projects have been contracted to various agencies.

## **BRIEF DESCRIPTIONS OF SUB-PROJECTS**

### *1. Study and Document Different Technological Options for using Biomass as Fuel in Lime Industry*

This is a pilot project started at Digana, Kandy with the objective of developing improved biomass technology for rural industry, for lime kilning. Project has been undertaken by the Energy Conservation Fund (ECF) and implemented at Suriya Lime Kiln. Producer gas technology has been adopted for production efficiency, energy efficiency and for cost reduction. In the long run it is expected to promote and replicate the technology as a means to address the problems of closing down of lime kilns, as has been identified the Industrial Development Board, due to fuelwood scarcities.

Gasifier has been designed to use the locally produced non-forest species – *Gliricidia sepium*. This enables to replace wood logs enabling the entrepreneur to use gliricidia sticks which are obtained from the farmers through the suppliers.

Project has been completed successfully and the gasifier is in use by the entrepreneur. The factory also has two other kilns – the traditional kiln and ITI modified kiln located at the same site.

### *2. Biomass Gasifier for Brass melting*

This is a pilot project implemented by Energy Conservation fund in collaboration with ‘Nuwan Brass Industry’ with the interest of promoting improved biomass technology for rural industries. This has been established in a traditional craft village in Pilimathalawa where the livelihood of the people depends heavily on brass craft. It is expected to promote the improved energy technology – gasification among other entrepreneurs engaged in the industry.

### *3. Thermal Efficiency Improvement in Biomass Conversion Technology in the Tea Industry of Sri Lanka*

This pilot project has been implemented by NERDC in collaboration with Dean Side Tea Factory in Gampola. Expected improvement of the project is the automation of the screw feeding system for controlling the feeding of fuelwood in the furnace. The owner’s interest in improving the technology has enabled to make this intervention in collaboration with private sector. Project has been completed and monitoring is done to evaluate the benefits.

### *4. Development of Solar Assisted Biomass Energy Based Dryers for Small Scale Spices Drying in Sri Lanka*

This project has been undertaken by ECF. A biomass energy based dryer has been developed by The Department of Mechanical Engineering of the University of Moratuwa. Technology is rather simple and has been developed at relatively low cost. The dryer has been installed in Wasanagama in the Badulla District in 2005. It is used for paper drying. It

has the capacity to dry around 50 kilograms per day. The technology is rather simple and heat generated in the woodstove is transferred to the inlet air of the drying chamber.

*5. Feasibility of using biomass gasifier system for efficient thermal application on Municipal Waste Gasification*

This project has been introduced with dual objectives, for efficient management of solid waste produced in the urban areas, and also to introduce improved biomass energy technology- gasifier for energy generation. This is a pilot project undertaken by the Energy Forum and implemented by one scientist. It is designed to make use of the king coconut husks through gasification and in three types of improved stoves. It has been tested on single-burner clay cooker, ‘husk stoves-kudu lipa’ and on NERDC cooker. Pilot project has been implemented in Dehiwala, Kotte and Kasbewa.

*6. Identification of Opportunities and Implications of Connecting Private Biomass Power Plant to the National Grid*

This project has been designed to identify the institutional, financial and technical requirements for connecting biomass based power generation to the national grid. This has been undertaken by NERDC and a 100kWe biomass gasifier based power plant has been installed at NERDC. It has carried out this pilot operation. The technical and institutional issues to be followed with respect to grid connection have been discussed. The scope of the project also includes design, development and fabrication of grid paralleling system and grid connection of 100 kWe biomass gasifier based power plant. The project delves on major issues to be addressed, government agencies to be contacted, guidelines to be followed, application/evaluation/interconnection procedures to be followed, design of protection system, and obtaining environmental clearance. Finally, demonstration of this is done through connecting the 100 kWe system at NERD center to the grid.

*7. Development of Pilot Fuelwood Plantation*

This is basically a feasibility study undertaken by the Energy Forum. Feasibility study has been conducted in Meegahakiula and Soranatota G.N. Divisions in Badulla. The initial objective was to identify sites/location for establish energy plantation and location for dendro power plant. In terms of technology the project has been developed with the interest of promoting dendro energy development in rural areas. In this regard a questionnaire survey has been conducted. As a follow up action the Energy Forum has undertaken awareness raising and training in respective areas.

*8. Cost Efficiency of Chipped Wood and Promotion of its Distribution*

This project has introduced technology for chipping to improve thermal energy application process. Chipping is essential for power generation applications and for even feeding for gasifiers. Wood chipping machines have been developed for three applications – power generation, industrial thermal applications and wood chipping for cook stoves. The implementing agency – ECF has involved in designing and trial testing of three models.

*9. Dissemination of information on Biomass Energy Development and Investment Opportunities*

Energy Conservation Fund has implemented the project on information dissemination. In this regard it has produce to pamphlets and video. Both pamphlets specifically mention the possible development of modern energy technology and its adoption for productive activities. Efficiency use of biomass energy in rural industries is discussed. Pamphlets on new strength of rural living and plant and energy disseminate the information in modern

energy technology for rural industries. Several examples are also given. In addition, potentials for growing gliricedia on non-forest lands through a process of integration is also demonstrated. A demonstration video has been developed covering all the aspects related to energy plantations and biomass power development. In addition, photographs, and case studies have been developed to present the experience and achievements.

## **PROJECT IMPLEMENTATION**

Following are the stakeholders of the project as donors, coordinators, implementers, contributors and beneficiaries.

Donor Agency: UNDP-Sri Lanka under thematic trust fund for energy.

National Agencies:

1. Ministry of Power and Energy;
2. Ministry of Science and Technology; and
3. Ministry of Environment and Natural Resources.

Implementing Agencies:

1. ECF;
2. NERDC;
3. Energy Forum (NGO);

Other Stakeholders:

1. Lanka Transformer Ltd.;
2. Ener-Fab Private Ltd.;
3. Provincial/District/Divisional Secretariats;
4. University of Moratuwa;
5. Entrepreneurs;
6. Manufacturers;
7. Farmers; and
8. Traders/suppliers

The project was implemented under the National Execution (NEX) modality and in accordance with the UNDP NEX Guidelines. This project was also considered as a supplementary activity of the REECB project and therefore it was executed through the Ministry of Power & Energy (MOPE). The Secretary of the MOPE had the overall responsibility of the execution of the project as National Project Director (NPD), and served as the focal point for the coordination with other involved parties including CEB, NERD Centre, ECF and Energy Forum. The executing agency had ensured that all partners, UNDP Colombo and the GoSL were part of the major decision-making processes.

A Project Management Committee (PMC) was constituted for coordinating team with responsibility of facilitating the implementation and monitoring the Project activities on a regular basis and undertook the responsibilities outlined in the NEX-guidelines. The members of the Committee were the NPD, the National Project Manager (NPM), biomass energy specialist, and representatives from UNDP, CEB, NERD Centre, ECF and Energy Forum. The daily management of the Programme was carried out by the NPM under the guidance of the NPD. NPM was responsible of producing the overall work plan, quarterly work plans, quarterly progress reports and the final progress report. He was required to liaise with NPD and other project partners in producing these documents and outputs of the project in time. Standard monitoring and evaluation functions were carried out by UNDP, Colombo.

The project implementation agencies were Energy Conservation Fund, National Engineering Research and Development Centre and Energy Forum. The first two are government agencies and the third one is an NGO. Table 2 contains project-agency matching information.

Table 2: Details of Sub-projects and Implementing Agencies

<b>No.</b>	<b>Project Title</b>	<b>Implementing Agency</b>	<b>Focus area</b>
01	Study and Document Different Technological Options for Using Biomass as Fuel in Lime Industry	Energy Conservation Fund (ECF) of Ministry of Power & Energy (MOPE)	Dendro Thermal Energy Increase Productivity Reduce Poverty
02	Biomass Gasifier for Brass Melting.	Energy Conservation Fund of Ministry of Power & Energy	Energy for village industry
03	Thermal Efficiency Improvement in Biomass Conversion Technology in the Tea Industry of Sri Lanka	National Engineering Research and Development Centre (NERDC)	Combustion efficiency in Tea Industry
04	Development of Solar Assisted Biomass Energy Based Dryers for Small Scale Spices Drying in Sri Lanka	Energy Conservation Fund of Ministry of Power & Energy	Small scale spices drying
05	Feasibility of Using Biomass Gasifier System for Efficient Thermal Application on Municipal Waste Gasification	Energy Forum	Gasification of urban waste
06	Identification of Opportunities and Implications of Connecting Private Biomass Power Plant to the National Grid	National Engineering Research and Development Centre (NERDC)	Power generation for national grid.
07	Development of Pilot Fuelwood Plantation	Energy Forum	Energy plantation for energy plant
08	Cost Efficiency of Chipped Wood and Promotion of its Distribution	Energy Conservation Fund of Ministry of Power & Energy	Chipping technology
09	Dissemination of Information on Biomass Energy Development and Investment Opportunities	Energy Conservation Fund Ministry of Power & Energy	Information dissemination

## PROJECT MILESTONES

This section chronologically presents the project milestones starting from project initiation to the completion.

- May 2002 – Initial project proposal was submitted
- June 2002 – UNDP headquarters recommends the proposal for funding under Thematic Trust Fund (TTF). Initially, the funding was supposed to be through OPEC funds to TTF on Energy for sustainable development. However, OPEC fund did not approve this proposal. Finally, the project got approved through Norway contribution to TTF.
- April 2003 – The project got TTF funding support from Norway contributions
- May 2003 – Project implementation was initiated with a communication to the Secretary, Ministry of Power and Energy (MOPE)
- June 2003 – First meeting at MOPE to plan the implementation of the project. Dr. V.U. Ratnayake was requested to develop the detailed project document
- December 2003 – Project got the approval from the government
- January 2004 – Expected commencement of the project
- February 2004 – MOPE agreed to recruit the National Project Manager (NPM)
- July 2004 – Mr. P. Liyanarachchi was appointed as NPM by the ministry
- July 2004 – The first meeting Project Management Committee took place on 23 July 2004.
- August 2004 – Participating organizations for contracting the sub-projects were identified. Three organizations Energy Conservation Fund (ECF), National Engineering Research and Development Centre (NERD) and Energy Forum were identified. Out of the three, the first two are government organizations and the third one is an NGO. Also, during this period the sub-projects were awarded to these agencies.
- August 2004 – Biomass energy specialist Mr. P.G. Joseph was inducted into the project management team.
- September 2004 – Project implementation started and was expected to complete by November 30, 2004.
- August 2004 – November 2004 – A total eight project management committee meetings were held on a fortnightly basis. The meetings were frequent during this period mainly to quicken the speed of project implementation and attempt to bring the process into streamline. There was inordinate delay in starting the implementation process and dead line for completion was November 30.
- 14 September 2004 – Request for extension of the period of implementation beyond 30<sup>th</sup> November 2004 submitted to UNDP (Resident Representative).
- 24 September 2004 – Letter supporting extension of the project from Department of External Resources was sent.
- November 2004 – Project got extension till August 31, 2005.
- December 2004 – August 2005 – 10 more project management committee meetings were held to regularly review the progress of implementation. The frequency of meetings reduced to monthly meetings because the process project implementation was found to be on the expected lines.
- August 31, 2005 – Submission of final reports to the MOPE.

It appears from the above that the implementation of project suffered because of long delay (17 months) in actual starting of the project from the date of approval. The project duration was in fact only one year. Further, there appears to be an attempt to complete as much as possible during the short period of three months before the deadline. This was because of uncertainty in getting the extension. One can expect serious implication of these on the quality of final outcomes of the project.

### **PROJECT DOCUMENTATION**

The project on Biomass energy development targeted two kinds of output – (i) technology development, deployment and demonstration and (ii) Documentation detailing all the efforts and analysis of various performance measures. Following were the outcome of documentation efforts:

- Final and interim project reports
- Dissemination booklets, brochures and videos
- Minutes of the programme committee meetings
- Progress reports – Descriptive and on percentage basis

### **PROJECT EXPECTATIONS AND ACTUAL OUTCOMES**

Table 3 presents the expected deliverables, indicated activities needed to perform to obtain the desired outcomes and remarks on actually performed activities. On the other hand, Table 4 presents the titles of sub-projects actually implemented, revised expected outputs and delivered outputs. From an overall perspective, the deviation from the target outputs set out in the project proposal document by the revised targets and actual outcomes are not very significant. However, one may observe significant deviations in terms of indicative activities, scope of the work, indicators of success and targeted stakeholders. It could be said that this deviation has resulted in dilution of the original intention of proposed project. Also, in terms of possible impact on the sustainability of biomass programme by the project in its present form is likely to be significantly less than if it had retained the original deliverables. The deviations are more visible with respect to the projects related to feasibility studies and information dissemination.

The information dissemination efforts could not cover all the stakeholders as expected in the original proposal. Seminars alone could not become effective dissemination strategies. The feasibility studies focused on only some of the stakeholders.

Table 3: Deliverables and Activities as per the original Proposal

<b>Intended Outputs</b>	<b>Indicative Activities</b>	<b>Remarks</b>
<p>1.1 Thermal efficiency of biomass energy conversion technologies in selected industries (tea, brick, spice and tile) improved and feasibility of using thermal applications in agricultural sector tested</p> <p>Indicator – Technology developed in 2 R&amp;D institutions</p> <p>1.2 Energy efficient biomass resources identified for application</p> <p>Indicator – Information gathered and disseminated from at least 5-10 industries and agricultural practices that generates biomass as byproducts</p> <p>1.3 Cost efficient chipped wood manufacturing and distribution promoted</p> <p>Indicator – One wood chipper designed and introduced to 10 local investors</p>	<p>1.1.1 Develop technology for pre-treating the raw material for biomass energy conversion through the preparation of saw dust and paddy husk for feeding the gasifiers for industrial thermal application testing</p> <p>1.1.2 Study and document different technological options for the utilization of biomass as a fuel</p> <p>1.1.3 Detailed characterization of wood residues from saw mills and carpentry industry and their applications</p> <p>1.1.4 Test the feasibility of agricultural product processing for spice and vegetable drying to be introduced for commercialization</p> <p>1.2.1 Study of suitable biomass resources from industrial and agricultural sectors, documentation and dissemination of information</p> <p>1.3.1 Design a wood chipper to reduce the size of wood, particularly to improve free flow down the gasifier hullers</p> <p>1.3.2 One exhibition held to promote the newly designed wood chipper to potential investors</p>	<p>This activity was not performed</p> <p>Successfully developed and demonstrated gasifiers for thermal application in a lime kiln and brass melting unit. Activity 1.1.3 was not performed.</p> <p>Completed successfully</p>      <p>Completed successfully</p> <p>Completed successfully</p>
<p>2.1 Feasibility of using biomass gasifier systems for efficient thermal applications for municipal waste studied</p> <p>Indicator – At least 2 sizes of gasifier systems</p>	<p>2.1.1 carry out a feasibility study using various gasifier equipment (small and medium size) and document</p>	<p>Partially completed</p>

Evaluation of Biomass Energy Development Project – Report

tested		
<p>3.1 Opportunities and implications of connecting private biomass plants to the national grid identified</p> <p>Indicator – Requirements for the connection of private biomass-generated electricity documented</p> <p>3.2 A pilot fuel-wood plantation developed to be fed into a proposed grid-connected biomass plant</p> <p>Indicator – One large-scale fuel wood plantation initiated</p>	<p>3.1.1 Identify and document the institutional, financial and technological requirements for allowing and supplying sale of biomass-generated electricity to the national grid</p> <p>3.2.1 Suitable land selected for the plantations and the <i>G. sepium</i> grown for harvesting</p> <p>3.2.2 Carry out a feasibility study of piloting a large scale plantation and document</p>	<p>Completed successfully. Perspectives of other stakeholders are not considered (only government was included)</p> <p>A feasibility study report was produced.</p>
<p>4.1 Awareness raising targeting potential industries, commercial groups and other types of prospective end-users (local authorities, CSOs and communities) promoted</p> <p>Indicator – Awareness raised in 5 industries, 5 commercial groups, 10 CSOs, 25 selected local authorities and communities</p>	<p>4.1.1 A campaign to disseminate information gathered on the feasibility of biomass energy development and investment opportunities held</p>	<p>Partially completed. All the stakeholders were not involved.</p>

Table 4: Revised Deliverables and Actual Outputs

<b>Sl. No.</b>	<b>Name of the Sub-Project</b>	<b>Expected Output</b>	<b>Delivered Outputs</b>
1	Improving thermal efficiency of biomass energy conversion in Tea industry	To improve biomass energy conversion technologies in Tea industry by introducing chipped fuelwood with feed controlling instead of manual feeding. Designing, developing and testing of an automatically controlled system of feeding chips by sensing hot sir generated and testing the chipped wood firing system with feed control in a tea factory using biomass was also an objective of the subproject (Gliricedia pieces were used as fuel wood).	A screw feeder integrated with VSD and temperature sensor was installed in a tea factory. With Gliricedia chips as input a saving of 45% in fuelwood input was reported. Some of the advantages were good control of temperature, user friendly operation, less deposition of ash, temperature could be maintained during rainy days and environment friendly system.
2	Identification of opportunities and implications of connecting biomass plants to the national grid	Identify and document the institutional, financial and technological requirements for connecting the gasifier plant to the grid and allowing sale of biomass generated electricity to the national grid. It also included designing, development and fabrication of grid paralleling system and grid connection of 100 kW biomass gasifier based power plant.	Identification and documentation of all the issues including procedural issues with regard to a proposed grid connect biomass power plant has been completed. Documentation covered government agencies to be contacted, procedures for application, interconnection technical issues, environmental clearance and protection licenses, etc.
3	Study and document different technological options for utilizing biomass as a fuel for lime kiln	Study and identify the areas needing improvement and select the most efficient technology, construction and field testing a gasifier using biomass and provide recommendation after analyzing results.	A gasifier plant for supplying thermal energy to the lime kiln was installed. Chipped wood from Gliricedia plant was the input and a drier was installed to dry the wood chips. A report was prepared documenting the technical and benefit details of the system.
4	Test feasibility of agricultural product processing for vegetable and spice drying	Estimating the technical potential of biomass resources as a source of energy for drying of spices and characterization of different stove designs/technologies suitable for small scale drying application	A report comparing different drying technologies was prepared. A wood stove/dryer system based on Netherlands design was developed and demonstrated for pepper drying. The report also contains details of technical performance this down draught dryer.

5	Introduction of biomass gasification for Brass melting furnaces	To increase energy efficiency and improve the quality of the final product while preserving environmental aspects in brass melting industry by introducing biomass gasification system.	A biomass gasification system was installed as an alternative to the existing system in a brass melting unit. It was found that there was significant savings in energy consumption. Documentation giving details of technical performance and savings was submitted.
6	Manufacture of cost efficient wood chipper and promotion its distribution	Designing a wood chipper to reduce the size of wood to enable free flow to the gasifier hullers and organizing an exhibition and a seminar to promote the newly designed wood chipper among potential investors and users.	The ECF designed three models of wood chipper and manufactured these through three sub-contractors. A booklet giving the details was produced. ECF also held a seminar and an exhibition to popularize these wood chippers.
7	Developing a private fuelwood plantation to be fed into a proposed grid connected biomass plant	Selecting suitable land for the plantation of Gliricedia, carrying out a feasibility study for piloting large scale plantations and documenting the findings	The Energy Forum implemented this study. As deliverables, a project report was prepared containing details of short-listed sites for locating biomass gasifier based power plant, suitable crown land for biomass plantations and a list of farmers who are willing to supply fuelwood for the power plant.
8	Study the feasibility of using biomass gasifier systems for efficient thermal application of Municipal waste	To study the feasibility of collecting and processing King Coconut husks and use them as a fuel in biomass gasifier for thermal applications.	Energy Forum delivered 10 tonnes of dry King Coconut husks to gasifier plant. The process involved was collection, cutting to proper sizes, sun drying, testing and transportation. The report was submitted and established the fact that King Coconut husk is ideal for gasifiers.
9	Dissemination of information on biomass energy development and investment opportunities	Enhancement of awareness on efficient and sustainable way of production and utilization of biomass fuel.	The ECF implemented this dissemination activity. As reported by them, they conducted 24 seminar programmes for school teachers (2,935) and students (6,493). Seminars were also conducted for industrialists (381). Information booklets and videos as dissemination material were prepared. A demonstration model of a biomass power plant was developed.

## **FINDINGS**

### ***Government and the Ministry of Power and Energy***

Considering the limited indigenous energy resources in the country and over dependency on imported sources of energy, the government of Sri Lanka has a progressive approach to support initiatives in renewable energy. Biomass energy is considered to be the most important alternative to meet the electricity needs of the left-out section of people (20% of the households). This support to biomass energy can easily be comprehensible from the initiatives taken by the Ministry of Power and Energy (MOPE) in implementing the project. The secretary, MOPE had actively participated in the implementation of project as its national project director. According to MOPE's perception, the programme is successful and had achieved all the objectives. Following are some specific observations:

- Actual implementation of the project got delayed significantly because of some happenings, which were beyond the control of both MOPE and UNDP. Change of government and resulting change of secretaries partially contributed to the delay.
- Importance attached to this project by the secretary, MOPE can be gauged from his initiatives with regard to the recruitment of national project manager and biomass specialist. Realising the possible delays in using government mechanism to appoint people for these positions, he requested the UNDP to take care of this responsibility. This resulted in at least partial make-up of the lost time.
- Secretary, MOPE was always available for guiding the project team.
- Even the current secretary of MOPE is very positive about the biomass energy programme. According to him, proposed power sector reforms in Sri Lanka can enhance demand for power from biomass, specially, as off-grid applications.

### ***United Nations Development Programme (UNDP), Sri Lanka***

UNDP's role in this project is quite commendable. Based on the documents referred and discussions had with UNDP staff, one could conclude that it was UNDP's efforts that lead to bringing back the project, which was hampered by inordinate delays, into streamline. Willingly accepted additional responsibilities (MOPE could not handle because of government regulations related delays) basically to speedup the process of project implementation. Some of the important observations are:

- Regularly participated in the project management meetings and contributed constructively to the completion of the project.
- Accepted additional responsibilities of recruiting national project manager and biomass specialist.
- Facilitated speedy awarding of the contracts for the sub-projects by actively involving in it.
- Involvement in continuous monitoring of the projects resulted in reasonable success in terms achieving the desired deliverables.
- Managing and coordinating such a project with so many sub-projects (many sub-activities) and many partners (and sub-partners) could pose a major challenge.

### ***Project Management***

Project implementation was planned, coordinated and controlled by the Project Management Committee (PMC). The PMC was head by the national project director (secretary, MOPE). The national project manager (NPM) was responsible all the implementation activities. The members of PMC included in addition to NPD and NPM,

representatives from UNDP, all the participating agencies, a biomass specialist and some experts. The PMC had to put significant efforts to bring back the project into streamline and actually start the implementation. With all efforts, the project could begin only in September 2004 (please refer the section on milestones). Frequent meetings and consultations were common thing. The whole team was putting efforts to complete the project in three months (since the deadline was November 30, 2004). Participating agencies were identified, proposals for sub-projects were invited and contracts were awarded to in quick time. Some of the specific findings based on interviews and review of documentations are:

- Project management team was efficient and willing to spend significant amount of time for the project.
- According to the Ex. Secretary, MOPE, the NPM took significantly less amount as honorarium in relation to the sanctioned amount.
- The PMC meetings were frequent (fortnightly) during the crisis time.
- Project management team's attempts/efforts to complete all the projects in a short period of three months seems to be unrealistic. Project of this size cannot be completed in such a short time. It appears that these attempts have resulted in the need for revising the original objectives significantly. This might have been the reason for deviations in actual outcomes and proposed deliverables.

### ***Project Implementation***

The main participating agencies were NERD center, ECF and Energy Forum. A total of nine sub-projects were awarded to these agencies. However, these agencies further sub-contracted various project related activities to other agencies (University, Manufacturers) and individuals. This partially resulted in complicating the overall implementation process. Project implementation suffered to a certain extent because of too many participating agencies. Thus project implementation suffered on two counts –

- i. Attempting to complete the project in three months
- ii. Too many agencies involved in implementation

It appears, both of the above have contributed to the deviation from original focus and dilution of objectives to a certain extent. Some of the specific findings are:

- It appears that the project implementers never planned for possibility of project getting the extension. Though they were aware of the fact that both MOPE and UNDP were putting serious efforts in getting the extension.
- Based on discussions with some of the implementing agencies, it seems that every one tried to finish the assignment somehow in time (before the deadline of November 2004).
- Finally, the project got extended till August 2005. The original plan of action and the need for revision might have resulted in some confusion.
- This has not affected the technology demonstration projects significantly. However, the feasibility studies have suffered because of this.
- Specially, the biomass supply feasibility study suffered because of this. Methodology and approach for a three months study will be entirely different from a one year study.

- The technology demonstration projects had installed the necessary equipments by the original deadline and used the extended period for demonstration, training, dissemination and documentation.
- Installation and demonstration of gasifier technologies for thermal applications in selected industries are the most important implementation outcomes.
- Efficient biomass feeder, wood chipper and biomass driers could be considered as the second most important outcomes.
- Feasibility studies on biomass supply for dendro power plant and for connecting a gasifier power plant to the grid formed third most important outcomes.
- Other than these physical indicators, the project reports presented the details of implementation process.

### ***Project Documents***

#### *1. Study and Document Different Technological Options for using Biomass as Fuel in Lime Industry*

- Objective is to improve combustion efficiency and reduce in the fuelwood consumption;
- Improved quality of output – ash free lime and equally burned lime;
- Reduced harmful gas emission and reduced pressure on the environment due to reduced air pollution;
- Economic returns to farmers/ wood suppliers – cash for gliricedia wood;
- Local capacity building through training and awareness;
- Possible contribution to promote tree growing among rural farmers;
- This is simply a demonstration for the possible use of improved biomass energy technology in rural industries. Nevertheless the technology extension beyond piloting has not been the focus. It has been successful due to the availability of financial assistance/capacity of the interventionists. This does not guarantee the replication of the technology among lime producers. The total capital investment is extremely high and therefore the promotion of technology depends on the accessibility to financial sources;
- The financial benefits of the improved quality of lime are unknown to the entrepreneur. One of the objectives of producing better quality lime should be to give better returns to the entrepreneur. The gasifier-based kiln output also mixed up with the ash containing lime. Therefore the market opportunities for ash free lime needs to be explored and promoted through market channels to stimulate others as well; and
- The extended opportunities for gliricedia producers in the area should be integrated through agricultural extension system and linking up the energy base enterprise with farm production system.

#### *2. Biomass Gasifier for Brass melting*

- Objective is replacement of wood logs with small wood produced in the area;
- Health associated risks of using the gasifier system is not clearly indicated;
- Economic returns for the investments are not known;
- Biomass gasifier based thermal system was designed and developed for brass melting unit;
- Gliricedia wood chips are being used as a replacement for waste fossil fuels like lubricant oil, furnace oil and oil sludge (mixed with kerosene) in a furnace;

- With the introduction of gasifier, the specific fuel cost came down from about Rs. 3.35/kg of brass to Rs. 1.15/kg of brass; and
- It appears that there was a serious problem of increasing the temperature to the required level. ECF people could solve this problem ultimately.

### *3. Thermal Efficiency Improvement in Biomass Conversion Technology in the Tea Industry of Sri Lanka*

- Objective is to enhance efficiency and the capacity to use gliricedia wood in place of split wood logs;
- Reduced time needed for heating up and reduction in accumulation of ash and debris;
- Enhance capacity to linking up the industry with the communities through gliricedia suppliers/producers providing economic and environmental benefits for the local farmers;
- Reduction in cost of labour spent on splitting, stacking and processing large wood logs;
- The willingness of the private sector to adopt this technology for very narrow benefits is a question; and
- Financial gains of this improvement seem to be relatively low and as a result replication potential of the technology seems to be marginal.

### *4. Development of Solar Assisted Biomass Energy Based Dryers for Small Scale Spices Drying in Sri Lanka*

- Enhanced quality of pepper;
- Labour saving (sun drying needs around 5 days);
- Avoided damage due to inclement weather and thereby free of fungal infection;
- Ability to fetch a better price in the market;
- Possibility to use dryer for drying other crop harvests (cloves, cardamom, coffee, and cocoa and also for dehydrating vegetables and fruits);
- With relatively low training the dryer could be made locally using local raw materials;
- High potential for promoting the dryer as a multi-functional unit with slight improvements enabling women to cook family meals using the heat released in combustion zone;
- The low cost indicates the possibility of promoting it in areas requiring such technology to avoid destructions related to rain and moisture by the producers as well as the traders;
- This could be promoted as a means to enhance farm income through agro-processing;
- Wider adoption and application requires promotion through extension and awareness raising; and
- Lack of integrated mechanism seems to impede the promotion of technology.

### *5. Feasibility of using biomass gasifier system for efficient thermal application on Municipal Waste Gasification*

- Efficient use of urban waste in energy generation has been demonstrated focusing heavily on its usage in cooking;
- It has also demonstrated the need for involving/collaborating with various parties to make this project a success;

- Gasification of dried coconut husk is a new technology that has evinced interest in people working in the area of modern biomass energy technology;
- Lack of collaboration among various groups including scientists, energy entrepreneurs, municipalities and vendors impede the replication of technology;
- Interest in using solid waste as a source of energy for cooking has not been promoted simultaneously;
- Replacement cost of fuelwood needs to be assessed in terms of human energy cost/opportunity cost; and
- Public demand for technology intervention has not been re-examined and as a result it is limited to experimentation.

#### *6. Identification of Opportunities and Implications of Connecting Private Biomass Power Plant to the National Grid*

- The report documents the need for biomass power generation in Sri Lanka;
- The clearance procedure discussed in the report is quite useful to private energy entrepreneurs;
- Contributes to raise awareness on the technology, institutional procedures in grid connection;
- Technical arrangements made to connect the biomass gasifier system to the grid are discussed;
- Major part of the report is devoted to describe the kind of clearances need to be obtained, procedures need to be followed and agencies need to be contacted. This document can be a ready reference for any prospective entrepreneur who wish to setup a grid connected power plant;
- Though this is an important contribution, the project, it appears, has not addressed issues related institutional and financial requirements. Focus was only on government institutions. Financial arrangements for capital and operational cost are not addressed and
- It would have been a good deliverable, if the project had focused on a “private sector entrepreneur” who wish to setup a grid connected biomass gasifier power plant. The issues that could have been included are technical (generation and connectivity), economic feasibility, biomass supply chain, financial arrangements, institutional (procedures, clearances, regulations), and pricing.

#### *7. Development of Pilot Fuelwood Plantation*

- A detailed report on feasibility study was prepared;
- Local government officials were taken into confidence and got assurance for supporting the initiative;
- A questionnaire based survey involving sample of 83 farmers was conducted to seek their perceptions on establishing energy plantations;
- Further meetings with farmer leaders, agricultural extension officers and farmers were organized to assess the extent of land available;
- Field visits were conducted and three potential sites for locating power plants were identified;
- Both potential land availability and possible number of Gliricedia trees were estimated;
- According to the project document, the currently available resources can support a Dendro power plant of the size 2 MW and with additional plantations this can go up to 11 MW;

- Cost-benefit analysis has been performed but not in a rigorous way. System-wide assessment is not made;
- Integration of supply chain of biomass and life cycle assessment of power plant could have been a better method of feasibility study;
- Biomass needs assessment from Dendro power plant point of view is not performed in detail;
- Economic analysis of Dendro power is not clear. It is not clear whether the analysis has been done for gasifier or combustion technology;
- Institutional mechanism has not been presented – Roles, responsibilities, type of institutions, financing, etc;
- Financing details of the whole system is missing;
- Linkages with stakeholders (private sector, state agencies, and NGO); and
- Since there has been no activities related to technology development and establishment this has very insignificant impact on biomass energy development; and

8. *Cost Efficiency of Chipped Wood and Promotion of its Distribution*

- Technology for saving labour/cost and reducing occupational risks;
- Enhanced combustion efficiency;
- Possibility uniform feeding;
- Employment and income generation; and
- Mechanization of processing and enhanced industrial application.

9. *Dissemination of information on Biomass Energy Development and Investment Opportunities*

- Stimulation of interest;
- Dissemination of information on technology;
- Economic benefits of biomass energy development.
- Target groups are not clearly specified;
- Public awareness; and
- Social contribution for scaling up.

Overall situation indicates that all nine sub-projects have been implemented, and there are differences in their objectives, status achievements.

All sub-projects have been implemented through the technical institutions. Where do we go from here with this technology is an unanswered question. Who would be the key stakeholders in promoting/extension? The potentials of the technology are multiple and could be replicated only if the replicating mechanisms are explored and information on potential uses and contributions goes to the parties who have an interest in adopting them.

Table 5: Summary of Project Status

#	Sub-project	Status	Requirement
01	Biomass gasifier in lime industry	Off the ground	Require technology transfer/extension
02	Biomass gasifier in brass melting	Off the ground	Require technology transfer/extension
03	Improving thermal efficiency in tea processing	Off the ground	Require technology transfer/extension
04	Agro-processing/drying	Off the ground	Require technology transfer/extension
05	Biomass gasifier on municipal waste	Experiment	?
06	Private biomass plant to national grid	Experiment	Require technology transfer/extension
07	Fuelwood plantation	Research	?
08	Wood chipper	Off the ground	Require technology transfer/extension
09	Dissemination of information	Off the ground	Require technology transfer/extension

### **Field Visits**

(i) *Study and Document Different Technological Options for using Biomass as Fuel in Lime Industry – Visit to a Lime Factory*

Had a meeting with the owner of the factory Mr. Suriya Bandara and Mr. Harsha Wickramasinghe of ECF. Following issues emerged during the discussions:

- The gasifier was installed six months ago to supply required thermal energy to the existing lime kiln. Chipped and dried pieces of Gliricedia plant forms the input to the gasifier. A drier was added to the system to dry the chipped wood to the required dryness (heat is supplied from the gasifier).
- The owner of the factory is innovative and has willingness to experiment. He is the only one in this sector, who has installed modern and efficient lime kilns. This made the task of ECF easy in convincing him in installing a gasifier and also possible and smooth operation of the plant in future can be guaranteed.
- Gasifier integrated lime kiln produces pure and white lime and the customers do not perceive this as a high quality product. They are used to contaminated lime (lime plus ash). Thus the white lime though good does not command high price. The factory is forced to mix this lime with coloured lime to satisfy the customer. This might act as a barrier to the spread of this technology. An attempt to change the behaviour of end-users are required to remove this barrier.
- There is a mismatch between gasifier and kiln capacity. Gasifier produces more energy than required. There is a plan to link the gasifier to other kiln in the premises.
- The system is six months old and still the training phase (on the job) is going on.
- Replication possibilities are not very high. Private sector and individual initiatives are required and there will be attempts to explore soft-loan approaches.
- Adopting to higher rate of production is a challenge and owner involvement is essential

- Still at pilot stage and popularization and dissemination is yet to take place. Technology is proven and functioning effectively.
  - Operation and maintenance is yet to be planned in terms of cost and responsibility. Replacement of shorter life and expensive equipments is critical for the survival of the gasifier.
  - Owner perceives the gasifier system consumes more wood compared to other kilns. Mismatch of capacity between gasifier and kiln may be the reason for this.
- (ii) *Thermal Efficiency Improvement in Biomass Conversion Technology in the Tea Industry of Sri Lanka – Visit to a Tea factory*
- Objective is to improve the combustion efficiency and demonstrate the use of wood chips from abundantly available *Gliricidia*.
  - Innovation is in terms of an attachment of “Screw Feeder” to control the rate of wood feeding to the existing furnace. In addition a motor with variable speed drive controller and a temperature sensor is included.
  - Ash produced is very low and system requires daily cleaning.
  - The system is functioning is for the past one year.
  - The owner is a progressive and motivated entrepreneur. His is the only Tea factory in Sri Lanka which has variable speed drive motors. This has resulted in a saving of 40% of electricity consumption. He has willingness to install more of such units.
  - Technology is proven and able to identify four more entrepreneurs who are willing to invest in this technology.
- (iii) *Development of Solar Assisted Biomass Energy Based Dryers for Small Scale Spices Drying in Sri Lanka - Visit to University of Moratuwa*
- Efficient wood stove (original design is from Eindhoven University of Technology, Netherlands) integrated with a dryer (five trays) is the system developed.
  - Field testing cum demonstration was carried out in a village Vasana Gama, Badulla District for pepper drying.
  - Critical to replication is the cost of drying of Rs. 12/kg of pepper compared zero cost for sun drying. This can act as a barrier.
  - Another barrier could be the use of 400Watt blower for heat exchanger requiring expenses on electricity, which the people do not want.
  - This can be easily overcome by redesigning the dryer by integrating the wood stove and drier in a single unit, and avoiding the heat exchanger. However, additional funding is required.
  - Advantage of this system is quick drying, independent of weather, no smoke and no contamination. However, pepper price remains the same irrespective of quality.
  - Input wood is chipped pieces of *Gliricidia* plant.
  - Developers of technology are not sure of functioning of the demonstration unit.
  - Solar drier technology was dropped because it was found that efficiency is very low and very high cost.
  - Farmers perceive that the cost is high in relation to the value they get for the product.
  - The stove-drier system can be easily modified to serve the dual purpose of smokeless cooking and farm product drying in the rural households. If

demonstrated and disseminated properly this can become very popular and cost effective solution. With Gliricedia as input fuel this can promote sustainability.

- The overall efficiency of the system was found to be low. This is because drying is a low temperature (about 55 °C) process where as the biomass stove produces temperature as high as 800°C. Thus waste heat generated is very high.

(iv) *Feasibility of using biomass gasifier system for efficient thermal application on Municipal Waste Gasification – Visit to Energy Forum and Site visit*

- Energy forum further subcontracted the project to Mr. Tissa De’ Silva. The objective is to supply 10 tonnes of dry King coconut husk to the gasifier plant.
- About nine wet coconut husks are required to get one kg of dry coconut husk (20% moisture).
- Most efficient drying process is natural drying under the sun light. The process involved in cutting the coconut husk into required sizes (8 pieces) and drying under the sun.
- Dry king coconut husk is found to be better than firewood.
- These dry coconut husks are good for household cooking with efficient wood stoves.

## **RECOMMENDATIONS**

The project as a whole could be termed as a reasonably successful project considering the actual outcomes. Though one could observe deviations from the originally proposed deliverables and the actual outputs, the reasons for this were beyond the control of project management committee and the implementation agencies. Sub-projects carried out under the main project could demonstrate technological capabilities of biomass energy technologies (gasifiers, dryers) for thermal applications quite successfully. This was the most important expected deliverable of the project. Second set of technologies demonstrated successfully was related to biomass preparation (wood chipper for preparing properly sized wood pieces for gasifiers) and feeding system (an innovative screw feeder to regulate biomass feeding to the furnace) to improve the efficiency of biomass utilization. Now the most important question would be what is next? How these technologies could be spread to fellow industries? How to disseminate the knowledge thus gained? How to move forward from mere demonstration to replication? How biomass energy can make significant contribution to the energy system in a sustainable manner? The following are some of the recommendations, which might provide solutions to the above challenges if implemented.

- Biomass energy is not just a solution for the energy problems. Whole supply chain of biomass energy can provide livelihood options to many? Biomass energy plantations could earn additional income to the farmers and villagers, cutting and transportation can provide additional employment opportunities, biomass chipping can provide entrepreneurship and employment opportunities, biomass gasifier plants could again provide entrepreneurship and employment avenues, increased access to modern energy carriers can result in many productive livelihood alternatives. These multiple benefits of biomass energy need to be emphasized, assessed and disseminated;
- Considering the above, biomass energy development need to be integrated into the mainstream national development goal;
- Integration of biomass energy development into other sectors such as agriculture/land management, rural development to enhance and to ensure the regular supply of raw materials for energy plants;

- Involving private sector and financial institutions are very important for sustainable replication of biomass energy technologies. There may be a danger of grant based free technology demonstration ending with demonstration itself. Implementations with end-user contributions, soft loans and performance related incentives could result in more diffusion.
- Target oriented training programmes to build local skills in installing and operating biomass energy plants (barefoot engineers).
- Information dissemination and awareness creation programmes need to be focused and capable of delivering the message that biomass alternatives are affordable, modern, easy to handle and saves money.
- Coordination mechanism to involve all parties interested in designing, developing, establishing and promoting technologies;
- Close linkages among stakeholders – industry/consumer, private sector, financial institutions, facilitators and end-users;
- Promotion of small and medium scale industry and means to recover the investment on technology should be introduced as integrated elements;
- Technology transfer/extension need to be accommodated as the second phase of the project by allocating financial resources for integration and scaling up with a full evaluation of the socio-economic impacts of biomass energy development.

Now more as observations rather than recommendations, some issues with respect to the project implementation.

- Implementation of the project activities started with substantial delay and the dead line for completion was just three months away. At this stage, the best strategy could have been to continue to implement activities as a one year project rather than attempting to complete every thing in three months. It could be observed that this has resulted in the dilution of expected deliverables in most of the projects.
- Out of the nine sub-projects, seven have been awarded to the government agencies and two to an NGO. Since sustainable deployment of bioenergy technologies needs private sector involvement, awarding a couple of projects to the private sector agencies could have resulted in additional learning.

## **LESSONS LEARNED**

- Proactive and committed leadership is required to sail through difficult situations. Even with inordinate delays, uncertainty with regard to extension and too many participating agencies, the project was able to deliver most of the targeted outputs.
- UNDP's willingness to lend a helping hand at testing times contributed to the success of the project. This has helped greatly in appointing project management team, monitoring and evaluation and getting the desired extension.
- The need for technology development and demonstration has been justified based on assessed needs for promoting technology from the perspectives of state agency – the energy suppliers, and quality of output and energy/environmental benefits.
- Committed, progressive, innovative and risk taking entrepreneurs are required for installing and testing the new technologies. The implementing agencies have been fortunate to identify such willing partners for the technology demonstration.
- The institutions engaged in technology development have successfully completed their tasks and proved their capacity in producing technology and demonstrating them.

- Opportunities are needed for replicating the acquired institutional capacity. Demand for technology could be realized through an extension and this could provide an enabling opportunity for further addressing the drawbacks. Success of these developments is limited to piloting. Many of them provide practical demonstration for modern biomass technology options.
- As a follow up, a promotional strategy should be introduced. There is wide range of potential benefits in using biomass energy technology in agro-processing/drying. For example, the unit installed for drying pepper, with further improvements, could be promoted as a multi-functional unit, enabling the end user to use it for cooking, drying vegetables, fruit, and other spices like cloves, cardamom, cocoa, etc.
- The outcomes could be taken as nine completed cases for demonstration, further work is needed for promotion, exploring the possible end users, social acceptability, contribution to economic advancement, financing arrangements to realize the ultimate goal of promoting biomass energy for enhancing efficiency and productivity.

In conclusion, we would like to state that there is a strong need for developing a national level strategy for sustainable exploitation of biomass energy resources, development and deployment of biomass energy technologies, and creation of an effective mechanism for technology diffusion and information dissemination. The framework of implementation needs to involve all the stakeholders from government, NGOs, private sector, academic institutions, community organizations, financial institutions, etc.

## **Annexure 1**

### **Terms of Reference Evaluation of the outcome of the UNDP Sri Lanka Thematic Trust Fund on Biomass Resource Development Project**

#### **A. BACKGROUND**

The Government of Sri Lanka and UNDP Sri Lanka have been undertaking Biomass Resource Development Project under Thematic Trust Fund on Energy since 2003. The project promotes the reduction of greenhouse gas emissions by expanding the use of efficient technologies in the utilization of biomass energy in public and private sectors, improve the understanding and feasibility of biomass development in isolated locations and provide training in new skills to potential biomass developers in Sri Lanka. R&D component applying gasification technologies customised to Sri Lankan conditions to promote biomass energy as an engine for economic growth will be also promoted. To promote these areas the project will be focusing on the following 4 areas of R&D:

##### **1. Thermal application of biomass**

The main output of this component is to improve thermal efficiency of existing biomass energy conversion technologies in tea, brick, spice, and tile-drying industry. These industries have been identified as the leading consumers of fuel wood for energy in the country.

In practice, residues from agriculture and forestry are the resources most frequently exploited. This is due to other biomass resources usually having alternative uses offering higher added value and residues may often be found in large amounts at some particular place. It is noteworthy to mention that agricultural wastes in Sri Lanka at present are creating environmental hazards. Waste products from saw mills and rice processing mills are dumped in local neighbourhoods with no accepted procedures of disposal. By strengthening R&D, the project will contribute to cleaning of the environment, and at the same time, derive energy available in such waste material for power generation and thermal applications. The project will be supporting R&D on kilns in the brick & tile and lime industries to allow utilization of agricultural waste such as paddy husks and saw dust as fuel. This component focuses the promotion of chipped wood manufacturing and distribution at commercial level.

##### **2. Municipal waste gasification**

There is scope for disposing municipal wastes through recycling and gasification. Dispose of solid wastes in sanitary landfills and recover gaseous fuel is already utilized in rural communities, although not generated at an industrial scale. The project will be studying the feasibility of using smaller and medium size biomass gasifier systems for efficient thermal applications for municipal waste as apposed to biogas generation. Large gasification equipment will be available soon from REECB project installed in NERD Centre for initial testing.

##### **3. Connecting private biomass plants to the national grid**

A study is proposed to identify the institutional, financial and technological possibilities and implications of connecting private biomass plants to the national grid feeding into the Governments' renewable energy strategy. The study would focus on institutional and financial requirements for allowing and supporting sale of biomass resource-generated electricity to the grid.

In order to guarantee operation of a biomass power plant, biomass supply needs to be stable and predictable. A problem that is prevailing in Sri Lanka is that the market for biomass energy

is not yet developed; therefore competitive uses still play an important role. While energy plantations are known to be feasible, so far they have not been demonstrated successfully on a large scale. This has mainly been attributed to the reluctance of interested parties to take any risks of piloting such plantations. However, dendro-energy plantations can provide an interesting option for reclamation of degraded land, and seeking the possibility of obtaining revenue from Certified Emission Reductions (CERs) of GHGs may help to make energy plantations viable in the near future. Under the policy of providing basic human energy needs, the development of commercialized fuel wood plantations and associated industry has been identified. A pilot activity to study the feasibility of developing dedicated plantations to grow and harvest fuel-wood plant; *Gliricidia sepium* in a degraded land to feed into a proposed grid-connected biomass plant will be carried out.

#### **4. Information dissemination**

The project promotes extensive partnership strategy for an effective implementation of project activities. It work in close collaboration with various government agencies, research institutions, NGOs, etc., including CEB, NERD Centre, ECF and Energy Forum to achieve the main outcome. It would also give opportunities for interested individuals and other organizations in the sector to incorporate their inputs into this project during the implementing stage of the project, especially in the promotional activities. Involvement of the private sector in adopting the technology and promoting it as an income generating activity is encouraged and supported through the project.

### **B. OBJECTIVES OF THE EVALUATION**

The outcome evaluation shall assess the following:

- (i) *outcome analysis* - what and how much progress has been made towards the achievement of the outcome (including contributing factors and constraints),
- (ii) *output analysis* - the relevance of and progress made in terms of the UNDP outputs (including an analysis of both project activities and soft-assistance activities),
- (iii) *output-outcome link* - what contribution UNDP has made/is making to the progress towards the achievement of the outcome, and
- (iv) Assess partnership strategy in relation to outcome.

### **C. SCOPE OF WORK**

Evaluation will assess:

- relevance of the strategic programme objectives to the current needs of the country;
- appropriateness of the tools and mechanisms applied by the programme;
- impact of the UNDP Sri Lanka: Biomass Resource Development on capacities of Sir Lankan institutions to implement sustainable development strategies and to introduce sustainable practices of biomass resource use;
- the geographic coverage;
- the performance and timeliness of the projects;
- best practices and main issues;
- factors beyond UNDP's influence
- appropriateness of UNDP's partnership strategy and recommendations for the future, and
- provide recommendations for the improvement of the programme planning, management and monitoring.

---

<sup>b</sup> *Gliricidia sepium* has been identified as the best species for fuel wood production for biomass plants.

## D. OUTCOME TO BE EVALUATED

**Goal:** Environment

**Sub-Goal:** Sustainable Environment Management & Energy Development for Livelihood of poor

Outcome 1: Enhanced awareness and improved capacity of energy R&D institutions, local authorities, CSOs and private sector in sustainable energy development and increased access to sustainable energy technologies

Strategic Area of Support: Institutional framework for sustainable environment management & energy development

Outcome Indicator:

Year 2003 Baseline:

SRF end Target (2004):

## E. METHODOLOGY

Although it is generally the responsibility of the evaluation team to decide on the concrete evaluation methodology to be used, the following elements should be taken into account for the gathering and analysis of data:

- Desk review of relevant documents (project document with amendments made, reviews-mid-term/final/TPR, donor-specific, etc)
- Discussions with the Senior Management and programme staff of UNDP;
- Interviews with and participation of partners and stakeholders; and
- Field visits to select key projects.
- Consultation meetings.

## F. EVALUATION TEAM

*The evaluation team will consist of two consultants: one international consultant (as the team leader) and one national consultant.*

- The international consultant should have at least a Master's degree and at least fifteen years of work experience in the field of sustainable development, natural resource management, energy studies, and sound knowledge about results-based management (especially results-oriented monitoring and evaluation). Previous experience from conducting evaluations, assessments and reviews is mandatory. The international consultant will take the overall responsibility for the quality of the evaluation report (including finalization of the evaluation report in English). Specifically, the international consultant (team leader) will perform the following tasks:
  - Lead and manage the evaluation mission;
  - Design the detailed evaluation scope and methodology (including the methods for data collection and analysis);
  - Decide the division of labour within the evaluation team;

- Conduct an analysis of the outcome, outputs and partnership strategy (as per the scope of the evaluation described above);
  - Draft related parts of the evaluation report; and
  - Finalize the whole evaluation report.
- The national consultants will have a Master’s degree in the relevant field and have at least 5 years experience in environment or energy studies. Excellent interpersonal skills are required together with strong analytical and writing skills. Each national consultant will perform the following tasks:
- Review documents;
  - Participate in the design of the evaluation methodology;
  - Conduct an analysis of the outcome, outputs and partnership strategy (as per the scope of the evaluation described above); and
  - Draft related parts of the evaluation report.
  - Assist Team leader in finalizing document through incorporating suggestions received on draft related to his/her assigned sections.

### **E. FINAL PRODUCT**

The key product expected from this outcome evaluation is a comprehensive analytical report in English that should, at least, include the following contents:

- brief introduction,
- objectives,
- implementation modality,
- process followed,
- outputs,
- project performance and impact,
- implementation issues,
- lessons learned,
- key lessons learned during the project implementation,
- future course of action, and
- Annexes: TOR, field visits, people interviewed, documents reviewed, etc.

### **F. IMPLEMENTATION ARRANGEMENT DATES OF ASSIGNMENT**

The UNDP CO Environment Unit and Evaluation Focal Point will provide full support to the Evaluation team members during their assignment. They will, among others, help identifying key partners to be interviewed.

*The international consultant (team leader) will work 13 days and the national consultant will work 10 days. The breakdown is as follows:*

<b>Activity</b>	<b>Timeframe and responsible party</b>
Evaluation design (home based)	1 day, by the team leader
Desk review of existing documents & Briefing with UNDP	3 days, by the evaluation team
Field visits	3.5 days, by the evaluation team
Interviews with partners	1 day, by the evaluation team
Drafting of the evaluation report	2 days, by the evaluation team
Debriefing with UNDP and the Government	0.5 day, by the evaluation team
Finalization of the evaluation report (home based)	2 day, by the team leader

**Annexure 2****Persons Interviewed and Consulted**

<b>Sl. No.</b>	<b>Name</b>	<b>Institution</b>	<b>Position</b>
1	Mr. M.M.C. Ferdinando	MOPE	Secretary
2	Mr. P. Weerahandi	Ministry of Housing Development	Secretary
3	Ms. Darshani De Silva	UNDP	Environment Programme Analyst
4	Ms. Judith Vannithamby	UNDP	Programme Associate
5	Mr. Liyanaratchchi		National Project Manager
6	Mr. Harsha Wickramasinghe	ECF	General Manager
7	Ms. Irosha S. Kalugalage	ECF	Engineer
8	Mr. Athula Jayathunga	ECF	Programme Manager
9	Mr. H.A. Vimal Nadeera	ECF	Programme Manager
10	Ms. Chamila Jayasekera	ECF	Programme Manager
11	Mr. P.G. Joseph	MOST	Director/Alternative Energy
12	Mr. Asoka Abeygunawardana	Energy Forum	Director
13	Mr. Tissa De Silva	Private sector	Engineer/Project undertaker
14	Mr. Suriya Bandara	Suriya Lime	Owner/Lime entrepreneur
15	Mr. Gayan	Ener-Fab Private Ltd.	Engineer
16	Mr. Azam	Dean Side Tea Factory	Owner
17	Mr. Munasinghe	NERDC	Engineer
18	Mr. Tiwanka Wickramasinghe	Dept. of Mechanical Engineering, University of Moratuwa	Academic staff
19	Ms. Inoka Manthilaka	--do--	Academic staff

### Annexure 3

#### Referred Documents

1. Biomass Energy Development Project Document, Prepared by UNDP for Government of Sri Lanka, 2004
2. ECF, *Brass Melting*, Ministry of Power and Energy.
3. ECF, *Dendro Thermal Energy Increase Productivity Reduce Poverty: Bio-energy for Lime Industry*, 2005.
4. ECF, *Gami Diviyata Nawa Saviyak (in sinhala)*, Pamphlet.
5. ECF, *Shaka Saha Balashakthiya (in sinhala)*, Pamphlet.
6. ECF, University of Moratuwa, *Solar Assisted Biomass Energy Based Dryers for Small Scale Spice Drying in Sri Lanka*, 2005.
7. Energy Forum, *Developing a pilot fuelwood plantation to be fed into proposed grid connected biomass plant* (Progress Report), October 2004.
8. Energy Forum, *Establishing 1MW grid connected Dendro power plant in Meegahakivula D.S. Division, Badulla District*
9. NERDC, *Identification of Opportunities and Implication of Connecting Private Biomass Power Plant to the National Grid: Grid connection of 100kWe gasifier based power generation system of NERDC*, August 2005.
10. NERDC, *Thermal Efficiency Improvement in Biomass Conversion Technology in the Tea Industry of Sri Lanka: Combustion efficiency improvement in hot air furnace – pilot plant operation*, 2005.
11. Minutes of Project Management Committee Meetings, July 2004 to August 2005.
12. Progress Reports and Interim Project Reports of all the sub-projects.
13. Terms of Reference (TOR) Evaluation of the outcome of the UNDP Sri Lanka Thematic Trust Fund on Biomass Resource Development Project, Prepared by UNDP