Ministry of Environment and
Renewable Energy
Sri Lanka

Technology Needs Assessment And Technology Action Plans For Climate Change Mitigation

Project Ideas Report

2012

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CLIMATE CHANGE SECRETARIAT

FORWARD

Sri Lanka being an island nation subjected to tropical climatic influences is highly vulnerable to climate change impacts. We are already experiencing significant climatic imbalances manifested through increasing average temperatures, drastic variations in rainfall patterns and extreme climatic events such as heavy rainstorms, flash floods, and extended droughts and weather related natural disasters in various forms and severity. These extreme and sometimes unseasonal events affect not only the human lives and properties but also have long term impacts on the ecosystems as well.

"*Mahinda Chinthana* – Vision for the Future", the Government of Sri Lanka's Ten Year Development Policy Framework assigns a very high priority to the management of the environment and the natural resources sector including addressing climate change impacts. In keeping with the Government's overall vision on tackling climate change impacts, the "National Climate Change Policy (NCCP) for Sri Lanka" identifies the need of active involvement in the global efforts to minimize the greenhouse gas emission within the framework of sustainable development and principles enshrined in the United Nations Framework Convention on Climate Change. The NCCP emphasizes the importance of exploring greenhouse gas mitigation technologies and best practices already available in the country and globally, and select nationally appropriate innovative technologies, disseminating, and implementation to the extent possible with sound monitoring mechanisms.

The Government and my Ministry in particular recognizes that the Technology Needs Assessment (TNA) Project implemented in collaboration with Global Environment Facility (GEF), United Nations Environment Programme (UNEP), UNEP-Risoe Center (URC) and the Asian Institute for Technology (AIT),as the first comprehensive national exercise undertaken towards addressing our climate change concerns. Thus, the TNA Report provides an assessment of the priority technology requirements and action plans for climate change mitigation activities in energy, industry and transport sectors. I am convinced that this exercise has been a nationally driven process involving local expertise and knowledge supplemented by international experiences.

In fulfillment of the Government's firm commitment towards taking appropriate national actions for tackling climate change related issues and also collaborative obligations to the international community in this context, I have great pleasure in presenting the **Sri Lanka's National Report on Technology Needs Assessment and Technology Action Plans for Climate Change Mitigation** to the policy makers, potential investors, technology developers, scientists and all other stakeholders who are actively participating in sustainable development efforts of the country. I also recommend this report for consideration and emulation of the world community and invite them to be partners in achieving our economic, environmental and social development goals.

Susil Premajayantha, MP

Minster of Environment and Renewable Energy

Government of Sri Lanka

PREFACE

Sri Lanka ratified the United Nations Framework Convention on Climate Change (UNFCCC) in November 1993 and acceded its Kyoto Protocol in September 2002. In keeping with the obligations of the UNFCCC, the Government of Sri Lanka submitted its Initial National Communication in 2000 and submitted the Second National Communication in 2012. Over the last two decades, Sri Lanka has made a significant progress towards improving the national policy framework and strengthening the legal and institutional capabilities to facilitate implementation of obligations under the UNFCCC and Kyoto Protocol. These timely actions demonstrate the Government's firm commitment in addressing country's environmental and climate change related issues.

Although Sri Lanka is a low greenhouse gases emitter, it is highly vulnerable to adverse impact of climate change. Analysis of past records suggests that air temperature throughout the island has been on a rising trend during the last century. The future scenarios predict higher levels of emissions and possibility of adverse climate change impacts, if no mitigatory and adaptation actions are undertaken now.

The TNA explores country needs for the reduction of greenhouse gas emissions and adaptation technologies. It also re-affirms the will of the Government along with the international community to contribute to the joint efforts in addressing the climate change threat. It is envisaged that this process will open up access to funds, create an enabling environment for the transfer of priority technologies which will improve the climate resilience of the most vulnerable sectors in the country.

I would like to take this opportunity to extent my gratitude to the Global Environment Facility (GEF) for funding and the United Nations Environment Programme (UNEP) and the UNEP Risoe Center (URC) for implementing this project in collaboration with the Asian Institute of Technology (AIT). A record of appreciation is also extended to the members of the TNA committee, Sectoral working Groups and all other experts who have contributed to this national exercise.

B.M.U.D Basnayake
Secretary
Ministry of Environment and Renewable Energy

ACKNOWLEDGMENTS

This report on Technology Needs Assessment and Technology Action Plans for Climate Change Mitigation was the outcome of the project on Technology Needs Assessment (TNA)on Climate Change Adaptation and Mitigation for Sri Lanka conducted by the Climate Change Division of the Ministry of Environment and Renewable Energy from June 2011 to April 2013.

The TNA project in Sri Lanka was funded by the Global Environment Facility (GEF) and technically supported by United Nations Environment Programme (UNEP) and the UNEP Risoe Center (URC) in collaboration with the Asian Institute of Technology (AIT). First and foremost, my appreciation goes to the GEF, UNEP, URC and AIT for their financial and technical supports.

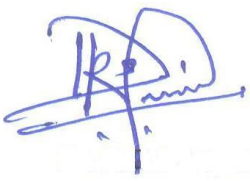
I wish to take this opportunity to express my sincere gratitude to Hon. Susil Premajayantha, Minister of Environment and Renewable Energy, Hon. Anura Priyadarshana Yapa, Former Minister of Environment, Mr. B.M.U.D. Basnayake, Secretary, Ministry of Environment and Renewable Energy and Mr. Gamini Gamage, Additional Secretary (Environment and Policy) of the Ministry of Environment and Renewable Energy for their leadership, directions and guidance provided to conduct this project successfully.

My appreciation is extended to the members of the TNA committee, sectoral working groups and all other experts who contributed to this project. I am grateful to the various governmental, non-governmental and private sector personnel who took time out of their busy schedules to meet with our consultants and to provide data and information.

I am thankful to all the consultants of the TNA project, namely Mr. H.M.Bandaratillake, Team Leader and sector experts Mr. P.G. Joseph (Energy Sector), Dr. (Mrs.) Erandathie Lokupitiya (Transport Sector), Mr. V.R. Sena Peris and Mr. Jagathdeva Vidanagama of National Cleaner Production Centre (Industry Sector).

My special thanks is also extended to the staff of the Climate Change Division of the Ministry of Environment and Renewable Energy, particularly to Ms. Anoja Herath, Coordinator of the TNA project, Ms. Nirosha Kumari and Ms. Surani Pathirana, Environment Management Officers of the Ministry of Environment and Renewable Energy.

Finally, on behalf of the Ministry of Environment and Renewable Energy I would like to thank all those who contributed to make this project realistic. Without their supports this project would never be success.



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Stakeholder Participation

TNA Committee	– Annex A1
Workshop Participants	– Annex A2

This document is an output of the Technology Needs Assessment project, funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Programme (UNEP) and the UNEP- Risoe Centre (URC) in collaboration with the Asian Institute for Technology (AIT), for the benefit of the participating countries. The present report is the output of a fully country-led process and the views and information contained herein are a product of the National TNA team, led by the Secretary, Ministry of Environment and Renewable Energy, Government of Sri Lanka.

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ABBREVIATIONS

ADB	Asian Development Bank
ARTI	Appropriate Rural Technology Institute
BEASL	Bio Energy Association of Sri Lanka
CCFL	Cold Cathode Fluorescent Lamp
CDM	Clean Development Mechanism
CEB	Ceylon Electricity Board
CETRAC	Construction Equipment Training Centre
CFL	Compact Fluorescent Lamp
CH4	Methane
CHP	Combine Heat and Power
CMC	Colombo Municipal Council
CO_2	Carbon Dioxide
CPC	Ceylon Petroleum Corporation
CRI	Coconut Research Institute
DMT-	Department of Motor Traffic
EEM	Energy Efficient Motor
EFF	Electronic Frontier Foundation
ESCOs	Energy Service Companies
ESMP	Energy Sector Master Plan
FD	Forest Department
GDP	Gross Domestic Product
GHG	Green House Gas
HE/VT	Higher Education & Vocational Training
HP	Horse Power
IDB	Industrial Development Board
IDEA	Integrated Development Association
IESL-	The Institute of Engineers Sri Lanka
IFS	Institute of Fundamental Studies
ITDG	Industrial Technology Development Group
kWh	Kilo Watt hour
LED	Light Emitting Diode
LKR	Sri Lanka Rupees
LPG	Liquid Petroleum Gas
MCDA	Multi-Criteria Decision Analysis
MoE	Ministry of Environment
MoPC	Ministry of Provincial Councils
MOST	Ministry of Science and Technology

MoT	Ministry of Transport
MSW	Municipal Solid Waste
MWe	Mega Watt
MWh	Mega Watt hour
N_2O	Nitrous oxide
NCRE	Non-Conventional Renewable Energy
NEMA	National Electric Manufacturer's Association
NEP&S	National Energy Policy and Strategies
NERDC	National Engineering Research & Development Centre
NGO	Non-Government Organization
NTC	National Transport Commission
O&M	Operations and Maintenance
OTEC	Ocean Thermal Energy Conversion
PPP	Purchasing power parity
PPP	Public Private Partnership
PRDA	Provincial road development authority
PUCSL	Public Utilities Commission of Sri Lanka
R&D	Research & Development
RDA	Road Development Authority
RDF	Residue Derived Fuel
RE	Renewable Energy
RERED	Renewable Energy for Rural Economic Development
SEA	Sustainable Energy Authority
SLMA	Sri Lanka Medical Association
SLSEA	Sri Lanka Sustainable Energy Authority
SRC	Short Rotation Coppice
TAP	Technology Action Plan
TNA	Technology Needs Assessment
UDA	Urban Development Authority
UNFCCC	United Nations Framework Convention on Climate Change
UOM	University of Moratuwa
US $	United State Dollar
VSD	Variable Speed Drive

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CHAPTER 1

Project Ideas for Energy Sector

1.1 Brief summary of the Project Ideas for Energy Sector

Under the Technology Needs Assessment (TNA) Project, the analysis of technology options for climate change mitigation in the energy sector was carried out through an extensive consultative process, by compiling a list of all potent technologies available in the energy sector to face the challenge of climate change mitigation. A prioritization process utilizing the Multi-Criteria Decision Analysis (MCDA) approach was used to rank the various technologies identified as potential means to mitigate the green house gasses emissions and contribute to the global effort to mitigate climate change impacts. Based on this process, the energy sector has prioritized the following three technology groups based on stakeholder's responses.

Two of the above technology groups have sub-technologies as components. (See table 1.1). In total the following six technologies and sub-technologies have been identified: 1(a). Co-Firing of Biomass with Coal; 1(b). Compact Biogas Digester for Urban Households; 1 (c). Waste To Energy; 2. Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration; 3 (a). LED Lighting; 3 (b). Solar Assisted Air Conditioning. The categorization of these technologies is shown in table 1.1.

Table1.1: Categories of the prioritized technologies – Energy Sector

No	List of Prioritized Technologies	Sub Technologies
1.	**Conversion of Biomass and Waste to Energy**	**a)** Co-Firing of Biomass with Coal
		b) Compact Biogas Digester for Urban Households
		c) Waste To Energy
2.	**Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration**	**a)** Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration
3.	**Building Management Systems**	**a)** LED Lighting
		b) Solar Assisted Air Conditioning.

This chapter (Chapter 1) outlines the proposals for the six project ideas developed based on the 6 prioritized technologies/technology groups for the energy sector.

1.2 Project Idea for Technology 1: Co-Firing of Biomass with Coal

1.2.1 Introduction and Background

In an attempt to increase the share of renewable resources based electricity generation, the government of Sri Lanka has introduced a scheme to attract the private sector to engage in this sector. Although many small hydro power projects have been commissioned in the past, the total capacity of biomass based electricity generation is very small. There are two primary reasons for this poor performance in this sector. (a) The capital cost of establishing a complete set of biomass based boiler-turbine-generator system is very high. (b) The consumption biomass fuel required to generate one unit of electricity in these conventional system is also very high. For the above two reasons, the financial viability of these projects are inadequate to attract private investors.

In the co-firing technology, as biomass and coal are used as fuels, a significant part of the machinery already installed is utilized for this purpose. Moreover, as the scale of operation is relatively large, the efficiency of electricity generation is much higher than conventional small scale biomass projects.

In the proposed technology, it is intended to use biomass and coal as fuels utilizing a part of the machinery already installed to generate electricity. Although several options are available for co-firing biomass with coal, consultations with the stakeholders of energy experts and representatives of relevant institutions the following option taking into account the need to minimize the extent of interference with the existing equipment at a coal fired power plant was recommended.

Use a separate biomass boiler to generate steam at the same temperature and pressure as that of the steam produced at the coal boiler. Steam produced in the biomass boiler is connected to a common steam header. Steam from this header is used to drive the existing steam turbines. This method is the most expensive option. But it has the following advantageous:

- The existing equipment such as coal conveyor, coal crusher, coal boiler etc. is not tampered with.
- The percentage share of biomass could be varied from 0% to 100%.

It is proposed to install this boiler adjoining the 300 MWe coal fired boiler in Nurachcholai, in Puttalam District in Sri Lanka.

1.2.2 Objectives

- To reduce GHG emissions
- To reduce the consumption of coal in the generation of electricity.
- To increase the share of electricity generation using indigenous resources.
- To enhance the rural economy by providing a market for locally cultivated biomass.

1.2.3 Outputs of the Proposed Project

- Availability of a Feasibility Report on Co-Firing of Coal with biomass.
- Reduction of imported coal by 96,000 tonnes /year.
- Generation of biomass based steam equivalent to 240 GWh of electricity per year.
- An annual income of US$ 31.2 million to the local community by way of purchase of wood for steam generation.

1.2.4 Relationship to the country's sustainable development priorities

According to the National Energy Policies and Strategies of Sri Lanka of October 2006, the policy is to generate at least 10% of the total electrical energy from new renewable energy resources by the year 2015. And as per "*Mahinda Chinthanaya:* Vision for a New Sri Lanka. A 10 Year Horizon Development Framework, 2006 -2016" this share is expected to be 20% by the year 2020. This project will enable the country to achieve these targets.

By increasing the indigenous share of electricity and other forms of energy the following social goals would be achieved:

(a) Increase in income for the rural community thus decrease in the gap between the rich and the poor.

(b) Poverty reduction in the country particularly in the rural areas.

(c) Better health and productivity amongst the rural agricultural communities.

1.2.5 Project Deliverables

- A comprehensive feasibility report on the financial and technical viability of co-firing coal and biomass to generate electricity. Such a document is a basic requirement from the point of view of local project approving agencies, particularly in the allocation of limited resources amongst competing project proposals.
- Installation and operation of a biomass boiler with a capacity of 30 MWe supplying steam to a 300 MWe existing coal-fired power plant. This will be done in collaboration with an identified private sector developer and the relevant government institutions such as the Sustainable Energy Authority, Ceylon Electricity Board etc. The annual generation of electricity generated by this project is estimated to be 240 GWh. This step of commissioning the first biomass based steam generation to be used in existing coal based generation would serve as the pilot project which would lead to the commissioning of many other larger units in the country.
- A reduction of 288,000 tCO2 emission per year. Sri Lanka, though not a member of Annex 1 countries of the UNFCCC classification, as a responsible country towards global environmental enhancement, such reductions in CO2 emission would demonstrate the sincerity of the country.
- Development of 6,000 hectare equivalent of Gliricidia plantations in underutilized lands in the region. This activity will be carried out in collaboration with institutions such the National Livestock Development Board, who has large extent of underutilized lands in the region. Also most of the rural homestead owners in the region will be incorporated in the cultivation and sale of Gliricidia wood to the biomass boiler operator. The total amount of biomass expected to be purchased by the boiler operator is about 200,000 tonnes per year.

1.2.6 Project Scope and Possible Implementation

The scope of the project is to facilitate the private sector investors to invest in a 30 MWe biomass boiler to supply steam to a 300 MWe exiting coal fired power plant there by reducing 10% of imported coal consumed in the existing power plant. Based on the success of this phase of the project, similar or much larger biomass co-firing boilers could be installed. Presently, this technology could be gradually expanded to meet a larger share of the 300 MWe coal-fired power plant already installed and operated.

In due course, this technology could be extended to all future coal power plants to be installed in the country. The total capacity of coal based power generation by the year 2020 is expected to be 1945 MW. The proposed feasibility report is expected to cover all necessary features of the project to facility the project approving agencies to take a favourable decision.

1.2.7 Project activities

The project activities are divided into two categories as direct activities and supporting activities. Direct activities include activities directly relevant to the biomass to energy conversion process. Supporting activities include government policy revisions related to promoting the transfer and diffusion of the technology.

Direct Activities (Activities directly relevant to the biomass to energy conversion process):

1. Preparation and publication of a Feasibility Report on the Financial and Technical viability of a 30 MWe equivalent biomass boiler to supply steam to an existing 300 MWe coal fired power plant.
2. State sector and private sector collaborating in the investment, construction, operation and maintenance of a 30 MWe biomass fired boiler and supplying steam to an existing 300 MWe coal-fired boiler through a PPP (public private partnership) program.
3. Donor Agencies to provide funds at low interest rate for renewable projects.
4. Making arrangements for the investors to cultivate Gliricidia as an agro-energy crop in underutilized lands.
5. Establishment and operation of Agro-energy plantations in underutilized lands and in home gardens by the investors of this project.

Supporting Activities (Policy revisions related to promoting the transfer and diffusion of the technology).

1. Eliminating Government taxes imposed on local construction in respect of renewable energy and energy efficiency projects.
2. Sustainable Energy Authority to incorporate co-firing as an option for electricity generation in Sri Lanka.
3. Sustainable Energy Authority to invoke the provision in the Act to impose a levy on fossil fuels and use this revenue to finance renewable energy and energy efficiency projects.
4. During generation planning the costs of impacts fossil fuel use on external entities (such as health, agriculture) to be added to the direct costs of electricity generation.

1.2.8 Timelines for the proposed activities

Table 1.2: Timelines for the Proposed Activities of Project 1

The time frames of year 1, year 2 and year 3 to 25 are chosen taking into account the project initiation, commissioning and operational phases of the project.

No	Activity	Year 1	Year 2	Year 3 to Year 25
Direct Activities				
1.	Feasibility Report on co-firing biomass and coal			
2.	Investment, construction, operation and maintenance of a 30 MWe biomass fired boiler and supplying steam to an existing 300 MWe coal-fired boiler through a PPP.			
3.	Donor Agencies to provide funds at low interest rate for renewable and energy efficiency project			
4.	Making arrangements for the investors to cultivate Gliricidia as an agro-energy crop in underutilized lands.			
5.	Establishment and operation of Agro-energy plantations in underutilized lands and in home gardens by the investors of this project			
Supporting Activities				
1.	Elimination of government taxes on local construction			
2.	SEA to incorporate co-firing as an option for electricity generation in Sri Lanka.			
3.	SEA to invoke the provision in the Act to impose a levy on fossil fuels and use this revenue to finance renewable energy and energy efficiency projects			
4.	During generation planning the costs of impacts fossil fuel use on external entities to be added to the direct costs of electricity generation.			

1.2.9 Budget/Resource requirements

Table 1.3: Budget Estimate for Proposed Activities of Project 1

The budget values assigned for "international" are expected to be raised as grant component from donor agencies without burdening the national consumers. The "local" component of the budget is ultimately expected to be provided by the consumers and citizens of this country.

No.	Activity	Proposed Budget (US $)		Remarks
		International	Local	
Direct Activities				
1.	Feasibility Report on co-firing biomass and coal	150,000	Nil	Outright Grant
2.	Investment, construction, operation and maintenance of a 30 MWe biomass fired boiler and supplying steam to an existing 300 MWe coal-fired boiler through a PPP (public private partnership) program	Nil	Nil	To be incurred by the investors
3.	Donor Agencies to provide funds at low interest rate for renewable and energy efficiency project.	15,000,000	Nil	Low interest loan
4.	Making arrangements for the investors to cultivate Gliricidia as an agro-energy crop in underutilized lands.	Nil	Nil	Policy
	Establishment and operation of Agro-energy plantations in underutilized lands and in home gardens by the investors of this project.	Nil	Nil	To be incurred by the investors
	Sub total	**15,150,000**	Nil	
Supporting Activities				
1.	Elimination of taxes on local construction	Nil	Nil	Policy
2.	SEA to incorporate co-firing as an option for electricity generation in Sri Lanka.	Nil	Nil	Policy
3.	SEA to invoke the provision in the Act to impose a levy on fossil fuels and use this revenue to finance renewable energy and energy efficiency projects	Nil	15,000,000	Guarantee fund for investors to secure loan for

				the project
4.	During generation planning the costs of impacts fossil fuel use on external entities to be added to the direct costs of electricity generation.	150,000	Nil	Outright grant by donor agencies
	Sub total	**150,000**	**15,000,000**	
	Total	**15,300,000**	**15,000,000**	

1.2.10 Measurement/Evaluation

Monitoring: The progress of project activities will be monitored and periodically evaluated by the committee coordinating the project. This committee will be constituted with representatives from the following institutions:

- Sustainable Energy Authority
- Ceylon Electricity Board
- Ministry of Environment
- Ministry of Finance
- Ministry of Plantation Industries

Evaluation: The Monitoring Committee is expected to nominate a suitable external evaluation team to evaluate the performance and progress of the project and recommend appropriate corrective measures.

The monitoring committee is expected to formulate quantitative and measurable indicators such as hectares of Gliricidia plantations established, tonnage of wood generated and the tonnage of coal replaced on a timely and regular basis.

1.2.11 Possible Complications/Challenges

The following complications and challenges need to be met:

- Although co-firing of biomass and coal are practiced extensively in many parts of the world, in Sri Lanka this is a new phenomenon. Moreover, the use of coal for electricity generation was reintroduced to Sri Lanka recently. The new system of coal based electricity generation has been encountering numerous technical problems. Hence the introduction of co-firing needs to done with due care.
- The use of underutilized state lands for agro-energy plantations by the private sector is a new activity in Sri Lanka. This too should be carefully handled.

- Inadequate support from some government institutions in the energy sector for full implementation of supporting activities proposed in the project may cause obstructions for implementation of these activities. Without full implementation of supporting activities it may not be possible to achieve proposed project targets as expected. Therefore it has to be treated as a risk factor.

1.2.12 Responsibilities and Coordination

The project will be coordinated by a committee consisting of representatives from the institutions and their respective responsibilities as per table given below.

Table 1.4: Responsibilities of Project Coordination

Institution/ Stakeholder	Responsibilities
1. Private sector developer	• Project Implementing Agency. • Raising necessary finances, acquiring the technology, procurement of equipment, installation, commissioning and operation of boiler. • Arrangements to cultivate and purchase necessary quantity of biomass fuel.
2.Sustainable Energy Authority	• Incorporating co-firing as an option for private sector participation in power generation including a provision to sell steam to the power utility. • Facilitating private sector developers in the establishment, operation of co-firing facility and sale of steam. • Collection of levy from fossil fuels and creation and operation of a renewable energy/energy efficiency guarantee fund.
3. Ceylon Electricity Board	• Cooperating with the private developer in the operation of co-firing facility and sale of steam.
4. Ministry of Environment	• Determining the costs of external impacts (such as on health) of fossil fuel use.
5. Ministry of Finance	• Receipt and disbursement of donor contributions
6. Ministry of Plantation Industries	• Arrangements of underutilized lands for cultivation of Gliricidia

Implementing Agency:

This project will be **implemented by a private or state sector project developer** identified by a process formulated by the Sustainable Energy Authority, Ceylon Electricity Board, Ministry of Power and Energy and the Ministry of Finance. This developer has the responsibility of raising the necessary capital, identifying and acquiring the technology, procuring, installing, commissioning and operating the boiler. In addition the developer is expected to arrange the cultivation of Gliricidia in lands arranged by the government as well as private land owners including homesteads. The developer should also arrange to purchase and store biomass fuel (Gliricidia wood).

A number of local promoters have expressed their desire to undertake the task of inviting private sector project developers from overseas.

1.2.13 List of References

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1.3 Project Idea for Technology 2: Compact Biogas Digester for Urban Households

1.3.1 Introduction and Background

The economic growth experienced in the past in the country is reflected in the per capita income of the population. With this increase, the standard of living of the population is rising. More and more households are switching from indigenous and renewable biomass fuel to imported fossil based LPG (Liquid Petroleum Gas). If a compact biogas technology could developed along with readily purchasable renewable feed material, households could be persuaded to move away from LPG.

In this technology, such a compact biogas digester and readily purchasable renewable feed materials are proposed to be introduced for the urban household as an alternative to LPG.

The technology is based on a compact biogas system developed by Appropriate Rural Technology Institute of Pune, Maharashtra, India (www.arti-india.org). The volume of this digester is 1.5 m3. It essentially consists of two plastic tanks. The larger tank acts as the digester vessel, while the smaller tank acts as the gas holder. The smaller tank is inserted into the larger tank with the mouth downwards. Capital cost including all materials and labour and a gas burner is US$ 200 (LKR 26,200). 2 kg of suitable material is needed as the feed stock to produce 500 g of methane required to cook a day's meals for a family.

As feed materials, it is proposed to use dried and powdered Gliricidia leaves. University of Moratuwa has conducted trials and confirmed its suitability. Such leave poder need to be manufactured by the private sector and marketed through super markets.

1.3.2 Objectives

- To reduce the national consumption of LPG consumed by the urban household sector for cooking of food and water heating.
- To provide an elegant and compact biogas digester at an affordable price suitable for an urban household.
- To ensure that a convenient renewable feed material is available to be purchased by urban households as feed material for the biogas unit.

1.3.3 Outputs of the Proposed Project

- Availability of a Feasibility Report on the use of Compact Biogas Unit by urban households.
- Use of 100 numbers of Compact biogas units in the country by the year 2014 and 60,000 units in 5 years.
- Reduction of consumption of imported LPG by 18 tonnes /year by 2014 and 8760 tonnes in 5 years.

1.3.4 Relationship to the country's sustainable development priorities

The Haritha (Green) Lanka Programme formulated by the Presidential Secretariat (The National Action Plan for Haritha Lanka Programme, Presidential Secretariat, January 2009) clearly identifies the use of biogas as a priority activity to reduce the consumption of fossil based LPG for household cooking and water heating.

1.3.5 Project Deliverables

- A comprehensive feasibility report on the financial and technical viability of the use of compact biogas digester and availability of appropriate feed material. Such a document is a basic requirement from the point of view of local project approving agencies, particularly in the allocation of limited resources amongst competing project proposals. The feasibility report should cover how adequate quantities of appropriate quality feed materials would be made available to the consumers.
- A working unit of a practical compact biogas digester at an affordable price along with appropriate feed material at an affordable price for the convenience of urban households.

  Such a demonstration unit would convince the potential users of the practicality of using such a unit in the urban household environment. It will also serve to determine the affordability of procuring the unit and the purchasing of the feed material on a regular basis.
- Market arrangements to fabricate and market such compact biogas units and feed material (Gliricidia leaf powder) at suitable locations for the convenience of urban households. Although the proposed unit is much smaller than conventional biogas units, it is essential to facilitate the purchase, installation and commissioning of such units. More importantly, it is essential to ensure the feed material is accessible to urban housewives at convenient places, just as how LPG cylinders are marketed. These tasks need to be undertaken by the marketing arm of this technology.

- Additional income for rural households by cultivation, harvesting, drying, powdering, picketing and marketing of Gliricidia leaf powder. In order to implement this technology, the producers of the feed material should be attracted to get into this business by ensuring that those engaged in producing the feed material are monetarily compensated.
- An annual additional income of US$ 10,000 to the rural community by selling biogas feed materials to urban households by the year 2014. Such an additional income would increase the income of rural poor thus narrowing gap between the rich and the poor.
- A reduction of 10 tonnes of CO2 emission reduction by the year 2014. Such a reduction would be a good starting point towards achieving the ambitious target of making Sri Lanka a tottaly carbon neutral country.

1.3.6 Project Scope and Possible Implementation

In this project it is first proposed to conduct a feasibility study on the technical financial viability of commercial production of compact biogas digesters and appropriate feed material. On the technical side Appropriate Rural Technology Institute of Pune, Maharashtra, India (www.arti-india.org) has already demonstrated the technical feasibility of the digester. University of Moratuwa also has demonstrated the technical viability of Gliricidia leaf powder as the feed material. The digester unit is being manufactured in India at US$ 200. As the price of LPG is steadily increasing, it is very likely that the feasibility study would give favourable results.

The proposed feasibility report is expected to explore and find necessary steps to be taken to ensure that the technology implemented in India could be effectively introduced in Sri Lanka. Moreover, the feasibility report should cover the technical and financial aspects of the production and marketing of the feed material in the local context.

Initially it is proposed to take action to provide these digesters to 100 urban households and make arrangement to regularly supply these households with 2 kg of Gliricidia leaf powder as feed material. If this phase of the project is successful it is likely that at least 10% of the total households in the country amounting to 400,000 would switch to this technology.

1.3.7 Project activities

The project activities are divided into two categories as direct activities and supporting activities. Direct activities include activities directly relevant to the development of the technology compact biogas digester. Supporting activities include activities related to government policies for promoting bio-energy.

Direct Activities of the project:

1. Preparation of a feasibility report on the technical and financial viability of using compact biogas digesters and Gliricidia leaf powder by urban households to generate the fuel required for cooking and water heating.
2. Making arrangements for cultivation of Gliricidia as an agro-energy crop in underutilized lands.
3. Donor Agencies to provide funds at low interest rate for renewable and energy efficiency project.
4. Establishment of Agro-energy plantations in underutilized lands and in home gardens by the private sector including communities.
5. Research institutions in Sri Lanka to resolve the issues in the production and use of feedstock for urban household biogas digester to a level acceptable by the consumer.

Supporting Activities of the project:

1. Eliminating the taxes imposed on local construction in respect of renewable energy and energy efficiency projects.
2. Sustainable Energy Authority to invoke the provision in the Act to impose a levy on fossil fuels and use this revenue to finance renewable energy and energy efficiency projects.

1.3.8 Timelines for Proposed Activities

Table 1.5: Timelines for the Proposed Activities of Project 2

The time frames of year 1, year 2 and year 3 to 25 are chosen taking into account the project initiation, commissioning and operational phases of the project.

No.	Activity	Year 1	Year 2	Year 3 to Year 25
Direct Activities				
1.	Preparation of a feasibility report on the technical and financial viability of using compact biogas digesters and Gliricidia leaf powder			
2.	Making arrangements for cultivation of Gliricidia as an agro-energy crop in underutilized lands.			
3.	Donor Agencies to provide funds at low interest rate for renewable and energy efficiency project.			
4.	Establishment of Agro-energy plantations in underutilized lands and in home gardens by the private sector.			
5.	Research institutions in Sri Lanka to resolve the issues in the production and use of feedstock for urban household biogas digesters			
Supporting Activities				
1.	Eliminating the taxes imposed on local construction in respect of renewable energy and energy efficiency projects.			
2.	Sustainable Energy Authority to invoke the provision in the Act to impose a levy on fossil fuels and use this revenue to finance renewable energy and energy efficiency projects.			

1.3.9 Budget/Resource requirements

Table 1.6: Budget Estimate for Proposed Activities of Project 2

The budget values assigned for "international" are expected to be raised as grant component from donor agencies without burdening the national consumers. The "local" component of the budget is ultimately expected to be provided by the consumers and citizens of this country.

No.	Activity	Proposed Budget (US$)		Remarks
		International	Local	
Direct Activities				
1.	Preparation of a feasibility report on the technical and financial viability of using compact biogas digesters and Gliricidia leaf powder	150,000	Nil	Outright Grant
2.	Making arrangements for cultivation of Gliricidia as an agro-energy crop in underutilized lands.	Nil	Nil	Policy
3.	Donor Agencies to provide funds at low interest rate for renewable and energy efficiency project.	6,500,000	Nil	Loan at low interest
4.	Establishment of Agro-energy plantations in underutilized lands and in home gardens by the private sector.	Nil	Nil	Cost to be borne by the private sector
5.	Research institutions in Sri Lanka to resolve the issues in the production and use of feedstock for urban household biogas digester to a level acceptable by the consumer.	Nil	10,000	NERD Centre could carry this out
	Sub total	**6,650,000**	**10,000**	
Supporting Activities				
1.	Eliminating the taxes imposed on local construction in respect of renewable energy and energy efficiency projects.	Nil	Nil	Policy

2.	SEA to invoke the provision in the Act to impose a levy on fossil fuels and use this revenue to finance renewable energy and energy efficiency projects.	6,500,000	Nil	Guarantee fund to be used for consumers to purchase biogas units on loan.
	Sub total	**6,500,000**	**Nil**	
	Total	**13,000,000**	**10,000**	

1.3.10 Measurement/Evaluation

Monitoring: The progress of project activities will be monitored periodically by the committee coordinating the project. This committee will be constituted with representatives from the following institutions:

- Sustainable Energy Authority
- Ministry of Finance
- Ministry of Plantation Industries
- The Research Institution entrusted with the task of developing this technology
- Representative of Biogas digester users.

Evaluation: The Monitoring Committee is expected to nominate a suitable team to carry out the project evaluation and evaluate the performance and progress of the project and recommend appropriate corrective measures.

The monitoring and evaluation committee is expected to formulate quantitative and measurable indicators such as hectares of Gliricidia plantations established, tonnage of leaf material produced, number of biogas units installed, amount of funds generated etc. on a timely and regular basis.

1.3.11 Possible Complications/Challenges

The following complications and challenges need to be met:

- Operation of biogas needs careful attention. Failure to feed the digester regularly would result in inadequate gas production. This might discourage the housewives to switch back to LPG. Hence training the households on the proper operation of biogas digesters is essential.
- The use of underutilized state lands for agro-energy plantations by the private sector is a new activity in Sri Lanka. This too should be carefully handled.

- In order to be cost effective, the price of a kg of Gliricidia leaf powder should be marketed at a retail price of around US$0.15 per kg. It will be challenge to develop a technology to achieve this target.
- Inadequate support from some government institutions in the energy sector for full implementation of supporting activities proposed in the project may cause obstructions for implementation of these activities. Without full implementation of supporting activities it may not be possible to achieve proposed project targets as expected. Therefore it has to be treated as a risk factor.

1.3.12 Responsibilities and Coordination

The project will be coordinated by a committee consisting of representatives from the institutions and their respective responsibilities as per table given below (Table 1.3).

Table 1.7: Responsibilities of Project Coordination

No.	Institution/ Stakeholder	Responsibilities
1.	Sustainable Energy Authority	• Preparation of feasibility Report • Identification of Research Institution/ Non Government Organization to implement the project. • Collection of levy from fossil fuels and creation and operation of a renewable energy/energy efficiency guarantee fund.
2.	Research Institution / Non Government Organization responsible for the research and propagation of the technology.	• Project Implementing Agency • Development of a technology to produce and market Compact Biogas Digester and Gliricidia leaf powder at affordable prices. • Market the Compact Biogas Digester and Gliricidia leaf powder to urban households in Sri Lanka.
3.	Ministry of Finance and Planning	• Receipt and disbursement of donor contributions

Project Implementing Agency:

The **Research Institution or a Non Government Organization** identified will be the Implementing Agency for this project. This institution is expected to carry out the following project activities:

- Develop a suitable compact digester on the principle of the digester developed by Appropriate Rural Technology Institute (ARTI) of Pune, Maharashtra, India utilizing locally available materials.
- Develop a commercial method of production, packaging and marketing of Gliricidia leaf powder as feed material on the basis of research done by the University of Moratuwa.
- Make arrangements to market the digester and the feed material so that urban households could purchase these items conveniently from nearby shops or super markets at affordable prices.

1.3.13 List of References

2. ARTI Biogas Plant: A compact digester for producing biogas from food waste.
3. Calorific Values for Wood and Bark and Bibiliography for Fuelwood. A.P.Harker, A. Sandels and J.Burley. August 1982. Tropical Products Institute.
4. Energy Sector Master Plan, Sri Lanka. Interim Report. Asian Development Bank, April 2004.

   http://www.arti-india.org/index.php?option=com_content&view=article&id=45:arti-biogas-plant-a-compact-digester-for-producing-biogas-from-food-waste&catid=15:rural-energy-technologies&Itemid=52
5. Mahinda Chinthanaya: Vision for a New Sri Lanka. A 10 Year Horizon Development Framework, 2006 -2016, Department of National Planning, Ministry of finance and Planning.
6. National Energy Policies and Strategies of Sri Lanka. Ministry of Power and Energy. October 2006.
7. Prof. Ajith De Alwis, UOM,
8. The National Action plan for Haritha Lanka Program. Presidential Secretariat. January 2009.

1.4 Project Idea for Technology 3: Waste to Energy

1.4.1 Introduction and Background

The major difficulty encountered when MSW is combusted to generate energy is the production of dioxin (a highly toxic substance). This toxic substance is formed when combusting halogenated plastic materials such as PVC. To resolve this issue, an attempt has been made to use Plasma Gasification Technology. This process is very capital intensive and incurs high operational costs. As such, up to date no such facility has been introduced in Sri Lanka.

The introduction of the manufacture of RDF from MSW would obviate the above issue. In the manufacture of RDF the following procedures are followed:

1) All recyclable/ reusable components in MSW such as large combustible solid items, large plastic pieces, bottles, large hardboard pieces, metallic cans etc are recovered and sent for reuse/ recycle.
2) The balance part of MSW is first shredded into fine particles in a mechanical shredder.
3) The shredded particles are dried to remove moisture.
4) The dried particles are mechanically/ pneumatically sorted into different components such as organic materials, plastic/ polythene, grit etc.
5) Such separated factions are stored in separate silos.
6) Such separated factions are then blended in strict proportions and peletised.
7) Such pelletized materials have the following features:
8) They are uniform in size.
9) They have uniform physical and chemical properties.
10) The moisture content is less than 10%.

Such pelletized materials are known as RDF. RDF could be used as fuel in combination with other high quality fuels such as coal. Usually, RDF is used as a fuel in combination with coal in cement manufacture. In this process, dioxins formed from the combustion of halogenated plastics are partly decomposed due to the high temperature resulting from the use of coal and then are absorbed by the presence of Calcium Carbonate introduced in cement manufacture.

In the event the local cement manufacturing industries are reluctant to use RDF, it could be exported as there is a ready market for RDF.

1.4.2 Objectives

- To develop a technology to dispose Municipal Solid Waste (MSW) by converting it into Residue Derived Fuel (RDF) to be utilized by the cement industry as a fuel for the manufacture of cement.
- To reduce the consumption of imported coal in the manufacture of cement.

1.4.3 Outputs of the Proposed Project

- Availability of a Feasibility Report on the production and use of Residue Derived Fuel (RDF) from Municipal Solid Waste (MSW).
- Development of a technology to produce RDF from MSW in a cost effective manner (Cost of production of 1 tonnes of RDF should not exceed US$ 150).
- Establishment of a RDF manufacturing facility with a capacity of 50 tonnes per day in 5 years time.
- Reduction of consumption of coal in local cement manufacture by 50 tonnes per day.

1.4.4 Relationship to the country's sustainable development priorities

The Haritha (Green) Lanka Programme formulated by the Presidential Secretariat (The National Action Plan for Haritha Lanka Programme, Presidential Secretariat, January 2009) clearly identifies the disposal of Municipal Solid Waste (MSW) in a manner to minimize the environmental hazard resulted from the dumping of MSW in open dumps.

The Haritha Lanka Programme specifically addresses the issues of community health, and rural poverty. As part of this programme , the Ministry of Environment has focused on addressing the health aspects of unmanaged MSW by supporting a programme to utilize MSW for the production of compost. The ministry of Science and Technology's input in this respect to the Haritha Lanka Programme is to popularize Biogas technology utilizing the easily digestable components of MSW. By these projects, not only the menaces of unmanaged MSW is addressed, but also other aspects such as better air quality in households (by providing an alternative to wood based combustion), employment opportunities for the rural sector by way of cultivation of Gliricidia and production of leaf powder are also addressed.

1.4.5 Project Deliverables

- A comprehensive feasibility report on the financial and technical viability of the production and use of residue Derived Fuel (RDF) by utilizing Municipal Solid Waste (MSW). Such a document is a basic requirement from the point of view of local project approving agencies, particularly in the allocation of limited resources amongst competing project proposals.
- Development of a technology to convert Municipal Solid Waste (MSW) into Residue Derived Fuel (RDF) in a cost effective manner (Cost of RDF manufacture should not exceed US$ 150 per tonne). For this technology to be acceptable in Sri Lanka, it is essential to ensure that the cost of production of RDF does not exceed the cost of an equivalent amount of coal, which RDF is expected to replace.
- Installation and operation of a RDF facility with an output of 50 tonnes per day. As the city of Colombo alone produces well over 1000 tonnes of MSW per day, for this programme to be nationally significant, at least 10% of the MSW generated in the City of Colombo need to be utilized for this purpose. Hence an output of 50 tonnes of RDF or 100 tonnes of MSW input is considered an appropriate capacity for this project.
- A reduction of 44,877 tCO2 emission per year. In order to reach the ambitious target of totally carbon neutral country, this initial step would give adequate encouragement in achieving the target.
- A reduction in the open dumping of 100 tonnes of MSW per day. This is about 10% of MSW generated in the city of Colombo. Achieving this 10% target would be a catalyst to resolve the entire MSW problem in the country.

1.4.6 Project Scope and Possible Implementation

The scope of the initial phase of this project is to manufacture 50 toones of Residue Derived Fuel (RDF) by utilizing 100 tonnes of Municipal Solid Waste (MSW). The daily production of MSW in the country is over 2,800 tonne. It is intended to use the RDF produced as fuel for cement manufacture. The daily demand for this in the cement industry at present is 200 tonnes per day In the future this quantity would be doubled.

If this technology is successfully developed, it could be expanded many fold. In the event the RDF manufactured is unable to be used locally, it could be exported, as many cement mills in the world are importing RDF.

1.4.7 Project activities

The project activities are divided into two categories as direct activities and supporting activities. Direct activities include activities directly relevant to the development of the technology Waste to Energy. Supporting activities include activities related to government policies which are important in promoting the diffusion of the technology.

a) Direct Activities of the Project:

1. Preparation and publication of a Feasibility Report on the Financial and Technical viability of a 50 tonne per day Residue Derived Fuel (RDF).
2. Donor Agencies to provide funds at low interest rate for renewable and energy efficiency project.
3. The Waste Management Authority of Western Province to ensure that 100 tonnes of Municipal Solid Waste (MSW) are available per day to an identified private investor.
4. State sector collaborating with the private sector in the investment and operation of a 50 tonne per day RDF facility through a PPP (public private partnership) program.
5. Establishment operation of a RDF facility with a capacity of 50 tonnes per day and sell RDF to the local cement industry or to export to cement industries overseas.

b) Supporting Activities of the Project:

1. Eliminating the taxes imposed on local construction in respect of renewable energy and energy efficiency projects.
2. Sustainable Energy Authority to invoke the provision in the Act to impose a levy on fossil fuels and use this revenue to finance renewable energy and energy efficiency projects.

1.4.8 Timelines for the Proposed Activities

Table 1.8: Timelines for the Proposed Activities of Project 3

The time frames of year 1, year 2 and year 3 to 25 are chosen taking into account the project initiation, commissioning and operational phases of the project.

No.	Activity	Year 1	Year 2	Year 3 to Year 25
a) Main Activities				
1.	Preparation and publication of a Feasibility Report on the Financial and Technical viability of a 50 tonne per day Residue Derived Fuel (RDF)			
2.	Donor Agencies to provide funds at low interest rate for renewable and energy efficiency project			
3.	The Waste Management Authority of Western Province to ensure that 100 tonnes of Municipal Solid Waste (MSW) are available per day to an identified private investor.			
4.	State sector collaborating with the private sector in the investment and operation of a 50 tonne per day RDF facility through a PPP (public private partnership) program.			
5.	Establishment and operation of a 50 tonne per day a Residue Derived Facility (RDF) and sell RDF to the local cement manufacturers or to export it.			
b) Supporting Activities				
1.	Elimination of taxes on local construction			
2.	SEA to invoke the provision in the Act to impose a levy on fossil fuels and use this revenue to finance renewable energy and energy efficiency projects			

1.4.9 Budget/Resource requirements

Table 1.9: Budget Estimate for Proposed Activities of Project 3

The budget values assigned for "international" are expected to be raised as grant component from donor agencies without burdening the national consumers. The "local" component of the budget is ultimately expected to be provided by the consumers and citizens of this country.

No.	Activity	Proposed Budget (US$)		Remarks
		International	Local	
a) Main Activities				
1.	Preparation and publication of a Feasibility Report on the Financial and Technical viability of a 50 tonne per day Residue Derived Fuel (RDF)	150,000	Nil	Outright Grant
2.	Donor Agencies to provide funds at low interest rate for renewable and energy efficiency project	500,000	Nil	Low interest loan
3.	The Waste Management Authority of Western Province to ensure that 100 tonnes of Municipal Solid Waste (MSW) are available per day to an identified private investor.	Nil	Nil	Policy
4.	State sector collaborating with the private sector in the investment and operation of a 50 tonne per day RDF facility through a PPP (public private partnership) program.	Nil	Nil	Disbursement of local and donor funds
5.	Establishment and operation of a 50 tonne per day a Residue Derived Facility (RDF) and sell RDF to the local cement manufacturers or to export it.	Nil	Nil	Necessary equity to be provided by the private sector
Sub total		**650,000**	**Nil**	
b) Supporting Activities				
1.	Elimination of taxes on local construction	Nil	Nil	Policy
2.	SEA to invoke the provision in the Act to impose a levy on fossil fuels and use this	Nil	500,000	Guarantee Fund to be used by developer to

	revenue to finance renewable energy and energy efficiency projects			raise a loan
Sub total		**Nil**	**500,000**	
	Total	**650,000**	**500,000**	

1.4.10 Measurement/Evaluation

Monitoring: The progress of project activities will be monitored and periodically by the committee coordinating the project. This committee will be constituted with representatives from the following institutions:

- Sustainable Energy Authority
- Ministry of Finance
- Ministry of Commerce and Industries
- Western Provincial Council/ Waste Management Authority
- Ministry of Local Government
- Ministry of Environment
- Representative of investor of RDF manufacturing facility.

Evaluation: The Monitoring Committee is expected to nominate a suitable team to carry out evaluation and to evaluate the performance and progress of the project and recommend appropriate corrective measures.

The monitoring and evaluation committee is expected to formulate quantitative and measurable indicators such as tonnage of MSW processed, tonnage of RDF produced, amount of funds generated etc. on a timely and regular basis.

1.4.11 Possible Complications/Challenges

The following complications and challenges need to be met:

- Although the manufacture of Residue Derived Fuel (RDF) from Municipal Solid Waste (MSW) is practiced extensively in many parts of the world, in Sri Lanka this is a new phenomenon. Hence the introduction of this technology should be done with due care.
- The marketing of the RDF produced in Sri Lanka involves another private sector institution (Holcim Ltd.). Establishing and honouring a long term agreement between two private sector institution is a challenge.

- Municipal Solid Wastes (MSW) available in Sri Lanka are high in moisture. Arrangement should be made to get this dried. This would involve special trucks to transport and delivery after drying. This would also involve another private sector institution.
- As MSW contains halogenated plastics and heavy metals, action should be taken to ensure that RDF manufactured out of MSW is used only in cement manufacture and not in any other heat generation facility.
- Inadequate support from some government institutions in the energy sector for full implementation of supporting activities proposed in the project may cause obstructions for implementation of these activities. Without full implementation of supporting activities it may not be possible to achieve proposed project targets as expected. Therefore it has to be treated as a risk factor.

1.4.12 Responsibilities and Coordination

Responsibilities of Project Coordination are provided in table 1.10.

Table 1.10: Responsibilities of Project Coordination

Institution/ Stakeholder	Responsibilities
Sustainable Energy Authority	• Conduct a feasibility study on the technical and financial viability of manufacturing Residue Derived Fuel (RDF) from Municipal Solid waste (MSW). • Collection of levy from fossil fuels and creation and operation of a renewable energy/energy efficiency guarantee fund.
Ministry of Finance	• Receipt and disbursement of donor contributions
Ministry of Commerce & Industries	• Coordinating the sale of RDF to Cement industry
Western Provincial Council/ Waste Management Authority/ Ministry of Local Government	• Identify a suitable private sector developer for the manufacture of 50 tonnes of RDF per day. • Ensuring the availability of 100 tonnes of MSW per day to the RDF manufacturer.
Private Sector Project Developer	• Project Implementing Agency • Identify and acquire the RDF manufacturing technology. • Procure, install and manufacture RDF. • Arrange with Waste Management Authority to obtain daily requirements of 100 tonnes of MSW. • Market RDF to a local or overseas cement industry.
Ministry of Environment	• Ensure that all environmental regulations are complied with.

Project Implementing Agency:

The private sector developer identified by the Waste Management Authority will be the implementing agency. This developer is expected to carry out the following tasks:

- Identify and acquire the RDF manufacturing technology.
- Procure, install and manufacture RDF.
- Arrange with Waste Management Authority to obtain daily requirements of 100 tonnes of MSW.

Market RDF to a local or overseas cement industry.

1.4.13 List of References

1. Calorific Values for Wood and Bark and Bibiliography for Fuelwood. A.P.Harker, A. Sandels and J.Burley. August 1982. Tropical Products Institute.
2. Energy Sector Master Plan, Sri Lanka. Interim Report. Asian Development Bank, April 2004.
3. European Commission – Directorate, General Environment, Refuse Derived Fuel, Current Practice and Perspectives (B4-040/2000/306517/Mar/E3); Final Report, Wrc Ref: Co5087-4, July 2003).
4. *Mahinda Chinthanaya:* Vision for a New Sri Lanka. A 10 Year Horizon Development Framework, 2006 -2016, Department of National Planning, Ministry of finance and Planning.
5. National Action Plan for Harith Lanka Programme, Presidential Secretariat, January 2009.
6. National Energy Policies and Strategies of Sri Lanka. Ministry of Power and Energy. October 2006.
7. Renewable Energy World, July-August 2011.

1.5 Project Idea for Technology 4: Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration

1.5.1 Introduction and Background

The potential for wind and solar PV based electricity generation in Sri Lanka is very significant. The capital costs of these two technologies are gradually getting reduced. In the near future, these two technologies are likely to reach grid parity status. When that state is reached, these two technologies could play very significant roles in meeting the electrical energy needs of Sri Lanka and in fulfilling the policy of generating 10% and 20% of the total electricity generation through new renewable energy resources by the year 2015 and 2020 respectively.

However, recent experiences in Sri Lanka with these two technologies have resulted in difficulties in balancing the supply and demand of the national grid and maintaining system stability. The reason for this phenomenon is that unsteady or variability of energy outputs of these two energy sources. The speed of wind at any given location in Sri Lanka is constantly changing. This results in the output of wind turbines constantly fluctuating. Similarly, the passage of clouds in the sky in the locations where solar PV panels are installed results in rapidly changing the output of solar PV systems. Such variations in the output of these two sources have created difficulties in balancing the input-output entities in the national electricity grid.

In fact, granting approvals for Wind and Solar based electricity generating projects by the private sector are presently suspended until this issue of managing the variability in output of these two technologies is resolved.

The problem of variability in outputs of Wind and Solar PV technologies has been resolved in some of the industrialized countries. In these countries, the variability in the supply side of wind and solar PV systems are managed by adjusting the demand side by varying the loads of identified consumers through Smart Grid Technology. Such technology could be applied in Sri Lanka by varying the outputs of hydro power plants according the variability of outputs of the wind and solar power plants.

It is proposed to introduce these technologies to the electricity network in Sri Lanka with the view of increasing the share of wind, solar and small hydro based generation.

1.5.2 Objectives

- To develop a set of technologies to balance the varying outputs of wind, solar and small hydro power plants with varying demand in the electricity network in Sri Lanka.
- To enhance the capacity of various components in the electricity network to enable it accept a larger share of input from wind, solar and small hydro power sources.
- To enhance the capability of the Metrological Department in Sri Lanka to enable it to provide more accurate and early weather forecasts.
- To build the capacity of all relevant institutions in Sri Lanka to enable these institutions to acquire adequate knowledge to deploy modern technologies to enhance the share of energy from wind, solar and small hydro power plants.

1.5.3 Outputs of the Proposed Project

- A comprehensive feasibility report on the financial and technical viability of enhancing the share of wind, solar and small hydro through smart grid and infrastructure improvement and improved weather forecasting technologies.
- Enhancement of national electricity network with the ability to absorb (3761 GWh/y) 20% of the total generation capacity from solar, wind and small hydro sources.
- Enhancement of weather forecasting facility at the national Metrological Department with the ability to forecast accurately the weather parameters to enable the electricity producers of solar, wind and small hydro to optimize their electricity generation.
- Enhancement of knowledge base of officials in electricity generation and weather forecasting sectors to enable them to optimize electricity generation from solar, wind and small hydro power plants.

1.5.4 Relationship to the country's sustainable development priorities

According to the National Energy Policies and Strategies of Sri Lanka of October 2006, the policy is to generate at least 10% of the total electrical energy from new renewable energy resources by the year 2015. And as per "Mahinda Chinthanaya: Vision for a New Sri Lanka. A 10 Year Horizon Development Framework, 2006 -2016" this share is expected to be 20% by the year 2020. This project will enable the country to achieve these targets.

1.5.5 Project Deliverables

As a result of the introduction of this technology, the capacities of solar, wind and small hydro power plants and their respect generation capabilities will be increased as per the table given below.

Year	Generation Capacity (MW)			Annual Electricity Generation (GWh/y)		
	Solar	Wind	Small Hydro	Solar	Wind	Small Hydro
2011	0	47	194	0	118	604
2020	161	401	399	240	1124	1468
2037	410	1079	499	647	3026	1836

The government of Sri Lanka has set the above targets taking into consideration the following:

- The present share of indigenous resources Vs. imported resources based electricity generation in the country is 40:60. In a decade, as per the present plan, this situation is expected to worsen reaching a value of 20: 80. In respect of transport fuel, the entire requirements of fuel are imported. Such a large share of imported energy is very unhealthy for the energy security of this country. Hence the government wants to reduce the share on import based energy.
- Out of a total of nearly 10 billion US$ worth of annual exports, over 60% goes for the import of fuels. This compounded by the very adverse balance of payments issues experienced in the country, has made the government to encourage all concerned to develop indigenous sources of energy.
- The development and utilization of indigenous resources also lead to increased local value addition thus increase the generation of local wealth. Most of such wealth goes to the poorer segment of rural communities. This will enable the government objectives of achieving better wealth distribution.

1.5.6 Project Scope and Possible Implementation

The scope of this project is to enhance the capability of the national electricity network to be able to absorb the large potential of electricity generation capacity from solar, wind and small hydro on a very long term basis (for the next 25 years). The electrical energy demand of the country is expected to grow around 8% per annum for the next 25 years. The utility is planning to generate at least 80% of these requirements

through coal based generation. The scope of this project is to maintain the share of electricity generation from solar, wind, small hydro and biomass at 20% of the total generation for the next 25 years.

1.5.7 Project Activities

The project activities are divided into two categories as direct activities and supporting activities. Direct activities include activities directly relevant to transfer and diffusion of the technology. Supporting activities include activities related to government policies which are important in promoting the diffusion of the technology.

Direct activities: (Activities relevant to the direct implementation of this technology)

1. Preparation and publication of a Feasibility Report on the Financial and Technical viability of enhancing the capability of the electricity network to be able to absorb 20% of the total electricity generation from solar, wind, small hydro and biomass starting from the year 2020 till about 2037. This enhanced capability is to be achieved through smart grid technology and optimization generation through better weather forecasting.
2. Technical colleges and universities should include Smart Grid/ Smart Meter technologies in their curricula.
3. Relevant officials of institutions involved in the implementation of these technologies to be sent for training to countries where these technologies are practiced.
4. Enhance the facilities at Meteorological Department to enable it to forecast accurately and quickly the weather parameters to facilitate the energy sector to optimize electricity generation from solar, wind and small hydro.
5. Improve the shape of the daily electricity load curve by combinations of measures such as: smart grid/ smart meter technologies, appropriate dynamic time based tariffs, regulatory measures and energy storage technologies including ice manufacturing during off-peak hours to be used for refrigeration during peak load time.
6. Ensure wider consultations prior to environmental legislations.

Supporting Activities: (Activities indirectly affect the implementation of the technology - Government policies which are important in promoting the diffusion of the technology)

1. Eliminating the taxes imposed on local construction in respect of renewable energy and energy efficiency projects.
2. Donor Agencies to provide funds at low interest rate for renewable and energy efficiency project.

3. Sustainable Energy Authority to invoke the provision in the Act to impose a levy on fossil fuels and use this revenue to finance renewable energy and energy efficiency projects.
4. During generation planning the costs of impacts fossil fuel use on external entities (such as health, agriculture) to be added to the direct costs of electricity generation.

1.5.8 Timelines for the Proposed Activities

Table 1.11: Timelines for the Proposed Activities of Project 4

The time frames of year 1, year 2 and year 3 to 25 are chosen taking into account the project initiation, commissioning and operational phases of the project.

No.	Activity	Year 1	Year 2	Year 3 to Year 25
Direct activities:				
1.	Feasibility Report on the Financial and Technical viability of enhancing the capability of the electricity network (As described in activity 1).			
2.	Technical colleges and universities should include Smart Grid/ Smart Meter technologies in their curricula.			
3.	Relevant officials of institutions involved in the implementation of these technologies to be provided with relevant training (As described in activity 3).			
4.	Enhance the facilities at Meteorological Department to enable it to forecast accurately and quickly the weather parameters to facilitate the energy sector.			
5.	Improve the shape of the daily electricity load curve as described in activity 5.			
6.	Ensure wider consultations prior to environmental legislations.			
Supporting Activities:				
1.	Eliminating the taxes imposed on local construction in respect of renewable energy and energy efficiency projects.			
2.	Donor Agencies to provide funds at low interest rate for renewable and energy efficiency project.			
3.	SEA to invoke the provision in the Act to impose a levy on fossil fuels and use this revenue to finance renewable energy and energy efficiency projects.			

4.	During generation planning the costs of impacts fossil fuel use on external entities (such as health, agriculture) to be added to the direct costs of electricity generation.			

1.5.9 Budget/Resource requirements

Table 1.12: Budget Estimate for Proposed Activities of Project 4

The budget values assigned for "international" are expected to be raised as grant component from donor agencies without burdening the national consumers. The "local" component of the budget is ultimately expected to be provided by the consumers and citizens of this country.

No.	Activity	Proposed Budget (US$)		Remarks
		International	Local	
	Direct activities:			
1.	Preparation and publication of a Feasibility Report on the Financial and Technical viability of enhancing the capability of the electricity network (As described in activity 1).	150,000	Nil	Outright Grant
2.	Technical colleges and universities should include Smart Grid/ Smart Meter technologies in their curricula.	Nil	Nil	Vote of the Ministries of HE/VT
3.	Relevant officials of institutions involved in the implementation of these technologies to be sent for training (As described in activity 3).	1,000,000	Nil	Outright grant by donor agencies
4.	Enhance the facilities at Meteorological Department to enable it to forecast accurately and quickly the weather parameters to facilitate the energy sector.	20,000,000	Nil	
5.	Improve the shape of the daily electricity load curve as described in activity 5.	Nil	Nil	Through tariff and regulatory measures
6.	Ensure wider consultations prior to environmental legislations.	Nil	Nil	Policy
Sub total		**21,150,000**		
	Supporting Activities:			
1.	Eliminating the taxes imposed on local construction in	Nil	Nil	Policy

	respect of renewable energy and energy efficiency projects.			
2.	Donor Agencies to provide funds at low interest rate for renewable and energy efficiency project.	50,000,000	Nil	Out right grant
3.	SEA to invoke the provision in the Act to impose a levy on fossil fuels and use this revenue to finance renewable energy and energy efficiency projects.	50,000,000	Nil	
4.	During generation planning the costs of impacts fossil fuel use on external entities to be added to the direct costs of electricity generation.	150,000	Nil	
Sub total		**100,150,000**		
	Total	**121,300,000**	**Nil**	

1.5.10 Measurement/Evaluation

Monitoring: The progress of project activities will be monitored periodically by the committee coordinating the project. This committee will be constituted with representatives from the following institutions:

- Ceylon Electricity Board
- Ministry of Power and Energy
- Ministry of Finance
- Sustainable Energy Authority
- Department of Meteorology
- Ministry of Environment
- Ministry of Higher Education

Evaluation: The Monitoring Committee is expected to nominate a suitable team to evaluate the performance and progress of the project and recommend appropriate corrective measures.
The monitoring and evaluation committee is expected to formulate quantitative and measurable indicators such as the share of renewable in the electricity mix on a timely and regular basis.

1.5.11 Possible Complications/Challenges

The following complications and challenges need to be met:

- Although Smart Grid / Smart Meter technology in conjunction with hydropower storage is practiced extensively in many parts of the world, in Sri Lanka this is a new phenomenon. Hence the introduction of this technology is bound to face many teething problems.

- The cost of implementation of this technology as perceived by the primary stakeholder – Ceylon Electricity Board (CEB) is extremely high, as it requires large amount of money for infrastructure developments of the CEB and the Meteorological Department. Moreover, CEB is also of the view that this cost should not be passed on to the electricity consumers. Raising such large amount of money as grant fund is very challenging.
- Inadequate support from some government institutions in the energy sector for full implementation of supporting activities proposed in the project may cause obstructions for implementation of these activities. Without full implementation of supporting activities it may not be possible to achieve proposed project targets as expected. Therefore it has to be treated as a risk factor.

1.5.12 Responsibilities and Coordination

Table 1.13: Responsibilities of Project Coordination

Institution/ Stakeholder	Responsibilities
Ceylon Electricity Board/ Ministry of Power & Energy	• Primary Implementing Agency – implementation of all aspects of electricity infrastructure expansion, incorporation of smart grid/ smart metering technology with the existing network, introduction of appropriate tariffs and enhancing knowledge and skills of employees.
Department Meteorology	• Enhancing the resources and providing accurate and quick forecasts of weather parameters with the view to optimize energy generation from solar, wind and small hydro sources.
Sustainable Energy Authority	• Collection of levy from fossil fuels and creation and operation of a renewable energy/energy efficiency guarantee fund.
Ministry of Finance	• Receipt and disbursement of donor contributions
Ministry of Environment	• Ensure that all environmental regulations are complied with.
Ministries of Higher Education and Vocational Training	• Introduction of these technologies in the respective curricula.

Implementing Agency:

Ceylon Electricity Board (CEB) has been identified as the Implementing Agency of this project. This project is all about optimization of the energy generation resources within the CEB's network. It also involves the managing the demands of over 5 million different consumers in a dynamic manner on a continuous manner. This institution should also receive data/ information from the Meteorological Department and integrate that with the operation and management of its generation resources. In addition, this institution should also enhance the knowledge and skills of its employees on Smart Grid/ Smart Meter technologies.

1.5.13 List of References

2. Standardized Power Purchase Tariff, 2011. Sri Lanka sustainable Energy Authority.
3. Long Term Generation Expansion Plan, 2011-2025. Ceylon Electricity Board. December 2010.
4. Long Term Transmission Development Plan 2011-2025. Ceylon Electricity Board. 2010.
5. Energy Sector Master Plan, Sri Lanka. Interim Report. Asian Development Bank, April 2004.
6. National Energy Policies and Strategies of Sri Lanka. Ministry of Power and Energy. October 2006.
7. Statistical Digest 2010. Ceylon Electricity Board, 2011.
8. Mahinda Chinthanaya: Vision for a New Sri Lanka. A 10 Year Horizon Development Framework, 2006 -2016, Department of National Planning, Ministry of finance and Planning.
9. http://www.energyservices.lk/statistics/esd_rered.htm
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12. Technical Report, NREL/TP-5000-50181, December 2011, IEA Wind Task 24 Integration of Wind and Hydropower Systems. Volume 1: Issues, Impacts, and Economics of Wind and Hydropower Integration. *Authors:* Tom Acker, Northern Arizona University on behalf of the National Renewable Energy Laboratory U.S. Department of Energy Wind and Hydropower Program. Prepared for the International Energy Agency Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems.
13. Integrating Wind Power into the Electric Grid – Perspective for Policy Makers. ISBN 978-1-58024-555-5. www.ncsl.org/programs/energy/RenEnerpage.html
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1.6 Project Idea for Technology 5: LED Lighting

1.6.1 Introduction and Background

Over 10% of the total electrical energy generated in Sri Lanka is utilized for lighting applications. A larger part of this energy is consumed during daily peak time. Hence it is imperative that for lighting purposes the most efficient technology should be utilized. Presently, the technologies used lighting includes incandescent lamps, mercury/ sodium discharge lamps, linear fluorescent lamps and compact fluorescent lamps. A new lighting technology utilizing Light Emitting Diode (LED) has been in many countries. This technology is slowly entering Sri Lanka. This project proposes to promote the wider use of this technology. LED lamps have the following advantages:

- The efficacy (light output in lumen per watt of electricity consumed) is much higher than any other type of lamp. Hence the energy consumption is much less for a given application.
- The life of the lamp is much longer. Typically LED lamps last 40,000 to 50,000 hours compared to 1000 hours for Incandescent and 10,000 hours for Compact Fluorescent Lamps (CFLs). This feature has two implications. (a) The cost of replacement lamps itself is reduced as replacement frequency is less. (b) In situations such as street lamps, it is not only the cost of the lamp, but also the cost of lifting devices, cost of interruption of traffic etc. are also reduced as the frequemcy of replacement is less.
- Lower cost of manufacturing the desired colour of illumination.
- Harmonics introduced in the power supply, if any, is very small compared to lamps such as CFL.
- LED lamps gives adequate indication of lamp failure by very gradually lowering their light outputs, instead of stop functioning all of a sudden. This feature of LEDs is very desirable in situations such as surgical operating theaters, where failure of lamps while in use could cause serious disruptions.
- LED lamps do not emit any ultraviolet or any other undesirable radiation. Hence health hazards associated with such radiations are eliminated.
- The disposal of discharge lamps (such as CFL, fluorescent lamps, mercury/ sodium vapour lamps encounters heavy metal pollution. Disposal of LED lamps do not encounter such problems.

1.6.2 Objectives

To assist the Sustainable Energy Authority to accelerate and enhance the promotion of LED lamps for appropriate applications in Sri Lanka.

1.6.3 Outputs of the Proposed Project

- A comprehensive feasibility report on the financial and technical viability of replacing Incandescent, Compact Fluorescent Lamp (CFL), Cold Cathode Fluorescent Lamp (CCFL), linear florescent and discharge lamps such as Sodium, Mercury lamps with Light Emitting Diode (LED) lamps for appropriate applications.
- Enhancing the knowledge on the merits of LEDs to relevant sections of the population.

1.6.4 Relationship to the country's sustainable development priorities

Section 2.3 of the National Energy Policies and Strategies of Sri Lanka of October 2006, specifically deals with Promoting Energy Efficiency and Conservation According to this section, Energy supply systems will be efficiently managed and operated while also ensuring efficient utilization and conservation of energy.
The government of Sri Lanka is very keen to reduce the foreign expenditure on energy related matters. Hence the government is promoting indigenous resources based energy development and energy conservation for the following reasons:

- The present share of indigenous resources Vs. imported resources based electricity generation in the country is 40:60. In a decade, as per the present plan, this situation is expected to worsen reaching a value of 20: 80. In respect of transport fuel, the entire requirements of fuel are imported. Such a large share of imported energy is very unhealthy for the energy security of this country. Hence the government wants to reduce the share on import based energy.
- Out of a total of nearly 10 billion US$ worth of annual exports, over 60% goes for the import of fuels. This compounded by the very adverse balance of payments issues experienced in the country, has made the government to encourage all concerned to develop indigenous sources of energy.
- The development and utilization of indigenous resources also lead to increased local value addition thus increase the generation of local wealth. Most of such wealth goes to the poorer segment of rural communities. This will enable the government objectives of achieving better wealth distribution.

1.6.5 Project Deliverables

As a result of this project at least 70 kW of lighting load will be reduced every year from 2013 to 2017. Such a reduction would enable the government in reducing energy consumption thereby reducing the foreign expenditure. This in turn will improve balance of payment and other related issues.

1.6.6 Project Scope and Possible Implementation

The Sustainable Energy Authority (SEA) has already initiated a comprehensive programme to reduce energy consumption in the lighting sector. Identification lighting applications suitable for the use of LEDs and the promotion of the use of LED is one such activity. This project will assist and support SEA by addressing the issue of awareness of the merits of LEDs amongst relevant stakeholders.

1.6.7 Project activities

The following are the project activities:

1. Preparation and publication of a Feasibility Report on the Financial and Technical viability of introducing LEDss in appropriate lighting applications.
2. Introduce and operate a labeling scheme for LEDs
3. Introduce a scheme to ensure replacement of defective LEDs
4. Support the Awareness Programme initiated by SEA on LEDs

1.6.8 Timelines for the Proposed Activities

Table 1.14: Timelines for the Proposed Activities of Project 5

The time frames of year 1, year 2 and year 3 to 25 are chosen taking into account the project initiation, commissioning and operational phases of the project.

No.	Activity	Year 1	Year 2	Year 3 to Year 25
1.	Preparation and publication of a Feasibility Report on the Financial and Technical viability of introducing LEDs for appropriate lighting applications.			
2.	Introduce and operate a labeling scheme for LEDs			
3	Introduce a scheme to ensure replacement of defective LEDs			
4.	Support the Awareness Programme initiated by SEA on LEDs			

1.6.9 Budget/Resource requirements

Table 1.15: Budget Estimate for Proposed Activities of Project 5

The budget values assigned for “international” are expected to be raised as grant component from donor agencies without burdening the national consumers. The “local” component of the budget is ultimately expected to be provided by the consumers and citizens of this country.

No.	Activity	Proposed Budget (US $)		Remarks
		International	Local	
1.	Preparation and publication of a Feasibility Report on the Financial and Technical viability of introducing LEDs for appropriate lighting applications.	150,000	Nil	Outright Grant
2.	Introduce and operate a labeling scheme for LEDs	150,000	Nil	Outright Grant

3.	Introduce a scheme to ensure replacement of defective LEDs	150,000	Nil	Outright Grant
4	Support the Awareness Programme initiated by SEA on LEDs	150,000	Nil	Outright Grant
	Total	**600,000**		

1.6.10 Measurement/Evaluation

Monitoring: The progress of project activities will be monitored periodically by the committee coordinating the project. This committee will be constituted with representatives from the following institutions:

- Ceylon Electricity Board
- Ministry of Power and Energy
- Ministry of Finance
- Sustainable Energy Authority

Evaluation: The Monitoring Committee is expected to nominate a suitable team to evaluate the performance and progress of the project and recommend appropriate corrective measures.

The monitoring and evaluation committee is expected to formulate quantitative and measurable indicators such as number and power of LED lamps introduced, amount of funds generated etc. on a timely and regular basis.

1.6.11 Possible Complications/Challenges

The following complications and challenges need to be met:

- As LED lamps are relatively expensive and one of the benefits of using LEDs arises from the long life of the lamps, arrangement should be made to ensure customers who purchase these lamps get a replacement in case of lamp defects or lamp failure.

1.6.12 Responsibilities and Coordination

Table 1.16: Responsibilities of Project Coordination

Institution/ Stakeholder	Responsibilities
Sustainable Energy Authority	• Collection of levy from fossil fuels and creation and operation of an energy efficiency guarantee fund. • Preparation of Feasibility Report • Study on the appropriate areas of application of LEDs. • Introduction of a Labeling Scheme for LED lamps. • Introduction of a Refund/ Replacement for premature failure of LED lamps. • Onducting Awareness Programmes on the meriots of LEDs.
Ministry of Finance	• Receipt and disbursement of donor contributions
Ministries of Higher Education and Vocational Training	• Introduction of these technologies in the respective curricula.

Implementing Agency:

Sustainable Energy Authority (SEA) has already initiated a very comprehensive programme on reducing the energy consumption in the lighting sector. As this project is an extension of the ongoing activity already undertaken by the SEA, it is appropriate that **Sustainable Energy Authority be the primary implementing agency for this project.**

1.6.13 List of References

1. Long Term Generation Expansion Plan, 2009-2022. Ceylon Electricity Board. December 2008.
2. Long Term Transmission Development Plan 2005-2014. Ceylon Electricity Board. 2005.
3. Energy Sector Master Plan, Sri Lanka. Interim Report. Asian Development Bank, April 2004.
4. National Energy Policies and Strategies of Sri Lanka. Ministry of Power and Energy. October 2006.
5. Statistical Digest 2010. Ceylon Electricity Board, 2011.
6. Mahinda Chinthanaya: Vision for a New Sri Lanka. A 10 Year Horizon Development Framework, 2006 -2016, Department of National Planning, Ministry of finance and Planning.
7. http://www.energyservices.lk/statistics/esd_rered.htm

1.7 Project Idea for Technology 6: Solar Assisted Air Conditioning

1.7.1 Introduction and Background

Over 10% of the total electricity generated in Sri Lanka is utilized for air conditioning of buildings. Almost all these air conditioners utilize the electrically operated vapour compression technology. In the proposed technology, solar heat is used to provide a part of the energy needed for this application. This would result a reduction about 20% of the electrical energy used for air conditioning.

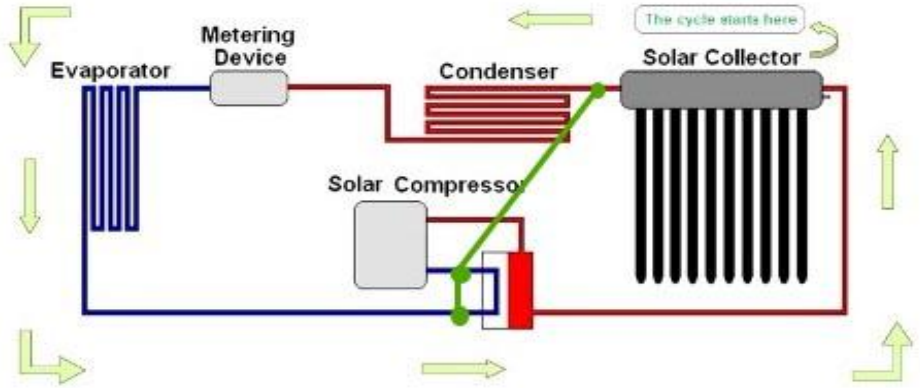

Figure 1.1: Solar Assisted Air Conditioning System

In the proposed technology, the green line part of the convention air conditioning cycle in the diagram shown above, is replaced by a solar collected and heat exchanger.

1.7.2 Objectives

To install a Window Type Solar Assisted Air Conditioner at the office of the Sustainable Energy Authority to monitor and verify its performance and disseminate the merits of this technology to all prospective users of this technology in Sri Lanka.

1.7.3 Outputs of the Proposed Project

- A comprehensive feasibility report on the financial and technical viability of Solar Assisted Air Conditioning Technology.
- Diffusion of Solar Assisted Air Conditioning Technology amongst all users of air conditioning systems in Sri Lanka.

1.7.4 Relationship to the country's sustainable development priorities

Section 2.3 of the National Energy Policies and Strategies of Sri Lanka of October 2006, specifically deals with Promoting Energy Efficiency and Conservation According to this section, Energy supply systems will be efficiently managed and operated while also ensuring efficient utilization and conservation of energy.

The government of Sri Lanka is very keen to reduce the foreign expenditure on energy related matters. Hence the government is promoting indigenous resources based energy development and energy conservation for the following reasons:

- The present share of indigenous resources Vs. imported resources based electricity generation in the country is 40:60. In a decade, as per the present plan, this situation is expected to worsen reaching a value of 20: 80. In respect of transport fuel, the entire requirements of fuel are imported. Such a large share of imported energy is very unhealthy for the energy security of this country. Hence the government wants to reduce the share on import based energy.
- Out of a total of nearly 10 billion US$ worth of annual exports, over 60% goes for the import of fuels. This compounded by the very adverse balance of payments issues experienced in the country, has made the government to encourage all concerned to develop indigenous sources of energy.
- The development and utilization of indigenous resources also lead to increased local value addition thus increase the generation of local wealth. Most of such wealth goes to the poorer segment of rural communities. This will enable the government objectives of achieving better wealth distribution.

1.7.5 Project Deliverables

As a result of this project at least 100 kW of air conditioning load will be reduced every year from 2013 to 2017. As an initial step, this would enable the government to demonstrate this technology so that a significant amount of air-conditioning load is reduced.

1.7.6 Project Scope and Possible Implementation

The scope of this project is to install, operate and monitor and verify the performance of a Solar Assisted Air Conditioning system and to take action to diffuse this technology to all users of air conditioning systems in Sri Lanka.

1.7.7 Project activities

The following are the project activities:

- Preparation and publication of a Feasibility Report on the Financial and Technical viability of Solar Assisted Air Conditioning System. Introduction of a government policy of not subsidizing fossil fuels.
- Eliminating the taxes imposed on energy efficiency projects.
- Donor Agencies to provide funds at low interest rate for energy efficiency project.
- Sustainable Energy Authority to invoke the provision in the Act to impose a levy on fossil fuels and use this revenue to finance energy efficiency projects.
- Technical colleges and universities to include Solar Assisted Air Conditioning System in their curricula.
- Procurement, installation, operation and monitoring of a Solar Assisted Air Conditioning System.
- Diffusion of Solar Assisted Air Conditioning System to all users of air conditioning system in Sri Lanka.

1.7.8 Timelines for the Proposed Activities

Table 1.17: Timelines for the Proposed Activities of Project 6

The time frames of year 1, year 2 and year 3 to 25 are chosen taking into account the project initiation, commissioning and operational phases of the project.

No.	Activity	Year 1	Year 2	Year 3 to Year 25
1.	Preparation and publication of a Feasibility Report on the Financial and Technical viability of Solar Assisted Air Conditioning Technology.			
2.	Eliminating the taxes imposed on local construction in respect of energy efficiency projects.			
3.	Donor Agencies to provide funds at low interest rate for energy efficiency projects.			
4.	Sustainable Energy Authority to invoke the provision in the Act to impose a levy on fossil fuels and use this revenue to finance energy efficiency projects.			

5.	Technical colleges and universities should include Solar Assisted Air Conditioning System technology in their curricula.			
6.	Procurement, installation, operation and monitoring of a Solar Assisted Air Conditioning System.			
7.	Diffusion of Solar Assisted Air Conditioning System to all users of air conditioning system in Sri Lanka			

1.7.9 Budget/Resource requirements

Table 1.18: Budget Estimate for Proposed Activities of Project 6

The budget values assigned for "international" are expected to be raised as grant component from donor agencies without burdening the national consumers. The "local" component of the budget is ultimately expected to be provided by the consumers and citizens of this country.

No.	Activity	Proposed Budget (US$)		Remarks
		International	Local	
1.	Preparation and publication of a Feasibility Report on the Financial and Technical viability of Solar Assisted Air Conditioning Systems	150,000	Nil	Outright Grant
2.	Eliminating the taxes imposed on local construction in respect of energy efficiency projects.	Nil	Nil	Policy
3.	Sustainable Energy Authority to invoke the provision in the Act to impose a levy on fossil fuels and use this revenue to finance energy efficiency projects.	Nil	1,000,000	Guarantee fund
4.	Technical colleges and universities should include Solar Assisted Air Conditioning System in their curricula.	Nil	80,000	Vote of the Ministries of HE/VT
5.	Procurement, installation and monitoring of a Solar Assisted Air Conditioning System	80,000	Nil	Out right grant
6.	Dissemination Programme on Solar Assisted Air Conditioning System	80,000	Nil	Out right grant
	Total	**310,000**	**1,080,000**	

1.7.10 Measurement/Evaluation

Monitoring: The progress of project activities will be monitored periodically by the committee coordinating the project. This committee will be constituted with representatives from the following institutions:

- Ceylon Electricity Board
- Ministry of Power and Energy
- Ministry of Finance
- Sustainable Energy Authority

Evaluation: The Monitoring Committee is expected to nominate a suitable team to evaluate the performance and progress of the project and recommend appropriate corrective measures.

The monitoring and evaluation committee is expected to formulate quantitative and measurable indicators such as the number and capacities of Solar Assisted ACs and their relative energy consumptions, amount of funds generated etc. on a timely and regular basis.

1.7.11 Possible Complications/Challenges

The following complications and challenges need to be met:

- Although it appears that a number of systems utilizing this technology are in operation in some countries, notably in the Philippines, the basic scientific principle of this technology is not very clear. Hence this aspect should be carefully addressed prior to embarking on this project.

1.7.12 Responsibilities and Coordination

Table 1.19: Responsibilities of Project Coordination

Institution/ Stakeholder	Responsibilities
Ceylon Electricity Board/ Ministry of Power & Energy	• Monitoring of the Project
Sustainable Energy Authority	• Primary Implementing Agency • Collection of levy from fossil fuels and creation and operation of a renewable energy/energy efficiency guarantee fund. • Procurement, installation and operation and monitoring of a Solar Assisted Air Condition

	system. • Dissemination of this technology to all users of Air Conditioning Systems.
Ministry of Finance	• Receipt and disbursement of donor contributions
Ministries of Higher Education and Vocational Training	• Introduction of these technologies in the respective curricula.

Implementing Agency:

Sustainable Energy Authority (SEA) has the skill, knowledge and resources required to procure, install and monitor a Solar Assisted Air Conditioning System. SEA is conducting many awareness programmes on different aspects of Renewable Energy and Energy Efficiency. Hence, **Sustainable Energy Authority is the most appropriate primary agency to implement this programme.**

1.7.13 List of References

1. Solar Assisted Air Conditioning, Felix Richard A. Cordova, President & CEO, Edward Marcs Philippines Inc. www.edwardmarcsphil.com ; E-mail: info@edwardmarcsphil.com Tel Nos: +632 9221371; +632 9221658; Mobile: +63917 6288839
2. American Solar Energy, LLC, Solar Cool™ Solar Air Conditioners, http://therealsolarman.com/solar-assisted-air-conditioning.html
3. http://www.fafcosolar.com/go-solar/hybrid-solar-air-conditioning/how-hybrid-solar-air-conditioning-works/. How Hybrid Solar Air Conditioning Works {Call(239) 574-1500)
4. Long Term Generation Expansion Plan, 2009-2022. Ceylon Electricity Board. December 2008.
5. Long Term Transmission Development Plan 2005-2014. Ceylon Electricity Board. 2005.
6. Energy Sector Master Plan, Sri Lanka. Interim Report. Asian Development Bank, April 2004.
7. National Energy Policies and Strategies of Sri Lanka. Ministry of Power and Energy. October 2006.
8. Statistical Digest 2010. Ceylon Electricity Board, 2011.
9. Mahinda Chinthanaya: Vision for a New Sri Lanka. A 10 Year Horizon Development Framework, 2006 -2016, Department of National Planning, Ministry of finance and Planning.
10. http://www.energyservices.lk/statistics/esd_rered.htm

CHAPTER 2

Project Ideas for Transport Sector

2.1 Brief summary of the Project Ideas for Transport Sector

Under the Technology Need Assessment (TNA) Project, the analysis of technology options for climate change mitigation in the transport sector was carried out through an extensive consultative process, by compiling a list of all potent technologies available in the transport sector and prioritizing three technologies through Multi-Criteria Decision Analysis (MCDA) approach. Mitigation of greenhouse gasses emissions was given the major emphasis in prioritization process. Based on this process, the transport sector has prioritized the following three technologies based on stakeholder consultation.

The project ideas for transport sector were developed based on the technology action plans (TAPs) developed through stakeholder consultation. Under each technology, the actions from the TAP were combined appropriately to come up with a list of concrete activities. The overall target of developing project ideas was to promote the transfer and diffusion of low-cost, low greenhouse gas (GHG) emitting technologies for the sector. Therefore the project ideas proposed through this report will help Sri Lanka achieve better and healthier transport modes, while promoting lower GHG emissions through an overall reduction of the number of personal vehicles on the road.

The project ideas developed for priority technologies for the transport sector are given in table 2.1.

Table2.1: Proposed Project Ideas for Prioritized Technologies in Transport Sector

Prioritized Technology	Project Idea
1. Integration of Non-motorized transport methods along with regularized public transport system	Non-motorized transport methods with regularized public transport system for better climate benefits in Sri Lanka
2. Promote carpooling and park-and-ride systems during rush hours and on roads with heavy volumes of vehicles	Park-and-Ride systems in Colombo and Gampaha districts of Sri Lanka for greener transport
3. Electrification of the existing railway system	Electrification of five percent of the existing railways of Sri Lanka for reduced greenhouse gas emissions

2.2 Project Idea for Technology 1: Integration of Non-motorized transport methods along with regularized public transport system

Project Idea:

'Non-motorized transport methods with regularized public transport system for better climate benefits in Sri Lanka'

2.2.1 Introduction and Background

Transport sector is one of the major greenhouse gas emitting sectors in Sri Lanka, and there is a need to reduce the emissions through reduced burning of fossil fuels in vehicular transport by discouraging the use of low- and single- occupancy vehicles and promoting non-motorized and public transport. Therefore, this project was developed under Technology 1 *(i.e. Integration of Non-motorized transport methods along with regularized public transport system),* to promote non-motorized transport methods with regularized public transport system for better climate benefits in Sri Lanka, while encouraging revision of policies and proper law enforcement within Colombo District, which currently hold the heaviest vehicle load in the country at any given time.

The problems addressed by the project include the lack of finances to fill the gaps in the existing pedestrian facilities, lack of concern and knowledge among the general public, especially motorists to obey road rules, and less priority for pedestrians and non-motorized transportation within the existing legislation relevant to transport. In overcoming these problems, several activities have been planned: Developing pedestrian facilities and road furniture, Improvement of road discipline by law enforcement and other means and increase the awareness creation, Amendment/s to the national policies and legislation and establishing an automated fine system with synchronized traffic signals, and Research and Development (R & D) activities on mitigating vehicular emissions and health impacts.

2.2.2 Objectives

The main objectives of the project are as follows:

- Having properly designed pedestrian facilities in suburbs of Colombo within a radius of ~ 10 km where currently such facilities (sidewalks, walkways connecting public transport terminals to main roads, and proper road furniture and traffic signals at pedestrian crossings) are lacking.

- Promote better road discipline and law enforcement
- Awareness creation on the need for lower number of personal vehicles on the road and reduced burning of fossil fuels, and health benefits of non-motorized transport
- More research & development measures on cleaner/low GHG-emitting technologies for public transport

2.2.3 Outputs of the Proposed Project

The expected, measurable outputs under each of the project activity are listed below.

Activity 1: Developing pedestrian facilities and road furniture

Outputs:

- Sidewalk construction in a road length of ~100 km
- Better traffic signals at pedestrian crossings (3 per km; total length 100 km)
- Walkway fragments as connections between main roads and public transport terminals (total length of walkways 20 km)
- Fencing of bad sidewalks: Fencing with florescent colored metal blocks and/or widening of selected narrow sidewalks accommodating all bus bays, and replacement of poor quality sidewalks/ shoulders in selected suburban areas of Colombo
- Pedestrian friendly road furniture: proper yellow lines and florescent/yellow poles by pedestrian crossings for visibility at night; tactile tiles for visually impaired people

Activity 2: Improvement of road discipline by law enforcement and other means and increase the awareness creation

Outputs:

- At least 2500 people trained on road discipline and the enforcement of road rules
- Weekly programs on TV and radio
- Biweekly advertisements on TV and radio
- A proper monitoring mechanism for strict road discipline and penalties for road rule violators

Activity 3: Amendment/s to the national policies and legislation and establishing an automated fine system with synchronized traffic signals

Outputs:

- Installation of automated surveillance *c*ameras and examining changes in accidents and violation of pedestrian rights after the installation of the same at Automatic Traffic Signal (ATS) junctions
- Necessary amendments in legislation/s relevant to road transport

Activity 4: Research and Development (R & D) activities on mitigating vehicular emissions and health impacts

Outputs:

- Research projects and studies on cleaner technology options for public transportation systems,
- Research on better road construction and paving material, and overall GHG mitigation in road transport

2.2.4 Relationship to the country's sustainable development

Sustainable development is a priority concern in Sri Lanka. '*Mahinda Chintana'*, the development policy framework of the government of Sri Lanka (Department of National Planning, 2010), envisages to adopt remarkable development in the country's transport system ensuring having better transport infrastructure with improved security and road safety. Improved sustainability in the transport system is a key component of the planned activities under '*Mahinda Chintana'*, which proposes a multimodal public transport system. The project idea 1 we propose here is in line with the development objectives under '*Mahinda Chintana'*, while it also includes activities that would help reduce overall GHG emissions from the transport sector, as it focuses on the parts of Sri Lanka with the highest vehicular congestion. It will also help the sustainable development in the country through promoting the transfer and diffusion of the technology 1.

2.2.5 Project Deliverables

A) Better pedestrian facilities: Better pedestrian facilities are part of the major deliverables anticipated through this project. Currently there are quite a few number of road segments in the metropolis of Colombo without proper sidewalks, shoulders, pedestrian crossings, sign posts, and traffic signals. The current project envisages filling the existing gaps in such pedestrian facilities in Colombo and the suburbs.

Overall, a total length of 100 km of sidewalks in a radius of ~10 km from the Colombo city center is anticipated, along with the fencing of too narrow segments of sidewalks. Establishment of three hundred new traffic signals at the pedestrian crossings in major spots is planned, along with luminous poles by the rest of the yellow pedestrian crossings for better night visibility, and tactile tiles for visually impaired people. Walkway fragments with all the pedestrian facilities including benches and bicycle racks will be installed for a total length of 20 km.

B) Better road discipline: Better road discipline is one of the most anticipated outcomes of the current project, as currently there is lack of proper road rule enforcement in the country. Proper amendments to the Motor Traffic Act with detailed penalties for violating pedestrian rights and automated fine systems based on surveillance cameras at automated traffic signals will help establish better road discipline in the country. The motor traffic act will also be amended with provisions leading the private buses to have strict schedules, avoiding unnecessary waiting times at each stop and restricted times for container transport.

C) Better technological improvements for road transport through R & D activities: Better, low-GHG emitting fuels, road paving materials, and other technological improvements will be introduced through R & D activities.

2.2.6 Project Scope and Possible Implementation

Project scope encompasses only certain metropolis in Colombo District, and with the availability of a proper financing scheme and labor availability, it should be feasible to accomplish the anticipated targets within the given time frame. Since the establishment of pedestrian facilities and installing proper road discipline has long-term impacts, the project itself will be a promising and sustainable project. Based on the success of the project in the metropolis surrounding Colombo, the project could be extended to the rest of the country in future.

2.2.7 Project activities:

The following are the main project activities:

1. Developing pedestrian facilities and road furniture
    1.1 Establishing sidewalks and traffic signals at necessary pedestrian crossings in a road length of 100 km
    1.2 Construction of walkways connecting sidewalks to main bus stations and train stations, along with attractive pedestrian facilities such as benches and bicycle racks

1.3 Fencing and/or broadening of existing narrow sidewalks with florescent colored metal blocks and/or widening of selected narrow sidewalks accommodating all bus bays, and replacement of poor quality sidewalks/ shoulders in selected suburban areas of Colombo

1.4 Provision of all required road furniture

2. Improvement of road discipline by law enforcement and other means and increase the awareness creation among road users including the drivers of different categories of vehicles
3. Amendment/s to the national policies and legislation and establishing an automated fine system with synchronized traffic signals
4. Research and Development (R & D) activities on mitigating vehicular emissions and health impacts

2.2.8 Timelines for the Proposed Activities

All the project activities will run for 0-3 years. Specific timelines for these activities are provided in Table 2.2 below.

Table 2.2: Timelines corresponding to Activities and Sub activities of Project 1												
Project Activities	**Year 1**				**Year 2**				**Year 3**			
	Q1	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
Activity 1: Developing pedestrian facilities and road furniture												
1.1. Establishing sidewalks and traffic signals at necessary pedestrian crossings in a road length of 100 km												
1.1.1. Identification of the road segments requiring such pedestrian facilities												
1.1.2. establishing sidewalks and traffic signals (100 km total road length; 3 traffic signals per km)												
1.2. Construction of walkways connecting sidewalks to main bus stations and train stations, along with attractive pedestrian facilities such as benches and bicycle racks												
1.2.1. Identification of the locations												
1.2.2. Establishment of walkway fragments connecting the public transport terminals and the sidewalks on main roads, while trying to bring all the public transportation (i.e. bus and train) terminals in close proximity												
1.3. Fencing and/or broadening of existing narrow sidewalks with florescent colored metal blocks and/or widening of selected												

narrow sidewalks accommodating all bus bays, and replacement of poor quality sidewalks/ shoulders in selected suburban areas of Colombo												
1.3.1. Identification of the locations												
1.3.2. Land acquisition based on availability												
1.3.3. Fencing and repairing sidewalks/shoulders												
1.4. Provision of all required road furniture												
1.4.1. Establishing proper yellow lines and yellow/luminous poles by pedestrian crossings for visibility at night; tactile tiles for visually impaired people)												
Activity 2: Improvement of road discipline by law enforcement and other means and increase the awareness creation among road users including the drivers of different categories of vehicles												
2.1 Quarterly workshops for government and provincial council officials and monthly workshops for new licensees												
2.2 Weekly TV and radio programs and advertisements												
Activity 3 Amendment/s to the national policies and legislation and establishing an automated fine system with synchronized traffic signals												
3.1. Regularization of private bus transport to have strict schedules and stricter times for container transport												

3.2: Introducing an automated fine system for motorists who violate pedestrian rights												
3.3. Traffic signal synchronization in busy road segments												
Activity 4: Research and Development (R & D) activities on mitigating vehicular emissions and health impacts												
4.1 Calling for proposals and inception												
4.2 Implementation												

2.2.9 Budget/Resource requirements

Budget requirements for project activities are provided in Table 2.3.

Table 2.3: Budget requirements for Proposed Project Activities of Project 1

Activity	Budge requirement US $ million	Potential funding source
1. Developing pedestrian facilities and road furniture	24.3	Local or donors
2. Improvement of road discipline by law enforcement and other means and increase the awareness creation	3.1	Local or donors
3. Amendment/s to the national policies and legislation and establishing an automated fine system with synchronized traffic signals	0.02	Local
4. Research and Development (R & D) activities on mitigating vehicular emissions and health impacts	1	Local or donors
Total	**28.42**	

Each project activity will depend on local or international funds from donors, as given in Table 2.2.

2.2.10 Measurement/Evaluation

a) Project progress will be monitored quarterly or half-yearly by the Ministry of Transport or an expert committee appointed by the Ministry of Transport.

b) Project Evaluation will be carried out periodically (i.e. Annual or Bi-annual) by an independent team of experts relevant to different aspects of the project appointed by the Ministry of Transport in consultation with funding agency.

2.2.11 Possible Complications/Challenges

Once the project starts it should flow smoothly, in order to avoid any inconvenience to the pedestrians or moving traffic, or any other party concerned. Therefore there should be a proper mechanism to release the funds and supplies necessary, in a timely manner, so that the project will not be withheld at any point. The project should have obtained all the required permission/s prior to inception, thus there will not be any interruption through any social or political process.

2.2.12 Responsibilities and Coordination

The overall project will be mainly **implemented by the Road Development Authority (RDA) and the Urban Development Authority (UDA), under the guidance of the Ministry of Transport**. Since the project activities requires the input from several important government agencies, the overall project will be coordinated by a team consisting of the officers from the following institutes: Ministry of Transport, RDA, Local authorities, Provincial road development authority (PRDA), Road Passenger Transport Authority- Western Province, National Transport Commission, Police, Ministry of Health, Ministry of private transport, Ministry of highways, UDA, National Physical Planning Department, Motor Traffic Department (DMT), National Council for road safety, Universities, Colombo Municipal (CMC), Construction Equipment Training Centre (CETRAC).

2.2.13 List of References

1. Department of National Planning. 2010. Sri Lanka the emerging wonder of Asia.
2. Mahinda Chintana. 90-110 pp. The Department of National Planning, Ministry of Finance and Planning.

2.3 Project Idea for Technology 2: Promote carpooling and park-and-ride systems during rush hours and on roads with heavy volumes of vehicles

Project Idea:

'Park-and-Ride systems in Colombo and Gampaha districts of Sri Lanka for greener transport'

2.3.1 Introduction/Background

Park-and-ride lots are parking lots where the commuters can leave their personal vehicles and transfer to a common shuttle or do carpooling for the rest of their journey. Currently, about 60% of the air pollution (especially in Colombo City) comes from the transport sector (AirMAC, 2009). Carpooling and park-and-ride options can be considered for roads where congestion is extremely high, causing traffic delays and heavy pollution due to vehicular emissions.

Once established, the availability of low cost systems like Park-and-Ride (FTPN, 2011) needs to be given enough publicity and awareness, with substantial details on who and where to contact regarding the same. This system is especially applicable in industrial zones and busy city areas, where the driving stress and the exposure to air pollution is high due to heavy volume of vehicles; park and ride systems help reduce single- or low- occupied vehicles on such traffic-congested roads.

The problems addressed by the project include the lack of finances, Lack of economic tools including road pricing (tariff barrier) and innovative public transport for utilizing such a system, Lack of awareness and concern in general public about the possibility of having this type of systems, Lack of proper and secure parking areas, etc. In overcoming these problems, the following activities have been planned under this project.

- Land purchase and clearance
- Purchase of better shuttles, possibly run on greener fuel, and reduction of the importation taxes for public transport vehicles
- Development of infrastructure and amenities within the parking lots, while ensuring the security
- Establishment of a proper regulatory and management system for sustainable operation
- Introducing a tax system for single or low occupancy vehicles at varied rates, with a reduced rate for the vehicles run on cleaner fuel
- Awareness creation through mass media

2.3.2 Objectives

The main objectives of the project are as follows:

- Promote Park-and-Ride systems in Sri Lanka as a trustworthy mass transportation means which would help reduce GHG emissions and air pollution on traffic congested roads
- Promote better road discipline and law enforcement
- Avoid unnecessary traffic delays caused by single occupancy personal vehicles
- Awareness creation on the need for lower number of personal vehicles on the road and reduced burning of fossil fuels

2.3.3 Outputs of the Proposed Project

The expected, measurable outputs under the overall project are listed below.

- Two secure Park-and-Ride systems commuting altogether at least 600 passengers each way a day in better fuel-efficient shuttles; this would avoid a similar or lower number of cars being on the road
- Having proper infrastructure with small shopping complexes and fuel stations will attract more Park-and-Ride users, and will reduce overall GHG emissions by avoiding unnecessary travel to other places in fulfilling such personal needs

- Introducing a tax system for single or low occupancy vehicles at varied rates, with a reduced rate for the vehicles run on cleaner fuel
- Awareness creation through mass media

2.3.4 Relationship to the country's sustainable development

In achieving sustainable development, establishment of sustainable transportation systems that will yield economic and social benefits including the reduction of environmental pollution is very important. The reduced number of vehicles will also help better sustained road transport, while avoiding unnecessary traffic delays, promoting the overall economic growth in the country. Transport sector is one of the major polluting and GHG emitting economic sectors in Sri Lanka, and therefore improving such unhealthy conditions through introducing Park-and-Ride systems, initially at two locations, will definitely support the sustainable development goals in the country.

2.3.5 Project Deliverables

- **Better, trust worthy mass transport in place of single occupancy personal vehicles** is one of the major deliverables.
- **Better quality, energy efficient shuttles on road**- Ten shuttles per Park-and-Ride system
- **Introduction of a tax system** on single- and low occupancy vehicles and **strict enforcement of a point system** for disciplining the drivers
- **A value added transport system,** where people have convenient ways of ticket purchase (online or using the smart card) and obtaining their personal needs within the same location

2.3.6 Project Scope and Possible Implementation

The current project aims at establishing only two Park-and-Ride systems in suburban locations within a 20 km distance from the Colombo city, in Colombo and Gampaha Districts. Based on the experience and success of the original two lots, it should be feasible to expand such systems to the other parts of the country in the future.

2.3.7 Project activities

The following are the main project activities:

1. Land purchase and clearance
2. Purchase of better shuttles, possibly run on greener fuel, and reduction of the importation taxes for public transport vehicles
3. Development of infrastructure and amenities within the parking lots, while ensuring the security
4. Establishment of a proper regulatory and management system for sustainable operation
5. Strict enforcement of the suggested tax system for single- or low-occupancy vehicles during the peak hours on roads with high congestion, along with a strict enforcement of a point system for disciplining the drivers
6. Weekly TV and radio programs and advertisements on the establishment and benefits of the Park-and-Ride systems
7. Evaluation of the applicability and success of this pilot project

2.3.8 Timelines

All the project activities will run for 0-3 years. Specific timelines for these activities are provided in Table 2.4.

Table 2.4: Timelines corresponding to activities and sub activities relating to the establishment of Park-and-Ride systems.												
Activity/Sub-Activity	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Activity 1 Land purchase and clearance												
1.1. Purchase and clearance of two-acre land pieces in suburbs of Colombo and Gampaha districts												
Activity 2. Purchase of better shuttles, possibly run on greener fuel, and reduction of the importation taxes for public transport vehicles												
2.1 Import of ten shuttles per Park-and-Ride lot (altogether 20)												
Activity 3. Development of infrastructure and amenities within the parking lots, while ensuring the security												
3.1. Establishing useful infrastructure and amenities within part of the carpooling and park-and-ride lots												
3.2. Proper electronic display of information related to bus transit (delays, on-time arrival, etc.) and establishment of proper signboards by the main road												
3.3. Establishment of security cameras and lighting systems, appointment of security personnel, and introducing insurance schemes for the parking lots												
Activity 4. Establishment of a proper regulatory and management system for sustainable operation												
4.1. Establishment of a proper registration system for regular users and maintenance of databases on the functionality												
4,2, Introduction of direct management regulations for carpooling and shuttle transit and initiative action by the Transport Ministry in												

collaboration with the Ministry of Provincial Councils												
4.3. Publishing manuals or directories with all the relevant information (i.e. guidelines and regulations on driver/passenger credit sharing, responsible authorities and officials, etc.)												
4.4. Develop a facility to use a smart card and online ticket purchasing ability												
Activity 5: Strict enforcement of the suggested tax system for single- or low-occupancy vehicles during the peak hours on roads with high congestion, along with a strict enforcement of a point system for disciplining the drivers												
5.1 Strict enforcement of the suggested tax system during the peak hours on roads with heavy traffic congestion, and strict enforcement of a point system for disciplining the drivers												
Activity 6. Weekly TV and radio programs and advertisements on the establishment and benefits of the Park-and-Ride systems												
6.1. Weekly TV and radio programs and advertisements												
Activity 7. Evaluation the applicability and success of this pilot project												
7.1 Evaluation by an independent expert committee, considering the socioeconomic and environmental benefits												

2.3.9 Budget/Resource requirements

Budget requirements for project activities under the establishment of Park-and-Ride systems provided in table 2.5.

Table 2.5: Budget requirements for project activities of Project 2

Activity	Budge requirement US $ million	Potential funding source
1. Land purchase and clearance	5.4	Local or donors
2, Purchase of better shuttles, possibly run on greener fuel, and reduction of the importation taxes for public transport vehicles	1.5	Local or donors
3. Development of infrastructure and amenities within the parking lots, while ensuring the security	2.06	Local or donors
4. Establishment of a proper regulatory and management system for sustainable operation	0.07	Local or donors
5. Introducing a tax system for single or low occupancy vehicles at varied rates, with a reduced rate for the vehicles run on cleaner fuel	0.02	Local
6. Awareness creation through mass media	2	Local or donors
Total	**11.05**	

Each project activity will depend on local or international funds from donors, as given in Table 2.5.

2.3.10 Measurement/Evaluation

a) Project Progress Monitoring: The quarterly or half-yearly project progress monitoring will be carried out by the Ministry of Transport or an expert committee appointed by the Ministry of Transport.

b) Project Evaluation: Periodic (i.e. Annual or Bi-annual) evaluation of the project will be carried out by an independent team of experts relevant to different aspects of the project appointed by the Ministry of Transport in consultation with funding agency.

2.3.11 Possible Complications/Challenges

Once established, the Park-and-Ride systems should be sustainable with sufficient commuters using it, in order to have benefits out of it without it being an economic failure. Therefore there should be a proper public private partnership (PPP) to have a high quality, sustainable system that is attractive to the commuters. Also, there should be proper and regular public transportation or pedestrian facilities from the final destination of the shuttle service to the work places of the commuters, for the sustainable use of such a system.

2.3.12 Responsibilities and Coordination

The overall project will be implemented by the Ministry of Transport and Ministry of Provincial Councils, in collaboration with the Private sector and Police Department. The overall project will be coordinated by a team consisting of the officers from the above institutes and Academia.

2.3.13 List of References

1. AirMAC 2009. Clean Air 2015. Air Resource Management Center. Ministry of Environment & Natural Resources, Sri Lanka
2. Florida Transit Planning Network (FTPN), 2011. Park & Ride Lots. Available at http://planfortransit.com/ozonereduction/Docs/Park%20&%20Ride%20Lots.pdf

2.4 Project Idea for Technology 3: Electrification of the existing railway system

Project Idea:

'Electrification of five percent of the existing railways of Sri Lanka for reduced greenhouse gas emissions'

2.4.1 Introduction/Background

The railway network in Sri Lanka, which has a length of ~1500 km, was initially built and used only for transporting export plantation products, and with increasing population and traffic needs, rail transport became more passengers oriented. Currently the existing trains are diesel powered, and electrification of part of the railway network has been proposed. In the past, during the first half of the twentieth century, an electric tram car system was operating in certain parts of Colombo. This early tram system is the only electrified rail experience Sri Lanka has had so far, and it has been more than half a century since the operation of the tram car system terminated. Therefore, the proposed electrification of ~5% of the existing railway system to meet the current passenger transport needs will bring a different experience with reduced greenhouse gas emissions. A feasibility study has been already done on electrification of the railway system[1]. However, the success of its operation will be dependent on the running frequency, the number of commuters, and the sustainable operation of the system.

The problems addressed by the current project include the lack of finances, lack of better locomotives and infrastructure, and proper training for facing any emergency situation in sustainable operation of an electrified railway system. Therefore the current project is aiming at fulfilling these needs that are required for sustainable operation and maintenance of such a system.

[1] IESL, 2008

2.4.2 Objective

The main objectives of the project are as follows:

- Establish a better, electrified railway system in a selected fragment of the existing railways of Sri Lanka, through installing necessary infrastructure changes, new locomotives and signal systems for efficient railway system with reduced GHG emissions
- Training and capacity building for proper and sustainable operation of the electrified railway system

2.4.3 Outputs of the Proposed Project

The expected, measurable outputs under the overall project are listed below.

Outputs:

- ~70 km of the existing railway track electrified with better infrastructure, locomotives, and signal systems
- The number of personnel (mostly engineers, technical officers, and planners) trained in the countries within the region (e.g. Singapore, Japan) and other developed countries (e.g. Europe, USA) are expected to contribute to the sustainable functioning of the electrified railway system
- Improvements and capacity building within the overall transport sector in Sri Lanka

2.4.4 Relationship to the country's sustainable development

Since the transport sector is one of the major GHG emitting economic sectors in Sri Lanka, reducing the emissions by shifting to electrification will yield better environmental benefits. It will also help the improvement of overall quality of life and development in the country. For proper operation of such a system, better infrastructure, locomotives, and enough capacity and training are needed. Development of human and physical resources to a higher level is also one of the transport sector priorities under the '*Mahinda Chintana'*, the development policy framework of the government of Sri Lanka (Department of National Planning, 2010),

2.4.5 Project Deliverables

- Smoother train operation by having an electrified railway system in place of diesel powered locomotives, for avoiding unnecessary idle times and system failures which finally result in reduction of GHG emissions.
- Improved standard in the infrastructure and locomotives
- Capacity strengthening of the nationally available experts and skilled people for proper operation and maintenance of the system

2.4.6 Project Scope and Possible Implementation

The project aims at improving part of the railway system in Sri Lanka, focusing reduced emissions and better passenger transport in a railway sector with heavy passenger load. It also plans on obtaining international training on the operation, management, and maintenance of an electrified railway system. The entire project is planned to be implemented within 3 years, and the required training is planned to be implemented in batches of government officers for obtaining experience needed for smooth operation and management of such a system.

2.4.7 Project activities

The following are the main project activities:

1. Identification of the fragment/s for electrification and electrification links
2. installing necessary infrastructure changes, new locomotives and signal systems
3. Fulfilling the maintenance requirements of the system
4. Capacity building and institutional strengthening through required training in collaboration with the countries with better experiences on electrified train systems.

2.4.8 Timelines for the Proposed Activities

Specific timelines for these activities are provided in Table 2.6.

Table 2.6: Timelines corresponding to activities and sub-activities relating to the electrification of the existing railway system												
Activity/Sub-Activity	**Year 1**				**Year 2**				**Year 3**			
	Q1	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
Activity 1 Identification of the fragment/s for electrification and electrification links												
1.1 Identification of the fragment/s for electrification												
1.2 Obtaining the support from the Transport Ministry to identify electrification links												
Activity 2 Installing necessary infrastructure, new locomotives and signal systems												
2.1 Provision of electricity through overhead lines (25 kilovolt) drawn above the railway lines and loops, better tracks, new locomotives, and signal systems, as needed												
Activity 3 Fulfilling the maintenance requirements of the system												
3.1 Periodic maintenance of the system for smooth functioning												
Activity 4 Capacity building and institutional strengthening through required training in collaboration with the countries with better experiences on electrified train systems												
4.1 Training of the relevant government officials needing specialized training, considering their area of expertise, qualifications, and experience												

2.4.9 Budget/Resource requirements

Budget requirements for project activities under the electrification of the existing railway systems provided in table 2.7.

Table 2.7: Budget requirements for Proposed Project 3

Activity	Budge requirement US $ million	Potential funding source
1. Identification of the fragment/s for electrification and electrification links	0.01	Local
2. Installing necessary infrastructure changes, new locomotives (EMUs) and signal systems	47.3	Local or donors
3. Fulfilling the maintenance requirements of the system*	N/A	N/A
4. Capacity building and institutional strengthening through required training in collaboration with the countries with better experiences on electrified train systems	0.3	Local or donors
Total	**47.61**	

* - Maintenance will cover by the income generated

2.4.10 Measurement/Evaluation

a) Project Progress Monitoring: The quarterly or half-yearly monitoring will be carried out by the Ministry of Transport or an expert committee appointed by the Ministry of Transport

b) Project Evaluation: Periodic (i.e. Annual or Bi-annual) evaluation of the project will be carried out by an independent team of experts appointed by the Ministry of Transport in consultation with funding agency.

2.4.11 Possible Complications/Challenges

The success of an electrified railway system depends on the frequency of its daily use. The success of such a system in Sri Lanka is still not known, and needs to be evaluated in the future.

2.4.12 Responsibilities and Coordination

The project will be implemented by the Sri Lanka Railways and the Ministry of Transport. The overall project will be coordinated by a team consisting of the officers from the Ministry of Transport, Sri Lanka Railways, The Institute of Engineers, Sri Lanka (IESL), Arthur C Clarke Institute of Sri Lanka, Ceylon Electricity Board, and Academia.

2.4.13 List of References

1. Mahinda Chintana, 2010. Department of National Planning, Sri Lanka the emerging wonder of Asia. 90-110 pp, Ministry of Finance and Planning
2. IESL (The Institute of Engineers, Sri Lanka), 2008. A proposal for railway electrification. IESL.

CHAPTER 3

Project Ideas for Industry Sector

3.1 Brief summary of the Project Ideas for Industry Sector

Under the Technology Need Assessment (TNA) Project, the analysis of technology options for climate change mitigation in the industry sector was carried out through an extensive consultative process by utilizing the Multi-Criteria Decision Analysis (MCDA) approach. The technologies were identified based on the mitigation of greenhouse gas emissions and contribution to the global effort to mitigate climate change impacts.

The entire process of selecting the prioritized technologies to final project idea selection, the opinions of the stakeholders were considered. Under the Technology Action Plans developed for the industry sector, there were key actions identified as the most important to successfully introduce and upscale the selected technologies. These key actions were then transformed into project ideas.

The key constrains in the transfer of low carbon technology and its wide spread deployment are lack of capital and cost of capital, inadequate capacity among service providers and demonstration projects to showcase the benefits of the proposed alternative technologies in comparison to widely used conventional technologies. The availability of financial instruments will definitely encourage industries / enterprises to use them to finance alternative technologies at a lesser financial risk. Besides, these enterprises will be able to obtain funds at a lower interest and lighter collateral making the process for obtaining finance easier. Therefore it is estimated that the payback of the investment will be faster leading to financial benefits to the enterprises quicker.

On the other hand developing capacity in ESCOs and service providers will ensure that the enterprises have competent technical assistance at hand to switch to alternative and green technologies minimizing the risk of failure. Therefore ESCOs and other service providers can act as change agents for the enterprises in introducing and deploying these novel technologies.

Therefore through the proposed project ideas the transfer, diffusion and deployment of proposed technologies can be achieved faster and effectively.

As per the guideline provided project ideas have been developed for the Industry sector covering all three prioritized technologies. This chapter for project ideas reports for the Industry sector includes three project ideas in all, one project idea for each technology identified. The most important actions identified under each technology were considered for this purpose.

The table shows proposed projects for each of the three prioritized technologies:

Table3.1: Proposed Project Ideas for Prioritized Technologies in the Industry Sector

Prioritized Technology	Project Idea
1. Energy Efficient Motors	Facilitation of emission reduction in industries by changing to high efficiency motor drives through availability of financial instruments and loan granting schemes, subsidies and green credit lines.
2. Variable Speed Drives	In country capacity development through strengthening of institutions / organizations for reducing carbon emissions in industry through switching to modern green drives.
3. Residue Biomass Combined Heat and Power	Reduce dependence of fossil fuel and resentment carbon emissions from process industries by building confidence to use CHP for in-situ electrical and thermal energy generation through development of champions

3.2 Project Idea for Technology 1: Energy Efficient Motors

Project Idea:

'Facilitation of emission reduction in industries by changing to high efficiency motor drives through availability of financial instruments and loan granting schemes, subsidies and green credit lines'

3.2.1 Introduction and Background

According to global energy surveys, it is estimated that two thirds of electrical energy in the industry is consumed by motors and hence high efficiency requirement is inevitable in view of overall energy efficiency. If every installation could contribute even by a fractional improvement of efficiency, the gross saving would be enormous. Already there are agreements between motor manufactures and various enactments in the USA and Europe. Energy Policy Act 1992 (Epact 92) has directives for minimum efficiency levels for general purpose motors up to 200HP in USA. Based on such directives NEMA (National Electric Manufacturer's Association) listed different efficiency bands for motors. The motors that have higher efficiency by 2% – 8% than the standard efficiency motors are categorized as "Premium Efficiency Motors'.

Manufacturers state the efficiency classes in three groups – EFF1, EFF2 and EFF3. The highest efficiency of a particular category varies with the power rating (kW or HP), number of poles (or the speed). EFF1 has the highest efficiency. To illustrate these relationships considering a 1.1kW motor, efficiency of EFF1 type is equal or more than 82.8% and that of EFF2 type is equal or more than 76.2% and any type with lower efficiency than the latter falls into EFF3 type. The similar efficiency values for 75kW motor are EFF1 $\geq$ 94.6% and, EFF2 $\geq$ 93.6%.

Energy efficient motors have other benefits in addition to energy savings. They have better life due to high quality insulation, magnetic circuits and bearings. These properties with high quality manufacturing processes; also lead to very low vibration and more susceptible to voltage unbalances and overloading.

Energy Efficient Motor technology is identified as a mitigation technology because of its high potential of green house gas emission reduction at electricity power generation. This technology helps to improve electrical energy efficiency especially at industries and generally at service sector.

Investment cost of EEM technology is about 71,000 US$ per ton of CO_2 reduction. Expected green house gas reduction (mitigation potential) is about 13,019 tCO_2e. Main financial benefit is electrical energy saving of 38,068 MWh per year.

3.2.2 Objectives

- Increase the amount of energy efficient motor use in local industry and service sector applications.
- Facilitate to industries and service organizations to use energy efficient motors and mitigation technologies to reduce their GHG emissions and cost of production/service.
- Develop capacity of banking sector on mitigation technologies and its benefits.

3.2.3 Outputs of the Proposed Project

- Availability of low interest credit schemes for mitigation technologies such as energy efficient motors. Output will be one credit scheme and one grant scheme.
- 30% increase of Energy Efficient Motor usage in local industrial sector.
- GHG emission reduction per grant given.
- Replacement of existing motors with EEM and expect to reduce energy consumption by 10 – 13 percent in 10 years period
- Expected GHG reduction is about 130,000tCO_2e.

3.2.4 Relationship to the Country's Sustainable Development Priorities

According to the Countries development plan, *Mahinda Chinthana* (Vision for the Future) the strategy of the government ensures that by 2020, Sri Lanka's industrial sector will be a highly value added, knowledge-based, internationally competitive and diversified sector which employs a highly paid, skilled

workforce. The sector is expected to mobilize more local raw material and have a large value creation particularly for a growing economy. The government is also promoting environmental sustainability and green technology in industrial activities.

Improve the energy efficiency and increase the renewable energy usage have been identified and given priority in National Action plan for *Haritha* (green) Lanka progrmme. Actions under the mission 1 (clean air-everywhere), mission 3 (meeting the challenges of climate change) and mission 9 (greening the industries) are developed for climate change mitigation and reduce the environmental pollution. In addition, National Cleaner Production policy and sectoral policies have been developed to improve resource efficiency of the industrial and service sectors.

3.2.5 Project Deliverables

- Calculate the funding requirement to replace existing low efficient motors and net saving through the reduction of energy and GHG emissions.
- Prepare a list of all possible donors, green banks and other funding agencies would like to contribute to financing mechanism.
- Prepare a report on a suitable financial mechanism with its working arrangements.
- Training programme for bank/financial institutions officials on evaluation of mitigation technologies and its benefits specific to the industry sector and country in general.

3.2.6 Project Scope and Possible Implementation

Energy Efficient Motor technology is specifically applicable for all industrial applications and generally all utility supplies of service sector as a crosscutting technology application. This project is lined to existing energy efficiency improvement initiatives at industrial, service and household sectors lead by Sri Lanka Sustainable Energy Authority. This project is sustainable project because the initial investment can be recovered at industry level as well as national level. Potential GHG emission reduction is a good sign for environmental sustainability of the project. Social benefits are gained by reducing cost of production, less environmental pollution and saving of natural resources such as fossil fuel. There is high potential for scaling up this project covering entire country.

3.2.7 Project Activities

Project activities are as follows for the Energy Efficient Motor technology.

1. Conduct a comprehensive survey (using technical university students) on the usage pattern of all the motors, VSDs.
2. Estimate the total energy consumption and GHG emission based on these results.
3. Develop a data base of global suppliers of energy efficient motors
4. Obtain the pricing details and the total funds requirement for all replacement of low efficient motors to be estimated
5. Submit findings to all potential donors and financial institutions for consideration to start a green/low interest credit lines
6. Develop comprehensive training programme with lessons, presentations and other information to educate banks officials on how to evaluate new loan application on mitigation technologies such as EEM and VSD.
7. Identify and develop financial mechanism based on stakeholder consultation
8. Forward all the relevant documents to treasury and Ministry of Finance and Planning through Ministry of Environment for further action.

3.2.8 Timelines for the Proposed Activities

Table 3.2: Timelines for the proposed activities with projected outputs for project 1

Activity	Time Frame	Duration	Output
1. Conduct a comprehensive survey (using technical university students) on the usage pattern of all the motors, VSDs.	Month 1 to Month 12	12 months	Survey completed
2. Estimate the total energy consumption and GHG emission based on these results.	Month 13 to Month 15	15 months	Energy & emissions estimated
3. Develop a data base of global suppliers of energy efficient motors	Month 16 to Month 19	19 months	Supplier registry

4. Obtain the pricing details and the total funds requirement for all replacement of low efficient motors to be estimated	Month 20 to Month 21	21 months	Funds requirement established
5. Submit findings to all potential donors and financial institutions for consideration to start a green/low interest credit lines	Month 22 to Month 25	25 months	Donors identified and requests made
6. Develop comprehensive training programme with lessons, presentations and other information to educate banks officials on how to evaluate new loan application on mitigation technologies such as EEM and VSD	Month 26 to Month 31	6 months	Training programmes developed
7. Identify and develop financial mechanism based on stakeholder consultation	Month 32 to Month 35	4 months	Stakeholder workshop held
8. Forward all the relevant documents to treasury and Ministry of Finance and Planning through Ministry of Environment for further action.	Month 36	1 month	Final project proposal submitted to treasury

Table 3.3: Timelines for the proposed activities of project 1

Activity	Year 1				Year 2				Year 3			
1. Conduct a comprehensive survey (using technical university students) on the usage pattern of all the motors, VSDs.												
2. Estimate the total energy consumption and GHG emission based on these results.												
3. Develop a data base of global suppliers of energy efficient motors												
4. Obtain the pricing details and the total funds requirement for all replacement of low efficient motors to be estimated												
5. Submit findings to all potential donors and financial institutions for consideration to start a green/low interest credit lines												
6. Develop comprehensive training programme with lessons, presentations and other information to educate banks officials on how to evaluate new loan application on mitigation technologies such as EEM and VSD												
7. Identify and develop financial mechanism based on stakeholder consultation												

8. Forward all the relevant documents to treasury and Ministry of Finance and Planning through Ministry of Environment for further action.	

The project will be carried out over a period of three (3) years.

3.2.9 Budget/Resource Requirement

Table 3.4: Budget Estimate for proposed activities of project 1

Activity	Total Budget (US$)
1. Conduct a comprehensive survey (using technical university students) on the usage pattern of all the motors, VSDs.	50,000
2. Estimate the total energy consumption and GHG emission based on these results	20,000
3. Global suppliers of EEM and VSDs will be contacted	10,000
4. Relevant pricing details will be obtained. The total funds requirement for all replacement of low efficient motors will be estimated	10,000
5. These results will be submitted to all potential donors and financial institutions for consideration to start a green/low interest credit lines	5,000
6. Develop comprehensive training programme with lessons, presentations and other information to educate banks officials on how to evaluate new loan application on mitigation technologies such as EEM and VSD	70,000
7. Discussion with relevant stakeholders to finalize the financial mechanism to identify the most suitable one	20,000
8. All the relevant documents will be forwarded to treasury and Ministry of Finance and Planning through Ministry of Environment	0
9. Total Cost	**185,000**

Project Management cost is about 20% of the total cost (US$ 37,000). Approximate operation cost is 80% of the total cost (US$ 148,000).

The funds necessary would be obtained through local and international donor agencies.

3.2.10 Measurement / Evaluation

Progress monitoring of this project would be done every quarter by a steering committee appointed by the Ministry of Power and Energy which is the executing agency of the proposed project. The steering committee will comprise Ministry of Power and Energy (Chair person) Sustainable Energy Authority, Ministry of Environment, Ministry of Industries, Treasury and Technical Service Providers.

The project evaluation would be done periodically by an independent expert group appointed by the Ministry of Power and Energy in consultation with the funding agency.

Possible Complications / Challenges

Possible Challenges are as follows.

- The banks might not willing to promote such a scheme.
- The need (total energy required by industries) might vary making the estimate inaccurate.
- The cost of technology on the global supplier can change leading to higher investment that what was estimated.

3.2.11 Responsibilities and Coordination

Project coordination and implementation will be done by the Sri Lanka Sustainable Energy Authority with the participation development banks and technical service providers such as National Cleaner Production Centre, Sri Lanka Energy Managers Association and National Engineering Research and Development Centre.

3.2.13 List of Reference

1. *Mahinda Chnthna* and *Mahinda Chinthan Idiri Dekma* – Vision for the Future, National Policy document of His Excellency President Mahinda Rajapaksha.
2. National Action Plan for Haritha (green) Lanka Programme – National Council for Sustainable Development, Presidential Secretariat, Colombo 1.
3. National Cleaner Production Policy and sectoral policies – Ministry of Environment

3.3 Project Idea for Technology 2: Variable Speed Drives for Motors (VSD)

Project Idea:

'In country capacity development through strengthening of institutions / organizations for reducing carbon emissions in industry through switching to modern green drive'

3.3.1 Introduction and Background

Constant speed motor drives are associated with various losses due to its inability to adjust the speed to suit the application. It is possible to save energy as much as 60% depending on the application using speed control. High savings can be achieved with fans and pumps that are very common in most of the industries. The traditional speed controls use mechanical speed reduction methods such as gearwheels and belt with pulleys. Both these methods have high energy losses due to friction. Moreover, motor running at a higher speed contributes additional losses such as frictional and iron losses. Further, such speed control systems are bulky or needs considerable space with the need of frequent maintenance depending on the usage and environment.

The variable speed control system or an electronic drive can adjust the speed to suit the application not only by adjusting the speed but also torque characteristics of the motor. Since the speed controller is electronic, the energy loss in the controller is very much less than that of a mechanical speed controller and also very compact. However, electronic drives should have stable supply for its trouble-free operation. Various manufacturers provide other technologies to achieve fine improvements of motor operation to achieve more energy saving and optimizing the operation.

Motor driven pumps and fans controlled by variable speed drives, as described above, can achieve high energy savings according to the theory. The basic law of fluid flow shows that the power requirement is proportional to the cube of the flow speed. If the speed is reduced by 80% (this does not affect most of the process unless high precision of speed is required) the energy requirement can be reduced by 51%. This is a typical application in withering process in tea manufacturing. Most of the pumping applications

can also achieve this type of saving if the speed is reduced, as it cannot be a problem as pumps generally operates only intermittently – runs at full speed and then idle. However, since average electronic drives generally produce non-sinusoidal current waveform, it is preferable to use motors recommended for such application for better life span.

Investment cost of variable speed drive technology is about 104,563 US$/$tCO_2$ reduction. Expected electricity (economic benefit) saving is about 151,109MWh per year. Expected greenhouse gas reduction is about 51,679 tCO_2e per year.

3.3.2 Objectives

- Increase the amount of VSD use in local industry and service sector applications.
- Strengthen institutions to facilitate to industries and service organizations to use VSD, EEM and mitigation technologies to reduce their GHG emissions and cost of production/service.
- Develop in house capacity for industry service providers to promote, implement and maintain mitigation technologies such as EEM, VSD.

3.3.3 Outputs of the Proposed Project

- Strengthened, enforced and expanded ESCOs and regulatory agencies. Expected output is to strengthen SLSEA and CEA officers and 30 ESCOs.
- Strengthened public private partnerships, joint ventures among ESCOs, universities, government institutes and private organizations. Expected output is to develop ten partnerships.
- Technical and financial facilitation for upgrading in-house capacity of institutions. Expected output is to enhance in house capacity of ESCOs.

3.3.4 Relationship to the Country's Sustainable Development Priorities

According to the Countries National Development Plan, Mahinda Chinthana (Vision for the Future) the strategy of the government ensures that by 2020, Sri Lanka's industrial sector will be a highly value added, knowledge-based, internationally competitive and diversified sector which employs a highly paid, skilled workforce. The sector is expected to mobilize more local raw material and have a large value creation particularly for a growing economy. The government is also promoting environmental sustainability and green technology in industrial activities.

Improve the energy efficiency and increase the renewable energy usage have been identified and given priority in National Action plan for *Haritha* (green) Lanka progrmme. Actions under the Mission 1 (clean air-everywhere), Mission 3 (meeting the challenges of climate change) and Mission 9 (greening the industries) are developed for climate change mitigation and reduce the environmental pollution.
In addition, National Cleaner Production policy and sectoral policies have been developed to improve resource efficiency of the industrial and service sectors.

3.3.5 Project Deliverables

- Results of capacities and in-house facilities of all ESCOs and service providers in the country
- Identified inadequacies and shortcomings of existing ESCOs and service providers
  Registry of all suppliers of electrical drives with their technical capacities
- Capacity development training package for ESCOs and service providers

3.3.6 Project Scope and Possible Implementation

The word VSD covers all Variable Speed Drives, Variable Frequency Drives and Variablen Volume Drives which are us in HVAC & R (Heating ventilation Air Conditioning and Refrigeration) systems, pumps and general industries such as tea industry. These industries are currently using standard electric drives wasting high amount of energy and leading to CO_2 emissions. With the development of tourism, anticipated 40,000 rooms in 2016, the use of this machinery become threefold. Therefore the scope of using these modern drives is very high.

The implementation of the project is made feasible through the new energy management regulations enacted under SLSEA portfolio (put regulation #). Under this regulation all electrical energy users consuming more than 50,000kWh have to report monthly about their consumption and steps taken to improve energy efficiency. This companies will be ready to implement low cost technologies to bring down the energy consumption in their enterprises.

3.3.7 Project Activities

Project activities are as follows for the Variable Speed Drives technology.

1. Survey of all ESCOs, service providers to identify their capacities, in-house facilities
2. Conduct a need/gap analysis to identify the inadequacies and the shortcomings
3. Develop training programme for capacity development of selected ESCOs and service providers
4. Develop a registration mechanism for all the suppliers of electrical drives with their technical capacities
5. Select ten companies for installing VSD/ VFD demonstration units and assess the requirement including specifications for equipments.
6. Conduct a survey on in-house facilitation available with the ESCOs, suppliers and service providers
7. Prepare specification for a standard toolkit set and fixture requirements for upgrading facilities at ESCOs
8. Obtain quotations for demonstrations VSD/VFD units and toolkits
9. Submit funds requirements for ten demonstration VSD/VFD units 25 toolkits to UNFCCC climate technology centre and network and green climate fund
10. Conduct one training programme to test the effectiveness of the capacity building training package
11. Install demonstration VSD/VFD units at selected companies using trained ESCOs
12. Prepare a report on institutional building of ESCOs, service providers, suppliers for further funding

3.3.8 Timelines for the Proposed Activities

Table 3.5: Timelines for Proposed Activities of Project 2

Activity	Time Frame	Duration	Output
1. Survey of all ESCOs, service providers to identify their capacities, in-house facilities	Month 1 to Month 8	8 months	Identified ESCOs and their capacity
2. Conduct a need/gap analysis to identify the inadequacies and the shortcomings	Month 9 to Month 12	4 months	Identified GAPs
3. Develop training programme for capacity development of selected ESCOs and service providers	Month 13 to Month 18	6 months	Developed training programmes
4. Develop a registration mechanism for all the suppliers of electrical drives with their technical capacities	Month 16 to Month 18	3 months	Developed registration mechanism
5. Select ten companies for installing VSD/ VFD demonstration units and assess the requirement including specifications for equipments.	Month 16 to Month 18	3 months	Ten companies selected to install demo units
6. Conduct a survey on in-house facilitation available with the ESCOs, suppliers and service providers	Month 16 to Month 19	4 months	Identified available in house capacity
7. Prepare specification for a standard toolkit set and fixture requirements for upgrading facilities at ESCOs	Month 20 to Month 21	4 months	Std. toolkit list ready
8. Obtain quotations for demonstrations VSD/VFD units and toolkits	Month 22 to Month 23	2 months	Price quotations received
9. Submit funds requirements for ten demonstration VSD/VFD units 25 toolkits to UNFCCC climate technology centre and network and green climate fund	Month 24	1 month	Fund proposal submitted
10. Conduct one training programme to test the effectiveness of the capacity building training package	Month 24 to Month 26	3 months	Tested training package
11. Install demonstration VSD/VFD units at	Month 27 to	8 months	Demo units installed

selected companies using trained ESCOs	month 34		
12.Prepare a report on institutional building of ESCOs, service providers, suppliers for further funding	Month 34 to Month 36	3 months	Completed report

Table 3.6: Timelines for Proposed Activities of Project 2

Activity	Year 1				Year 2				Year 3			
1. Survey of all ESCOs, service providers to identify their capacities, in-house facilities												
2. Conduct a need/gap analysis to identify the inadequacies and the shortcomings												
3. Develop training programme for capacity development of selected ESCOs and service providers												
4. Develop a registration mechanism for all the suppliers of electrical drives with their technical capacities												
5. Select ten companies for installing VSD/ VFD demonstration units and assess the requirements												
6. Conduct a survey on in-house facilitation available with the ESCOs, suppliers and service providers												
7. Prepare specification for a standard toolkit set and fixture requirements for upgrading facilities at ESCOs												
8. Obtain quotations for demonstrations VSD/VFD units and toolkits												
9. Submit funds requirements for ten demonstration VSD/VFD units 25 toolkits to relevant authorities as indicated above												
10. Conduct one training programme to test the effectiveness of the capacity building training package												
11. Install demonstration VSD/VFD units at selected companies using trained ESCOs												
12.Prepare a report on institutional building of ESCOs, service providers, suppliers for further funding												

3.3.9 Budget/Resource Requirement

Table 3.7: Budget Estimate for Proposed Activities of Project 2

Activity	Proposed Budget (US$)
1. Survey of all ESCOs, service providers to identify their capacities, in-house facilities	50,000
2. Conduct a need/gap analysis to identify the inadequacies and the shortcomings	30,000
3. Develop training programme for capacity development of selected ESCOs and service providers	40,000
4. Develop a registration mechanism for all the suppliers of electrical drives with their technical capacities	10,000
5. Select ten companies for installing VSD/ VFD demonstration units and assess the requirement including specifications for equipments.	4,000
6. Conduct a survey on in-house facilitation available with the ESCOs, suppliers and service providers	18,000
7. Prepare specification for a standard toolkit set and fixture requirements for upgrading facilities at ESCOs	7,000
8. Obtain quotations for demonstrations VSD/VFD units and toolkits	4,000
9. Submit funds requirements for ten demonstration VSD/VFD units 25 toolkits to UNFCCC climate technology centre and network and green climate fund	2,000
10. Conduct one training programme to test the effectiveness of the capacity building training package	12,000
11. Install demonstration VSD/VFD units at selected companies using trained ESCOs	35000
12.Prepare a report on institutional building of ESCOs, service providers, suppliers for further funding	3,000
Total Cost	**215,000**

The project will be carried out over three (3) years.

Project Management cost is about 20% of the total cost (US$ 43,000). Operation cost is about 80% of the total cost (US$ 172,000). The funds necessary will be obtained through local and international sources

3.3.10 Measurement / Evaluation

Progress monitoring of this project would be done every quarter by a steering committee appointed by the Ministry of Power and Energy which is the executing agency of the proposed project. The steering committee will comprise Ministry of Power and Energy (Chair person) Sustainable Energy Authority, Ministry of Environment, Ministry of Industries, Treasury and Technical Service Providers. Progress monitoring would be done by the steering committee every quarter or once in six months.

The project evaluation would be done periodically by an independent expert group appointed by the Ministry of Power and Energy in consultation with the funding agency.

The measurement and evaluation will be started with high energy users registered with SLSEA where the enterprises are mandated to report energy consumption on regular basis. There are 1600 enterprises identified high energy users which are covered by 800 registered energy managers from the companies. This project will ensure a reduction in their energy bill and resultant drop in carbon emissions. Therefore it will be easy to evaluate the success of the project through a monthly records of the enterprises send to SLSEA. SLSEA mechanisms will be used to measure the reduction in energy consumption.

3.3.11 Possible Complications / Challenges

Possible Challenges are as follows.

- The need (total energy required by industries) might vary making the estimate inaccurate.
- The cost of technology on the global supplier can change leading to higher investment that what was estimated.

3.3.12 Responsibilities and Coordination

Project coordination and implementation will be done by the Sri Lanka Sustainable Energy Authority with the participation of Ministry of Environment, Sri Lanka Sustainable Energy Authority, Technical and Vocational Universities, industry chambers and professional associations.

3.3.13 List of Reference

1. *Mahinda Chnthna* and *Mahinda Chinthan Idiri Dekma* – Vision for the Future, National Policy document of His Excellency President Mahinda Rajapaksha.
2. National Action Plan for Haritha (green) Lanka Programme – National Council for Sustainable Development, Presidential Secretariat, Colombo 1.
3. National Cleaner Production Policy and sectoral policies – Ministry of Environment

3.4 Project Idea for Technology 3: Biomass Combined Heat and Power (CHP)

Project Idea:

'Reduce dependence of fossil fuel and resentment carbon emissions from process industries by building confidence to use CHP for in-situ electrical and thermal energy generation through development of champions'

3.4.1 Introduction and Background

Biomass is the term used for all organic material originating from plants (including algae), trees and crops and is essentially the collection and storage of the sun's energy through photosynthesis. Biomass energy, or bio-energy, is the conversion of biomass into useful forms of energy such as heat, electricity and liquid fuels. Biomass for bio-energy comes either directly from the land, as dedicated energy crops, or from residues generated in the processing of crops for food or other products such as pulp and paper from the wood industry. Another important contribution is from post consumer residue streams such as construction and demolition wood, pallets used in transportation, and the clean fraction of municipal solid waste (MSW). The biomass to bio-energy system can be considered as the management of flow of solar generated materials, food, and fiber in our society

An application of this CHP is the provision of energy requirement of the rubber processing factory using saw dust. It is a waste material from saw mills which creates several negative environment issues.

The average thermal requirement of the rubber processing factory studied is 1720 kW, and its average electrical power requirement is 1,138 kW, giving a heat to power ration of about 1.5:1. The proposed combined heat and power (CHP) plant will run at a constant load of 2250 kW electricity (net); excess electricity will be fed into the national grid. Process stream will be available at a constant rate of 3,375 kW. Steam in excess of the demand will be either wasted or used for preheating of combustion air or

boiler feed water. The design capacity factor of the plant is 0.8, while overall efficiency is 34.5% (13.8% electric, 20.8% thermal)

CHP is applicable in Sri Lanka. Through this technology Greenhouse gas (GHG) emissions could also be reduced by the equivalent of about 11,300 t CO_2 per year. The lower cost of energy from cogeneration systems could be a key to the survival of local industrial plants in today's competitive environment.

The estimated cost of electricity delivered by the CHP plant is US$ 0.04/kWh and the estimated cost of thermal energy is US$ 0.019/kWh, both of which are lower than the corresponding cost of grid electricity at US$ 0.044/kWh and the cost of furnace oil-based thermal energy at US$ 0.021/kWh. This is a highly recommendable alternative energy generation method.

3.4.2 Objectives

- Increase the renewable energy share in local industry sector and reduce GHG emissions as well as cost of production
- Reduce the cost of oil imports and give more income opportunities for local biomass producers and farmers
- Develop local technologies, technology modifications, business models for biomass supply and popular this renewable energy technologies in Sri Lanka.

3.4.3 Outputs of the Proposed Project

- No. of industries implement biomass CHP projects in Sri Lanka. Expected output is to install and run three demo projects.
- Total amount of energy requirement fulfilled by biomass CHP. Local industries use about 165 thousand tones of fossil fuel (SLSEA energy balance 2010) for their heating processes.
- Total amount of GHG reduction by applying biomass CHP is about 113,000 tCO_2e

3.4.4 Relationship to the Country's Sustainable Development Priorities

According to the Countries development plan, Mahinda Chinthana (Vision for the Future) the strategy of the government ensures that by 2020, Sri Lanka's industrial sector will be a highly value added, knowledge-based, internationally competitive and diversified sector which employs a highly paid, skilled workforce. The sector is expected to mobilize more local raw material and have a large value creation particularly for a growing economy. The government is also promoting environmental sustainability and green technology in industrial activities.

Improve the energy efficiency and increase the renewable energy usage have been identified and given priority in National Action plan for *Haritha* (green) Lanka progrmme. Actions under the Mission 1 (clean air-everywhere), Mission 3 (meeting the challenges of climate change) and Mission 9 (greening the industries) are developed for climate change mitigation and reduce the environmental pollution.
In addition, National Cleaner Production policy and sectoral policies have been developed to improve resource efficiency of the industrial and service sectors.

3.4.5 Project Deliverables

- Implemented demonstration projects for selected industrial sectors
- Exchange programmes to go to successfully implemented industries locally and internationally
- Technical and financial facilitation for upgrading in-house capacity of institutions
- Technical capacity building of suppliers of raw materials and manufacturers of parts and equipments

3.4.6 Project Scope and Possible Implementation

Currently industries use 218.17 thousand tons of fossil fuel[2]. About 80% of this can be switched to renewable energy (RE) sources and most of them are process industries. Then they can generate

[2] SLSEA, 2012, Energy Balance, 2012

electricity and thermal energy by switching to RE sources. The scope for reducing the fossil fuel use in industry such as rubber, tea and ceramic is about 150 thousand tons of fossil fuel.

3.4.7 Project Activities

Project activities are as follows;

1. Call for volunteer Industries for setting up 3 CHP demonstration projects in 3 different sectors
2. Call for contracting companies to implement CHP demonstration projects in industries
3. Select three industries in 3 different sectors for implementing demo projects
4. Select contractor companies to implement the demonstration plants in selected industries
5. Study and Develop the demonstration CHP Project for each Industry selected
6. Obtain funding through a donor/government to implement demo projects
7. Enter into agreements with selected industries and contractor companies
8. Procure/fabricate equipment and other necessary materials
9. Install demonstration CHP Plants in selected locations
10. Commission the plants in Industries and conduct trial runs
11. Train personnel in beneficiary Industries for effective running of Demo CHP Plants
12. Document the achievements as a success story

3.4.7 Timelines for the Proposed Activities

Table 3.8: Timelines for proposed activities of project 3

Activity	Time Frame	Duration	Output
1. Call for volunteer Industries for setting up 3 CHP demonstration projects in 3 different sectors	Month 1 to Month 2	2 months	Installed 3 CHP projects
2. Call for contracting companies to implement CHP demonstration projects in industries	Month 1 to Month 2	2 months	Implemented projects
3. Select three industries in 3 different sectors	Month 3 to	2 months	Selected 3

for implementing demo projects	Month 4		industries
4. Select contractor companies to implement the demonstration plants in selected industries	Month 3 to Month 4	2 months	Selected contractor companies
5. Study and Develop the demonstration CHP Project for each Industry selected	Month 4 to Month 8	6 months	Developed CHP projects
6. Obtain funding through a donor/government to implement demo projects	Month 4 to Month 15	12 months	Obtained funds
7. Enter into agreements with selected industries and contractor companies	Month 9 to month 12	4 months	Entered agreements with selected companies
8. Procure/fabricate equipment and other necessary materials	Month 16 to Month 21	6 months	Fabricated equipments
9. Install demonstration CHP Plants in selected locations	Month 26 to Month 31	6 months	Installed demo CHP plants
10. Commission the plants in Industries and conduct trial runs	Month 32 to Month 34	3 months	Commissioned plants
11. Train personnel in beneficiary Industries for effective running of Demo CHP Plants	Month 32 to Month 34	3 months	Trained personnel in beneficiary industries
12. Document the achievements as a success story	Month 35 to Month 36	2 months	Documented success stories

Table 3.9: Timelines for proposed activities of project 3

Activity	Year 1				Year 2				Year 3			
1. Call for volunteer Industries for setting up 3 CHP demonstration projects												
2. Call for contracting companies to implement CHP demonstration projects in industries												
3. Select three industries in 3 different sectors for implementing demo projects												
4. Select contractor companies to implement the demonstration plants in selected industries												

5. Study and Develop the demonstration CHP Project for each Industry selected												
6. Obtain funding through a donor/government to implement demo projects												
7. Enter into agreements with selected industries and contractor companies												
8. Procure/fabricate equipment and other necessary materials												
9. Install demonstration CHP Plants in selected locations												
10. Commission the plants in Industries and conduct trial runs												
11. Train personnel in beneficiary Industries for effective running of Demo CHP Plants												
12. Document the achievements as a success story												

The project will be carried out over three (3) years.

3.4.8 Budget/Resource Requirement

Table 3.10: Budget estimate for proposed activities of project 3

Activity	Budget (US$)
1. Call for volunteer Industries for setting up 3 CHP demonstration projects in 3 different sectors	1,500
2. Call for contracting companies to implement CHP demonstration projects in industries	1,500
3. Select three industries in 3 different sectors for implementing demo projects	2,500
4. Select contractor companies to implement the demonstration plants in selected industries	2,500
5. Study and Develop the demonstration CHP Project for each Industry selected	27,000
6. Obtain funding through a donor/government to implement demo projects	20,000

7. Enter into agreements with selected industries and contractor companies	5,000
8. Procure/fabricate equipment and other necessary materials	1,500,000
9. Install demonstration CHP Plants in selected locations	200,000
10. Commission the plants in Industries and conduct trial runs	175,000
11. Train personnel in beneficiary Industries for effective running of Demo CHP Plants	45,000
12. Document the achievements as a success story	20,000
Total Cost for the Project 3	**US $ 2,000,000**

Project Management cost is about 20% of the total cost (US$ 400,000). Operation cost is about 80% of the total cost (US$ 1,600,000). The funds necessary will be obtained through local and international sources.

3.4.10 Measurement / Evaluation

Progress monitoring of this project would be done every quarter by a steering committee appointed by the Ministry of Power and Energy which is the executing agency of the proposed project. The steering committee will comprise Ministry of Power and Energy (Chair person) Sustainable Energy Authority, Ministry of Environment, Ministry of Industries, Treasury and Technical Service Providers. Progress monitoring would be done by the steering committee every quarter or once in six months.

The project evaluation would be done periodically by an independent expert group appointed by the Ministry of Power and Energy in consultation with the funding agency.

The measurement and evaluation will be started with high energy users registered with SLSEA where the enterprises are mandated to report energy consumption on regular basis. There are 1600 enterprises identified high energy users which are covered by 800 registered energy managers from the companies. This project will ensure a reduction in their energy bill and resultant drop in carbon emissions. Therefore it will be easy to evaluate the success of the project through a monthly records of the enterprises send to SLSEA. SLSEA mechanisms will be used to measure the reduction in energy consumption.

3.4.11 Possible Complications / Challenges

Possible Challenges are as follows.

- Fossil fuel price fluctuations and
- The need (total energy required by industries) might vary making the estimate inaccurate.
- The cost of technology on the global supplier can change leading to higher investment that what was estimated.

3.4.12 Responsibilities and Coordination

Project coordination and implementation will be done by the Sri Lanka Sustainable Energy Authority with the participation of Ministry of Environment, Sri Lanka Sustainable Energy Authority, Ministry of Industry and Commerce, industry chambers and Industries.

3.4.13 List of Reference

1. *Mahinda Chnthna* and *Mahinda Chinthan Idiri Dekma* – Vision for the Future, National Policy document of His Excellency President Mahinda Rajapaksha.
2. National Action Plan for Haritha (green) Lanka Programme – National Council for Sustainable Development, Presidential Secretariat, Colombo 1.
3. National Cleaner Production Policy and sectoral policies – Ministry of Environment

Annex I

List of Stakeholders Involved and their Contacts

MEMBERS OF THE NATIONAL TNA COMMITTEE

No	Designation	Institution
1.	Secretary	Ministry of Environment – Chairman
2.	Addl. Secretary (Environment & Policy)	Ministry of Environment
3.	Director (Policy Planning)	Ministry of Environment
4.	Director (Air Resources Management & International Resources)	Ministry of Environment
5.	Director (Biodiversity)	Ministry of Environment
6.	Director (Sustainable Environment)	Ministry of Environment
7.	Director (Climate Change)	Ministry of Environment
8.	Director General	Department of External Resources
9.	Director General	Department of National Planning
10.	Secretary	Ministry of Agriculture
11.	Secretary	Ministry of Water Supply and Drainage
12.	Secretary	Ministry of Fisheries and Aquatic Resources Development
13.	Secretary	Ministry of Health
14.	Secretary	Ministry of Economic Development (Tourism)
15.	Secretary	Ministry of Transport
16.	Secretary	Ministry of Power and Energy
17.	Secretary	Ministry of Local Government and Provincial Council
18.	Secretary	Ministry of Technology and Research
19.	Director	Industrial Technology Institute of Sri Lanka

ENERGY SECTOR

List of Stakeholders

No	Name	Institution	Contact Address
1.	Mr. Rohitha Gunawardane	Head Ceylon Electricity Board	50, Sir Chittampalam A. Gardiner Mawatha, Colombo 02.
2.	Mr. Chamila Jayasekara,	Head/ Energy Efficient Sustainable Energy Authority	3G-17 BMICH Bauddhaloka Mawatha, Colombo 07.
3.	Mr. A.H.S. Ariyasinghe	Senior Assistant Secratary Ministry of Petroleum Industries	No. 80, Sir Ernest De Silva Mawatha Colombo 07
4.	Mr. N.R. Wickramasinghe	Deputy Manager Ceylon Petroleum Corporation	No.609, Dr. Danister de Silva Mawatha, Colombo 09.
5.	Mr. W.S. Lakmal	Electrical Engineer Lanka Electricity Company (Pvt) Ltd	411, Galle Road, Colombo 03
6.	Mr. J.A.A.D. Jayasuriya	HOD/ Energy & Envt. National Engineering Research & Development Center	2P/17B, IDB Industrial Estate, Ekala, Ja-Ela , Sri Lanka.
7.	Mr. Gayantha Kodikara,	Research Scientist Aurther C. Clark Center for Modern Technologies	Katubedda, Moratuwa
8.	Mr. Nilantha Kumara,	Consultant Practical Action of Sri Lanka	5, Lionel Edirisinghe Mawatha Kirulapone, Colombo 5
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10.	Mr. Nalin De Silva,	Member Bio Energy Association of Sri Lanka	465/1, Sunethradevi Rd, Pepiliyana, Boralesgamuwa
11.	Mr. Gamini Senanayake,	Director General Gamini Senanayake Association	“Senanayake Villa”, Negombo Road, Malkaduwawa, Kurunegala, Sri Lanka
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13.	Mr. Nalin Edirisinghe	Director Public Utilities Commission of Sri Lanka	6th Floor , BOC Merchant Tower, St. Michael's Road, Colombo 3

TRANSPORT SECTOR

List of Stakeholders

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1.	Dr. S.N.Bentotage	Senior Lecturer	University of Moratuwa
2.	Mr. K.M.V.J.Priyanjith	Assisting Director (Planning)	M/ PrivateTransport Service
3.	Mr. G.H.P.Dharmarathna	Met.Expert	M/Airport and Aviation
4.	Mr. K.A.B.Pathirathna	Engineer	Sri Lanka Railway Department
5.	Dr.D.S.Jayaweera	Driector General	Department of Development Finace
6.	Mr. Wijaya Samarasinghe	Director/Planning	Sri Lanka Railway Department
7.	Mr.S.P.Sirimana	Assisting Secretary	Ministry of Transport
8.	Mr. A.W. Dissanayake	Director/VET PMT	Department of Motor Traffic
9.	Ms. Amanthi Wickramasinghe	Research Assistant	MOFP
10.	Mr. S.M Werahera	Assistant Director/Air Resources Management Center	Ministry of Environment
11.	Mr. Ranjith Punyasoma	Supervisor/Landscaping	M/Airport and Aviation

INDUSTRY SECTOR

List of Stakeholders

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1.	Dr. H.V.P. Wijewardana,	Director Industrial Development Board	Industrial Development Board 615,Galle Road, Katubedda
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3.	J.A.A.D. Jayasuriya	HOD NERD	IDB Industrial Estate , Ekala, Ja-ela
4.	Ms. R.D.S. Gunarathna	Asst. Director Ministry of State Resources & Enterprise Development	561/3, Elvitigala Mawatha Col 05.
5.	Mr. K. Fonseka,	Senior Research Officer Industrial Technology Institute	Industrial Technology Institute, Bauddhaloka Mawatha, Colombo 7.
6.	U. Senarathne	Board of Investment SDD	Level 26, West Tower, WTC, Col. 01.
7.	Mr. Priyantha S. Dissanayake	General Manager Plantation Management Ltd Elpitiya Plantations	Plantation Management Ltd Elpitiya Plantations
8.	Mr. Chamila Jayasekara	Sustainable Energy Authority	3G-17 BMICH Bauddhaloka Mawatha, Colombo 07.
9.	Mr. K.J. Wanasinghe	President Plastic and Rubber Institute	No 341/12, Kotte Road, Rajagiriya
10.	Ms. Vishaka Hidallage	Director Practical Action Sri Lanka	05, Lionel Edirisinghe Mw, Kirulapone, Col. 05

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13.	Ms. Induni Chathupama	Environmental Officer Center for Environment Justice	20A, Kuruppu Road Colombo 08