Ministry of Environment and
Renewable Energy
Sri Lanka

Technology Needs Assessment And Technology Action Plans For Climate Change Mitigation

Technology Action Plan

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
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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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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
BEASL	Bio Energy Association of Sri Lanka
CDM	Clean Development Mechanism
CEB	Ceylon Electricity Board
CH_4	Methane
CHP	Combine Heat and Power
CO_2	Carbon dioxide
CPC	Ceylon Petroleum Corporation
CRI	Coconut Research Institute
EEM	Energy Efficient Motors
EFF	Electronic Frontier Foundation
ESCOs	Energy Service Companies
ESMP	Energy Sector Master Plan
FD	Forest Department
GDP	Gross Domestic Product
GHG	Greenhouse Gases
HP	Horse Power
IDB	Industrial Development Board
IDEA	Integrated Development Association
IFS	Institute of Fundamental Studies
ITDG	Industrial Technology Development Group
kWh	Kilo Watt hour
LPG	Liquid Petroleum Gas
MOST	Ministry of Science and Technology
MSW	Municipal Solid Waste
MWh	Mega Watt hour
N_2O	Nitrous oxide
NCRE	Non-Conventional Renewable Energy
NEP&S	National Energy Policy and Strategies
NERDC	National Engineering Research & Development Centre
NGO	Non-Government Organization
O&M	Operations and Maintenance
OTEC	Ocean Thermal Energy Conversion
PPP	Purchasing power parity
PUCSL	Public Utilities Commission of Sri Lanka
R&D	Research & Development
RERED	Renewable Energy for Rural Economic Development
SLSEA	Sri Lanka Sustainable Energy Authority
SRC	Short Rotation Coppice

UNFCCC	United Nations Framework Convention on Climate Change
UOM	University of Moratuwa
VSD	Variable Speed Drive

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EXECUTIVE SUMMARY

The Technology Needs Assessment (TNA) for Climate Change in Sri Lanka was carried out from June to December 2011. The priority sectors identified for mitigation are Energy, Transport and Industry. A list of potential technologies for each sector were identified through stakeholder consultations and prioritized by using the Multi Criteria Decision Analysis (MCDA) process. Three technologies were prioritized for each sector. The barrier analysis was carried out through stakeholder consultations during March to July 2012, and enabling framework was developed for each technology, in order to overcome the potential to ensure successful technology transfer and diffusion followed by the Technology Action Plans (TAP) for each technology.

The Technology Action Plan (TAP) Report presents Action Plans for the prioritized technologies. For each technology, a brief description of the technology, targets, identified barriers to technology transfer and diffusion, and measures/actions recommended through detailed action plans are presented. The Action Plan is a concise proposal for an enabling framework for the technology implementation which includes responsible implementing agencies, priority of the proposed measure/action, the time frame for implementation, estimated costs, potential sources of funding and indicators for the measurement of success.

Technology Action Plans for the Energy Sector

Sri Lanka's energy supply is primarily based on biomass (48%), petroleum oil (43%) and hydroelectricity (9%), with the total amounting to about 415 PJ. The Non-Conventional Renewable Energy sources are contributing only about 0.1% of the total energy supply, while the contribution to the electricity grid is about 4%. The government plans to increase this ratio to 10% by 2015. Emissions of CO_2 from fossil fuel combustion has been the major source of GHGs with a rapid growth from 5,447 Gg in 1994 to 10,430 Gg for the year 2000 and the corresponding per capita CO_2 emissions are 304 and 545 kg respectively. Sri Lanka has no petroleum oil or coal resources. Nevertheless, due to the geo-climatic conditions of the country, it is blessed with several forms of renewable energy resources. Some of them are already being used and developed to supply the energy requirements of the country while the others have the potential for development with the respective technological advances and established economic feasibility. Currently about 56.9% of the primary energy supply comes from renewable resources. As per the National Energy Policy and Strategies (NEPS) of Sri Lanka, the government endeavors to reach by 2015, a minimum level of 10% of electrical energy supplied to the grid to be from Non-Conventional Renewable Energy (NCRE).

The Technology Action Plan (TAP) report presents a quick overview of the existing laws and policies relating to energy sector. Two existing national policies and four laws related to energy sector together with a brief content of the policy/law are presented in the report. The climate change mitigation technologies proposed for the Energy sector are; 1. **Conversion of Biomass and Waste to Energy** which includes 3 sub-technologies as, *(i) Co-Firing of Biomass with Coal, (ii) Compact Biogas Digester for Urban Households, (iii) Waste To Energy*, 2. **Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration** and

3. **Building Management** which includes 2 sub-technologies as *(i) LED Lighting and (ii) Solar Assisted Air Conditioning.*

Three (03) general/common barriers which are likely to impact upon successful transfer and diffusion of the prioritized technologies in the energy sector have been identified and they are; (i) High capital cost and difficulties to access finance (ii) Economic feasibility either not examined or relevant information not available (iii) Technology either not established at the desired scale or not fully developed. Measures recommended to overcome these barriers are; Fiscal policy reforms aiming at reducing costs of Renewable Energy and Energy Efficient project related fabrications and constructions; Activate the provisions in the SEA Act to create a Fund to support Renewable Energy and Energy Efficient projects by imposing a cess on all imported fossil fuels; Assign a multi-disciplinary team of experts including economists and engineers to conduct economic feasibility studies and disseminate study results; Commercialize the production and marketing of Glricidia leaves through supporting R&D; Expose local officials to the relevant technologies already being practiced in other countries. The enabling framework of the technology action plan identifies 8, 12 and 10 measures/actions for diffusion of Technologies 1, 2 and 3 respectively and also provides targets and estimated time frame for technology transfer and diffusion.

Technology Action Plans for the Transport Sector

Transport sector is a major GHG emitting sector in Sri Lanka. About 60% of air pollution in Colombo City comes from the transport sector. The main means of transportation is through the existing road network, which is supplemented by rail, air, and water transport modes. Road transport accounts for about 96% of passenger and 99% of freight transportation whereas the railways accounts for about 4% and 1% passenger and freight transport respectively. Currently, the transport sector in Sri Lanka utilizes petroleum fossil fuels *(LPG, Gasoline and Diesel, Coal, Aviation Gasoline, Aviation Turbine and Fuel Oil)* contributing significant amounts of carbon dioxide (CO_2) and other GHG emissions into the atmosphere. The transport sector contributes 27% of the total GHG emissions in the country. The total CO_2 equivalent emissions from transport sector in year 2000 has been 5,084 $GgCO_{2Eq}$ and CO_2 accounts for more than 95% of the transport related emissions.

The prioritized technologies for the transport sector are*;* (1) **Integration of Non- motorized transport methods along with regularized public transport system,** (2) **Carpooling and park-and-ride systems,** (3) **Electrification of the existing railway system.**

The Technology Action Plan (TAP) report briefly describes these prioritized technologies, barriers for the transfer and diffusion of technologies and the enabling framework to overcome the barriers. Report also briefly presents an outline of the draft National Transport Policy and five laws related to the transport sector. The general/common barriers likely to impact upon transfer and diffusion of the technologies are: (i) Lack of finances, (ii) Lack of knowledge on potential benefits and other aspects related to the prioritized technologies, (iii) Inadequate enabling policy and legal environment for technology promotion, (iv) Lack of infrastructure and locomotives, and (v) Lack of economic tools such as road pricing, taxes, and tariffs. Measures proposed to overcome these general barriers are establishment of appropriate financing

mechanisms; Awareness creation on potential benefits of the technologies including training; Appropriate policy and legal reforms; Introduction of improved infrastructure, amenities and facilities for pedestrians & passengers of motorized transport and; Provision of technological features related to convenience and safety measures. Proposed enabling framework identifies 8, 12 and 6 measures/actions for the Technologies 1, 2 and 3 respectively and also provides targets and the estimated time frame required for technology transfer and diffusion.

Technology Action Plans for the Industry Sector

Industry sector of Sri Lanka is not a high energy and resource consuming sector and it includes traditional as well as technology intensive industries, SMEs and micro industries. Cement manufacture, lime production for construction industry and other industries using $CaCO_3$ containing material and soda ash are among the key industries contributing to significant amount of GHG emissions. The other industries that cause GHG emission are Glass manufacturing, Metal & Paper and Food & Beverage industries. The total CO_2 equivalent emission from the industry sector in the year 2000 has been recorded as 1,447.4 $GgCO_{2Eq}$. This amounts to around 8% of the total GHG emissions in the country.

The prioritized technologies for the industry sector are: (1) **Energy Efficient Motors,** (2) **Variable Speed Drives for Motors,** (3) **Biomass Residue Based Cogeneration Combined Heat and Power (CHP).**

The Technology Action Plan (TAP) report for the industry sector briefly describes the prioritized technologies, barriers for the transfer and diffusion of technologies and the enabling framework to overcome the barriers. The Action Plan also briefly outlines existing national policies and laws related to the industry sector. Amongst the barriers identified some are considered as general/common barriers and they are: (i) High capital costs (ii) Lack of adequate financial resources and incentives (iii) Insufficient regulatory framework and inadequate enforcement (iv) Lack of and limited capacity in existing institutions (v) Lack of skilled personnel for technology implementation and inadequate training for maintenance (vi) Poor operations and maintenance facilities (vii) Absence of Standards, Codes and certification and (viii) Inadequate information, awareness, feedback and difficulties in comprehending technical contents. The measures recommended to overcome these general barriers are: Government tax policy reforms as appropriate to enable reducing capital costs for high efficient and sustainable technologies; Appropriate financial instruments and credit facilities, tax concessions and subsidies; Set up development Bank to provide credit facilities on concessionary terms to promote Biomass CHP; Establish an appropriate regulatory mechanism to promote mitigation technologies; Streamline biomass supply process; Institutional strengthening and capacity development; Focus on technical education and awareness creation, training and skills development; Establish factory level operation and maintenance management system with registered after sale services providers and spare parts suppliers; Avail service of international certification agencies to set up local institutions; Energy labeling and standards, awareness creation through demonstration projects and pilot programs; Promote Technology through Energy Associations, Industry Associations and stakeholders.

The Action Plan of the industry sector identifies 8 measures/actions each for successful diffusion of Technologies 1, 2 and 6 for Technology 3. In addition, the TAP provides targets and the estimated time frame for technology transfer and diffusion.

Crosscutting Issues

Amongst the barriers and enabling measures identified for each of the technologies under the respective technologies, some cross sectoral/crosscutting barriers and enabling measures have been identified. As such cross sectoral measures are beneficial for technological development; the TAP explores possibilities of combining these measures/actions to overcome the respective cross-cutting barriers. The major groups of common barriers across sectors are; (i) Inadequacy of finances, (ii) Inadequate information and awareness (iii) Lack of enabling policy and regulatory environment, (iv) Institutional capacity constraints, (v) Inadequate Technology Development.

These common/crosscutting enabling measures are; Establishment of a proper financial mechanism including appropriate fiscal reforms; Awareness creation on potential benefits of the technologies;, Provide technology related technical education and training; Establish enabling policy and legal environment to promote implementation of the technologies; Institutional strengthening and capacity development of the officials; Initiate appropriate steps to develop the technologies including marketing.

Since these measures have the potential to impact upon all the three mitigation sectors simultaneously, such measures/actions need to be given high priority when implanting the TAPs.

CHAPTER 1

Technology Action Plan for the Energy Sector

1.1 Actions at sectoral level

The main GHG emitted from the energy sector is CO_2. In addition to CO_2, various industrial processes cause the emission of CH_4, N_2O, CO, NO_x, SO_2 and NMVOC. The total CO_2 emission from energy sector (excluding transport sector) in the year 2000 has been 4,529.79 Gg[1] and it is estimated as 29% of the overall emissions in the country. The GHG contributions from other key sectors are transport – 27%, agriculture – 25%, waste - 11& and industry - 8%[8].

1.1.1 Short sector description

As per the Second National Communication (SNC) on climate change, CO_2 emission from fossil fuel combustion has increased from 5,447 Gg in the 1994 to 12,410 Gg in 2000 and the corresponding per capita CO_2 emissions are 304 and 648 kg, respectively.

GHG Emission Trends: The scope of the Energy sector in the present TNA includes energy industries (electricity generation), household & commercial and refinery operations. According to the SNC, CO_2 emissions from these sub-sectors are 3,065.84, 1,195.70 and 268.25 Gg respectively. The contribution of CO_2 emissions by these sub-sectors are shown in Figure 1.1

For the period 2000 to 2007 the transport and the industry sectors have shown average annual growth of 3.8% and 5.6%, respectively[2]. The projected emission up to the year 2020 from each of these sub-sectors has been estimated on the basis of an annual growth rate of 4% and 6% for transport and industry[1] respectively.

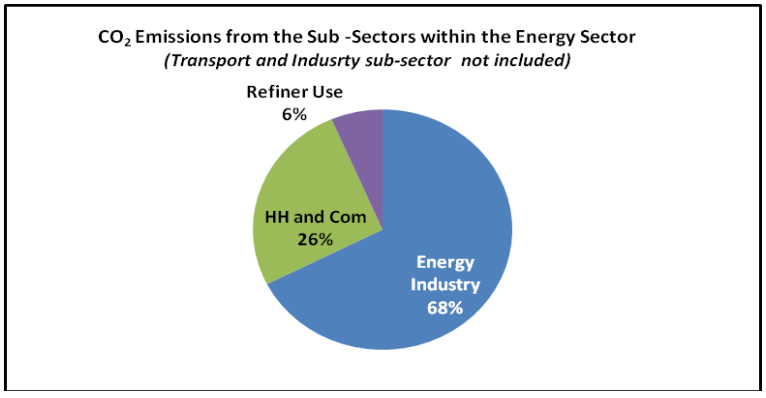

Figure 1.1: CO_2 Emissions from the Sub -Sectors within the Energy Sector

Source: SNC on climate change, 2012

[1] ME, 2012, Second National Communication on Climate Change, Ministry of Environment, Sri Lanka

[2] SLSEA, 2007, National Energy Balance 2007 and available data in 2008 – Sri Lanka Sustainable Energy Authority

The fuel consumption data for the Power, Transport, Industries and Household & Commercial sectors for the period 2000 – 2007 are shown in Fig. 1.2.

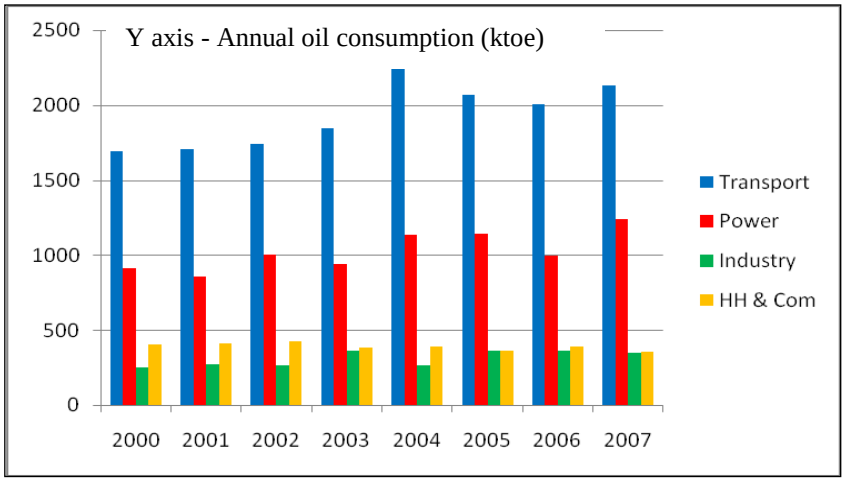

Figure 1.2: Oil consumption in ktoe during 2000-2007

Source: SLSEA. Sri Lanka Energy Balance *(2007)*

Mitigation Targets in the Power Sector:

The current (2011) generation mix of CEB (installed capacity in MW) is (Statistical Digest of CEB 2011) :

Oil	1390 MW	44.3%
Large Hydro	1207 MW	38.5%
Coal	300 MW	9.6%
Small Hydro	194 MW	6.2%
Wind	36 MW	1.1%
Biomass	11MW	0.3%

According to the Power sector mitigation scenario as described in the LTGE Plan (2009 – 2022) of the CEB, 150 MW from Upper Kotmale hydro power plant and 612.5 MW from the renewable energy sources will be added by 2020, along with 2,260 MW from thermal power generation. These mitigated emissions along with the BAU emissions in the power sector are shown in Fig. 1.3 and accordingly the estimated CO_2 emission reduction by 2020 is 28%.

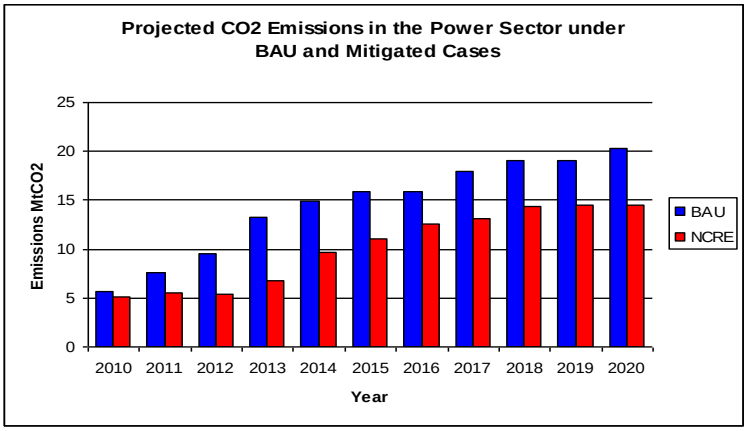

Figure 1.3: Projected CO_2 emissions under BAU and Mitigated cases up to 2020;

Source: CEB (2008)

Mitigation Options:

The National Energy Policy and Strategies (NEPS) of Sri Lanka envisages a minimum contribution of 10% of electrical energy to the grid from NCRE by 2015,. With a view to encourage the development of the NCRE sources, the Ceylon Electricity Board (CEB) has revised its tariff structure so as to enable purchasing power at a price based on the technology used and cost incurred in its development. As a result of the revised tariff structure, already 36 MW of wind and 11 MW biomass based power plants have been added to the grid.

The CEB is also embarking on measures to reduce losses amounting to 12% incurred during generation, transmission and distribution as well as demand side management which involves consumer awareness and education on use of energy efficient appliances and designing of energy efficient households and commercial establishments etc.

In the event that all NCRE projects which at present are under construction and in the pipeline at various stages of approval become operational by 2015 (Mini hydro power – 519 MW; Dendro power – 96 MW; Wind power – 246 MW and Waste to energy – 192 MW), the total energy generated by them and by those already commissioned would be about 4,400 GWh. Thereby achieving the National Energy Policy target of 10% by 2015.

1.1.1.1 Existing Policies and Laws Related to the Energy Sector and Technology Development

The existing policies and laws relevant to the Energy Sector are given in table 1.1 below.

Table 1.1: The existing Policies and Laws relevant to the Energy Sector

Name of the Policies /Laws	Date of Enactment	Content
Existing Policies		
1. National Energy Policy and Strategies of Sri Lanka	2006	Energy Policy of Sri Lanka Implementation strategies to achieve specific targets
2. The Development Policy Framework, Government of Sri Lanka	2010	Policies and targets for all sectors, including energy for 2010-2020
Existing Laws		
1. Ceylon Electricity Board Act No. 17	1969	For the development and co-ordination of the generation, supply and distribution of electricity in Sri Lanka

2. Electricity Reform Act No. 28	2002	To provide for the regulation of the generation, transmission and distribution and supply of electricity in Sri Lanka. To provide for the taking over and discharge of Lanka Electricity Companies.
3. Public Utility Commission of Sri Lanka Act No. 35	2002	A multi-sector Regulator for certain physical infrastructure industries such as electricity, water and petroleum in Sri Lanka
4. Sri Lanka Sustainable Energy Authority Act No.35	2007	To provide to develop renewable energy resources, to declare energy development areas, to implement energy efficiency measures and conservation programs, to promote energy security, reliability and cost effectiveness in energy delivery and information management

1.1.1.2 An overview of the prioritized technologies

The prioritized technologies which comprise of seven Sub-technologies are shown in table 1.2.

Table 1.2: Prioritized technology groups for the 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.

Brief descriptions of these technologies are provided in sections 1.2.1, 1.3.1 and 1.4.1.

1.1.2 General Barriers and Proposed Measures

Although some barriers are technology specific, yet some general barriers for all the technologies can be identified. The general barriers identified can be broadly categorized as: (a) High capital cost and difficulties to access finance, (b) The economic feasibility not examined or not published and (c) Technology not established at the proposed scale or not fully developed.

a) Barrier: High capital cost and difficulties to access finance

All the renewable energy projects and energy efficiency projects in Sri Lanka encounter the dual barriers of high capital cost and difficulties in accessing finance. The escalation in the capital costs is much higher than the tariff increase granted for NCRE projects. Some of these projects have been made possible by investments from overseas. Taxes on local fabrications and constructions is one of the contributory factors in this regard. Further, fossil fuel based thermal power generations enjoy a substantial government subsidy and coal is exempted from all taxes and duties. Removal of these barriers would positively contribute for realising all the projects in the pipeline.

(i) Measure: Consider reducing by at least 50% or removing taxes on local fabrications and constructions of Renewable Energy and Energy Efficiency projects.

One of the major reasons for the slow progress of Renewable Energy and Energy Efficiency projects in Sri Lanka is the high government taxes on local fabrications and constructions. Review and reform of these taxes would enable popularizing these technologies which would result not only enhancing the environment by reducing GHG emissions from fossil fuels, it would also reduce expenses incurred on importation of fossil fuels.

(ii) Measure: Consider imposing a cess on all imported fossil fuels under the provision of the SEA ACT to establish a Fund for assisting Renewable Energy and Energy Efficiency Projects.

The other factor which impedes popularization of Renewable Energy and Energy Efficiency projects is the lack of credit facilities available from the local banks for these projects. Establishment of a special fund to provide finances at concessionary terms would address this constraint. The Sri Lanka Sustainable Energy Act, No. 35 of 2007 empowers the SEA to create a Fund to support projects of this nature by imposing a cess on all fossil fuels imported. Therefore, invoking this provision of the ACT would facilitate generating significant amount of funds to support initiatives under this technology.

b) Barrier: The economic feasibility not established

This barrier is common to Co-firing of biomass with coal (conversion of MSW into RDF), Compact biogas digester for urban households, Smart grid technology for integrating wind, solar and small hydro power projects with the grid, the use of LED for task lighting and for the Solar assisted air conditioning projects.

Measure: Engage a multidisciplinary team of experts to conduct economic feasibility studies on relevant Renewable Energy and Energy Efficiency projects.

Economic feasibilities have not been established for some of the Renewable Energy and Energy Efficiency projects identified under this initiative. Without such studies, it would not be possible to convince the decision makers to accept any proposals to implement such projects. In view of various aspects that require to be addressed in these feasibility studies, a multidisciplinary team consisting of competent economists, engineers etc. should be constituted to undertake this study. The study results needs to be made available to public to enable the potential private sector investors to positively consider undertaking these projects.

c) Barrier: Technology either not established or not fully developed.

This barrier is applicable to the technology related to Co-firing of biomass with coal, Compact biogas digester for urban household, smart grid technology to integrate wind, solar and small hydro power projects with the national grid.

(i) Measure: Commercialize the production and marketing of Glricidia leaves through appropriate R&D

The production and marketing of Gliricidia leaves is yet to reach a commercial level due to want of adequate R&D. The NERD Centre and the Universities could play an important role in achieving this objective. It is important to develop a technology to powder Gliricidia leaves in order to facilitate the bacterial fermentation as well as to make it user friendly for regular use. Further, the research should ensure that the cost of producing Gliricidia leaf powder is kept within limits.

(ii) Measure: Provide opportunities for the local officials to get familiarized with the relevant technologies already practiced in other countries.

The local officials appear to br less familiar with some of the technologies identified. Therefore, action needs to be taken to get these officials familiarized with the respective technologies already being practiced in many other countries through exposure visits to such countries.

1.1.3 Specific Measures Proposed for the Selected Technologies:

The specific measures proposed for prioritized technologies in the Energy sector are given in tables below. Refer to the report on Barrier Analysis and Enabling Framework (Report II) for explanations of barriers and measures.

Table 1.3: Specific Measures for Conversion of Biomass and Waste to Energy

No.	Recommended Measures
1.	Relevant state institutions to conduct feasibility studies and publicize such studies.
2.	(i) Review and reform as appropriate Government taxes on technology related local fabrications and constructions (ii) Donor agencies to consider providing adequate funds on concessionary terms.
3.	Sustainability Energy Authority (SEA) to exercise provision in the Act by imposing a levy on fossil fuels and to use such proceeds to provide low interest finance for Renewable Energy and Energy Efficiency projects.
4.	Sri Lanka Sustainable Energy Authority to include “Co-firing” as a technology option for electricity generation for the grid.
5.	Costs of technology options to be integrated into costing during generation planning.
6.	(i) Underutilized state lands to be made available for multipurpose agro-energy cultivation by private sector; (ii) Consider removing subsidies on fossil fuels; (iii) Ensured MSW for manufacturing RDF by the private sector
7.	State should play a proactive role in demonstrating co-firing and RDF technologies
8.	(i) Research institutions in Sri Lanka to resolve the issues in the production and use of feedstock for urban household biogas digester (ii) Ensure availability of funds required for such studies.

Table 1.4: Specific Measures for Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration

No.	Recommended Measures
1.	Cost of technology options to be integrated when costing during generation planning
2.	(i) Review and reform as appropriate Government taxes on technology related local fabrications and constructions (ii) Donor agencies to provide required funds on concessionary terms for these sectors:
3.	Sustainability Energy Authority to exercise provision in the Act by imposing a levy on fossil fuels and to use such proceeds to provide low interest finance for Renewable Energy and Energy Efficiency projects.
4.	(i) Relevant state institutions to conduct feasibility studies and disseminate study results. (ii) Ensure adequate funds for such studies.
5.	Technical Colleges and Universities to include these subjects in respective curricula.
6.	Provide adequate exposure to relevant officials to application of respective technologies
7.	Provide required training for respective State officials.
8.	Meteorological Department to be provided with specific instrumentation and other resources to enable regularly provide adequate weather related information to the energy sector.
9.	Explore State and donor funding for infrastructure improvement.

10.	Provide adequate exposure to officials to get familiarized with the technologies
11.	Consider modifying the load profile by; (i) Appropriate time based tariffs with appropriate meters.(ii) Impose regulations to reduce electricity load during peak time.
12.	Strengthen inter agency coordination

Table 1.5: Specific Measures for Building Management Systems

No.	Recommended Measures
1.	(i) Review and reform as appropriate Government taxes on technology related local fabrications and constructions (ii) Donor agencies to consider providing adequate funds on concessionary terms
2.	(i) Sustainability Energy Authority to exercise provision in the Act by imposing a levy on fossil fuels and to use such proceeds to provide low interest finance for Energy Efficiency projects. (ii) Donor agencies to providing adequate funds on concessionary terms
3.	(i) Relevant state institutions to conduct feasibility studies and disseminate study results (ii) Ensure adequate funds for such studies.
4.	Review and revise householder tariff based on marginal cost and provide relief to targeted consumers only
5.	Technical Colleges and Universities to include relevant subjects in the curricula.
6.	Update information through appropriate media
7.	Provide publicity through appropriate media.
8.	Train technicians at state owned technical and vocational training institutions
9.	Introduce legislations for vendors to compensate for failure before manufacturers' warranty
10.	Introduce certification by testing under more rigorous conditions

1.2 Action Plan for Technology 1: Conversion of Biomass and Waste to Energy

1.2.1 Description of the technology

Three technology applications being considered under this technology are; (a) Co-firing Biomass with Coal (b) Compact Biogas Digester for Urban Households (c) Waste to Energy [Manufacture of Residue Derived Fuel (RDF) from Municipal Solid Waste (MSW)].

(a) Co-Firing of Biomass with Coal

In the proposed technology, it is intended to use biomass in conjunction with coal as fuels. Although several options are available for co-firing biomass with coal, taking into account the need to minimize the extent of tampering with the existing equipment at a coal fired power plant, the option recommended is to 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 thus produced in the biomass boiler is connected to a common steam header to drive the existing steam turbines. Although this method is the most expensive option, it has the advantages such as the existing equipments such as coal conveyor, coal crusher, coal boiler etc. are not tampered with and the share of biomass could vary between 0% to 100%.Presently, there are no co-firing facilities in Sri Lanka and the technology will involve sustainable cultivation, harvesting and transport of biomass to the energy conversion facility.

It is estimated that about 479,000 tonnes of Gliricidia wood is annually used by biomass based power generation plants and industrial processing centers such as rubber gloves manufacturing facilities[3]. Around 3800 workers are presently engaged in this sector

(b) Compact Biogas Digester for Urban Households

The "Compact Bio Gas Digestor" has been recently developed to resolve issues related to conventional biogas digester[4]. " The volume of this digester is 1.5 m3. It essentially consists of two plastic tanks. The research studies have shown that leaves of Gliricidia is the most effective material to be used as the feed material for biogas production using this technology. An average household could generate adequate biogas through this technology to meet the energy required for cooking.

This technology is in a very early stage of development and the number of people engaged in this sector at present is around 12. It is proposed to process and utilize the foliage from Gliricidi plantations as feed material for this purpose. Once this technology is developed to a commercial scale, it will have the potential for integrating with the co-firing technology discussed above.

(c) Waste To Energy

The major problem encountered when Municipal Solid Waste (MSW) is combusted to generate energy is the production of dioxins due to combustion of halogenated plastic materials such as PVC found mixed with MSW. Although, use Plasma Gasification Technology could resolve this issue, this process is very capital intensive and incurs high operational costs. As such, no such facility has been introduced to date in Sri Lanka.

In this technology, MSW is shredded, dried and separated into organic, plastic, paper, etc. and recyclable fractions are separated while the remaining components are blended in appropriate proportions and compacted into pellets known as Residue Derived Fuel (RDF). This could be used as fuel replacing coal in the manufacture of cement.

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[3] (Reference: United Nations Industrial Development Organization, Market and Economic Study of the Biomass Energy Sector in Sri Lanka, January, 2011.)

[4] Developed by Appropriate Rural Technology Institute, Pune, Maharashtra, India (www.arti-india.org)

At present the use of MSW as a source of energy is limited to a few small projects, where MSW is anaerobically digested to generate biogas. At present the total number of people employed in the MSW based anaerobic digestion is around 12.

Conversion of Biomass and Waste to Energy has the following economic, social and environmental reasons;

a) Direct and indirect economic benefits arising from this technology (i.e. Biomass based electricity generation is in fact the cheapest way of generating electricity *(Co-Firing of Biomass with Coal)*; reduce the cost of fuel used for cooking by switching from expensive LPG to cheap biomass feed materials *(Compact Biogas Digester);* The 8000 tonnes of RDF to be produced annually would be equivalent to 5000 tonnes coal valued at US$750,000 *(Waste To Energy).*
b) Numerous potential employment and economic opportunities.
c) Environmental benefits such as elimination of health problems associated with open dumping of MSW and increasing the green cover in the country.
d) Potential for reduce GHG emissions.
e) Low cost of production.
f) Annual National Mitigation Benefits accruable from this technology would be around 9,057,593tCo_2/year.

(Please refer to Annex C - Technology Fact Sheets (TFS) in the TNA report (Report I) for further details)

1.2.2 Targets for technology transfer and diffusion

The Tables 1.6, 1.7 and 1.8 give the primary targets for technology transfer and diffusion of each technology along with expected economic benefits and expected lifetime of the technology and the climate change mitigation impacts including the other environment impacts.

Table 1.6: Primary targets of Co-firing Biomass with Coal

Technology	Co-Firing Biomass with Coal
Primary target	Substituting 30 MWe (10% of capacity) equivalent of coal with biomass by 2019. The required amount of biomass would come from measure No. 6 recommended above.
Expected life time	Minimum 30 years
Expected economic benefits	The annual economic benefit of replacing 30MWe equivalent of imported coal with indigenous biomass is estimated as US$ 75 million in the form of foreign exchange savings based on the following assumptions: • Price coal (CIF): US$ 150/tone • Specific fuel consumption: 0.4 kg coal/kWh • Annual operating hours: 7000h/ y
Climate Change Mitigation Impacts	Estimated CO_2 reduction potential for 30 years is 6,180,000 tCO2e based on the following assumptions:

	• Emission: 94.6 tCO2/TJ for coal (UNFCCC) • Calorific Value of coal: 26,000 kJ/kg (CEB) • Annual operating hours: 7000 h/y (CEB) • Specific fuel consumption: 0.4 kg/kWh (CEB) (CEB) • Emission factor for Renewable Biomass is zero.
Expected future target of employment	At the Boiler: 25 persons Supply Chain: 1000 persons
Other Environment Impacts	• Less acidification as biomass has practically no sulphur. • Less emission of mercury or other heavy metals.

Table 1.7: Primary targets of Compact Biogas Digester for Urban Households

Technology	Compact Biogas Digester for Urban Households
Primary target	60,000 household units in four years each replacing 0.4 kg LPG per day.
Expected life time	10 years
Expected economic benefits	Foreign exchange saving US$ 34,133 /y based on following assumptions: • A household consumes 0.4 kg LPG per day • Price of LPG : Rs. 192/kg • Exchange Rate: Rs. 135/US$
Climate Change Mitigation Impacts	Mitigation of 25,482 tCO2/y The above is based on following assumptions: • Emission factor for LPG: 63.1tCO2/TJ • Calorific Value of LPG: 46,100 kJ/kg • A household consumes 0.4 kh LPG per day
Expected future target of employment	480 persons
Other Environment Impacts	• Liquid effluent from the biogas digesters would replace part of chemical fertilizers thereby mitigating all negative impacts of chemical fertilizers.

Table 1.8: Primary targets of Waste to Energy

Technology	Waste to Energy
Primary target	Daily production of 50 tonnes of RDF from Municipal Solid Wastes (MSW) in four years.
Expected life time	10 years
Expected economic benefits	Foreign exchange saving of US$ 2,737,500 /y. The above is based on the following assumptions: • 1 kg RDF=1kg Coal • Price of Coal: US$ 150/t (CIF)

Climate Change Mitigation Impacts	Mitigation of 44,887 tCO2/y The above is based on the above assumptions: • Emission: 94.6 tCO2/TJ for coal • Calorific Value of coal: 26,000 kJ/kg • 1 kg of RDF = 1 kg of Coal
Expected future target of employment	50 persons
Other Environment Impacts	• Reduction of Methane emission from open dumping of MSW. • Reduced health risks and bad odor from open dumping of MDW

1.2.3 Barriers to the technology's diffusion

Potential barriers for ***Conversion of Biomass and Waste To Energy*** and the hierarchical classification in Table 1.9.

Table 1.9: List of key barriers and hierarchy classification for Conversion of Biomass and Waste to Energy

Technology Name: Conversion of Biomass and Waste to Energy			
No.	**Key Barriers Identified**	**Priority Rank**	**Category of Barriers**
1.	Economic and financial feasibility not available	1	Economic and financial
2.	High capital cost	2	Economic and financial
3.	Difficulty to access finance	3	Economic and financial
4.	Private sector not informed or not invited to participate	4	Information & awareness
5.	Externalities of coal firing not internalized	5	Policy, legal and regulatory
6.	Non availability of well established supply chain of biomass/waste	7	Market failure
7.	Technology not established at the scale envisaged (for co-firing and RDF):	8	Technical
8.	Technology not fully developed (for Compact biogas digester)	9	Technical

1.2.4 Proposed Action Plans for Conversion of Biomass and Waste to Energy

The Proposed Action Plan is provided in table 1.10.

ENERGY SECTOR

Proposed Action Plan for Technology 1

Table 1.10: Action Plan for Conversion of Biomass and Waste to Energy

Measure/Action 1: Relevant state institutions to undertake feasibility studies and disseminate study results (See note below)					
Justification for the action: The Economic and financial feasibility is not well established. Therefore financial viability of the technology need to be assessed and relevant information be made available to the private sector to consider investing in the technology					
Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source (US $)**	**Indicators**
i. Relevant state institutions to conduct feasibility studies and disseminate study results	V. High	Sustainable Energy Authority	Year 2014	150,000 International	Feasibility Report on (1) Co-Firing and (2) Municipal Solid Waste to Residue Derived Fuel to be available before end of 2014
Measure/Action 2: (i) Review and reform government taxes on imports and local fabrications and constructions related to Renewable Energy and Energy Efficiency Projects. (ii) Explore donor support on concessionary terms for renewable energy and energy efficiency projects					
Justification for the action: The related barrier is '*High capital cost'.* The recommended action is aimed reducing implementation costs of renewable energy and energy efficiency projects thus attracting the private sector investments. At present renewable energy and energy efficiency projects are funded mostly by local equity and local funds at higher interest rates which is a hindrance to the expansion of the technology.					
Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US$**	**Indicators**
I. Government to consider reforming existing tax regimes for imports and local	V. High	M/Power and Energy,	To be effective	US$ 10 million. This amount, in local	Gazette notification to the effect published and operational from 2014

fabrications and constructions related to Renewable Energy and Energy Efficiency Projects.		M/Industry and Commerce, M/Finance & Planning	from Year 2014 the latest	currency to be raised by imposing a very small tax on fossil fuels.	
II. Donor agencies to consider providing funds on concessionary terms for renewable energy and energy efficiency projects	V. High	Sustainable Energy Authority/ Department of External Resources	2014-2017	International US $ 168 m from 2014 - 2017.	Donor agencies provide following funds during the time frame indicated; 2014:US$43 m 2015:US$35 m 2016: US$85 m 2017: US$ 5 m Assumptions: 50% of funds to be provided by donor funding. Total cost of projects : US$ 2000/ kW for 168 MW
Measure/Action 3: SEA to exercise the provision in the Act to impose a levy on all fossil fuels and constitute a fund for the development of renewable energy and energy efficiency projects. The magnitude of the levy should not adversely affect the economy in a significant manner.					
Justification for the action: The related barrier is '*Difficulties to access finance'.* Presently the fossil energy projects are funded by international agencies and such financing facilities are not available for renewable energy and energy efficiency projects.					
Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US$**	**Indicators**
I. Sustainability Energy Authority (SEA) to exercise provision in the Act by imposing a levy on fossil fuels and to use such proceeds it to establish a Fund to provide low interest finance for Renewable Energy	High	Sustainable Energy Authority	2014-2017	local 2014:US$50 m 2015:US$60 m 2016: US$70 m 2017: US$ 80m	Commissioning of Renewable Energy Projects due to these activities: In 2014:48 MW In 2015: 35 MW In 2016: 85 MW

and Energy Efficiency projects.				International 2014:US$48 m 2015:US$35m 2016: US$85 m 2017: US$ 5 m Assumptions: US$2000/kW	In 2017: 5 MW
Measure/Action 4: Include Co-firing also as a potential technology for electricity generation for the grid by the private sector under the Standardized Power Purchase Agreement					
Justification for the action: The related barrier – '*Private sector not informed or invited to participate'.* (i) The private sector and some sections of the CEB are not aware of this technology. (ii) Capital cost and fuel cost of co-firing is much cheaper than that of conventional biomass power plant					
Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US$**	**Indicators**
I. Include Co-firing as a technology in the options available for electricity generation for the grid by the private sector	High	Sustainable Energy Authority/ Ceylon Electricity Board	2014-2017	Funds available through 2 and 3 could be utilized for this.	Establishment of the following capacities of co-firing: 2014: 30 MW 2015: 60 MW 2016: 120 MW 2017: 240 MW
Measure/Action 5: During generation planning, integrate externalities such as impacts on health, agriculture etc when costing of technology options.					
Justification for the action: As the direct and indirect costs of are not considered during generation planning, renewable energy based electricity appears to be more costly. This anomaly could be corrected by integrating all externalities into the costing formula.					

Action No	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source US$	Indicators
I. Internalize all direct and indirect costs during generation planning as such an approach ensure determining the actual costs of generation to enable informed policy decisions. .	High	Ministry of Environment	2014-2017	150,000 International funds	Commissioning of Renewable Energy Projects due to this activity: 2014:48 MW 2015: 35 MW 2016:85 MW 2017: 5 MW
Measure /Action 6: (i) Underutilized state lands be made available for multi-purpose agro-energy cultivation by the private sector. (ii) Consider removing subsidies on fossil fuels (iii) Ensure availability of Municipal Solid Waste (MSW) for Residue Derived Fuel (RDF) manufacture by the private sector.					
Justification for the action: Barrier: As per the available reports of the Land Use Policy Planning Division, over 1.6 million ha of State land remain under utilized. Accordingly, these lands are suitable for agro-energy plantations. By arranging the use of this land for agro-energy plantations 48 million tones of biomass could be generated annually; (ii) Subsidies on fossil fuels has direct impact on the price of fuel wood. (iii) Access to municipal solid wastes is not presently ensured to the private sector.					
Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US$**	**Indicators**
I. Underutilized state lands be made available for multi-purpose agro-energy cultivation by the private sector.	High	Sustainable Energy Authority/ Ministry of Land	Year 2014-2018	Costs to be borne by the private sector	Establishment of agro-energy plantations: 2014: 1 00ha 2015:1,000 ha 2016: 10,000 ha 2017: 20,000 ha 2018: 40,000 ha

II. Consider removing subsidies on fossil fuels.	High	Ceylon Petroleum Corporation/ Ministry of Finance	Now onwards	None	Subsidy component removed in the sale price of fossil fuels.
III. Ensure availability of Municipal Solid Waste (MSW) to the parties interested in the manufacture of Residue Derived Fuel (RDF).	Medium	Ministry of Local Government	2014 - 2017	None	MSW is accessible to private sector for the use of energy generation from year 2014
Measure /Action 7: Proactive State sector involvement with the private sector in the initial phase of Co-firing and Municipal Waste to Energy projects (As done for small hydro, wind and solar PV)					
Justification for the action: Barrier: '*Technology not established at the scale envisaged'.* The private sector would be hesitant in investing in unproven technologies for obvious reasons. In the past, when such new technologies are introduced, the government has acted proactively to demonstrate the technical and commercial viability of such technologies. Hence in respect of co-firing and RDF manufacture, the government should make capital contributions towards the first set of these projects to convince the private sector.					
Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US$**	**Indicators**
I. The state sector play a collaborative role with the private sector in the initial phase of Co-firing and RDF manufacture	Medium	Sustainable Energy Authority	2014 onwards	US$15 million for co-firing and US$1 million for RDF manufacture International Funding	Year 2015: Commencement of Co-firing and Residue Derived Fuel (RDF) manufacturing operations.
Measure /Action 8: Research institutions in Sri Lanka should resolve the issues in the production and use of feedstock for urban household biogas digester.					
Justification for the action: Related barrier is '*Technology not fully developed for compact biogas digester technology'.* Number issues in the manufacture and operation of urban household biogas digesters remain unresolved. In view of competing business interests, opportunities private sector involvement in such research activities is minimal. Hence the state research institutions should address these issues.					

Action No	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source US$	Indicators
I. Research institutions in Sri Lanka to undertake R&D activities to resolve issues related to production and use of feedstock for urban household biogas digester.	Medium	Research institutions such as NERD C, ITI, Universities	Year 2014-2015	Local US$ 10,000	- Implementation of the technology commence from 2015. - Successful operations at least 100 Compact Biogas Digesters in 2015.
Total Cost for Technology 1				**Approx: US $ 617 million**	

Following feasibility studies are proposed under Measure/Action 1:

1. Co-Firing of Biomass with Coal
2. Compact Biogas Digester for Urban Households
3. Waste To Energy
4. Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration
5. LED Lighting
6. Solar Assisted Air Conditioning.
7. Establishment of appropriate energy crops and extraction of fuel in the waste lands in the coastal areas in the country.
8. Establishment of appropriate energy crops and extraction of fuel in suitable locations in the sea in the country.

1.3 Action plans for Technology 2: Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration

1.3.1 Description of the technology

The potential for wind and solar PV based electricity generation in Sri Lanka appears to be highly significant. Each of the above technology options has the combined potential to generate more than the total electrical energy presently generated in the country. However, the development of these two technologies to meet grid-based electricity generation is not at desired level due to the reluctance on the part of the national electric service provider in view of the frequent and rapid output variations of these technology based power plants. The cost of storing electricity generated by these sources to mitigate the output fluctuations is prohibitively expensive.

Many developed countries have addressed such issues by adjusting the demand of energy in the system and outputs of hydropower generators to match the output variations of wind and solar PV based power generators through application of Smart Grid/ Smart Meter technologies.

Following table provides the present (2011) status of wind, solar and hydro power plants connected to the national grid.

Type of Power Plant	No. of Power Plants Connected to Grid	No. of People Employed at these Power Plants
Wind	1	12
Solar	1	1
Hydro	120	1800
Total	122	1813

This technology has received its due priority due to following potential social and economic benefits of the technology.

a) High potential of employment generation opportunities for all categories of work force in the country
b) Economic benefits to the country through the expansion of wind and solar PV based power projects.
c) This technology would lead to reduction of fossil fuel based electricity generation which in turn would result in the following environmental benefits:
    - Reduction on GHG emissions
    - Reduction in NOX, SOX, particulate matter, heavy metal and radioactive chemical deposits.
d) The annual national mitigation benefits of the technology is 1,497,000tCO_2/y/ 1000 MW

(Please refer to Annex C - Technology Fact Sheets (TFS) in the TNA report (Report I) for further details)

1.3.2 Target for technology transfer and diffusion

Table 1.5 gives the targets for technology transfer and diffusion along with expected economic benefits and lifetime of the technology and climate change mitigation impacts including the other environment impacts.

Table 1.11: Targets of Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration

Technology	Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration
Primary target	Smart Grid will enable integration of additional, 100MW of Solar and 100 MW of Wind Penetration by 2018 (if project starts in 2014). The government has a target of generating 20% of the forecasted electrical energy requirement of over 4000 MW by 2020 from NCRE sources and the primary target of this technology would enable achieving this goal. .
Expected life time	20 years
Expected economic benefits	**1. 100 MW Solar** Foreign exchange savings of US$ 13.8 million /y. The above is based on the following assumptions: • Calorific Value of diesel: 40,000 kJ/kg • Price of Diesel: US$ 700/t (CIF) • Efficiency of Combined Cycle power plant: 60% • Annual Plant factor of Solar plants: 15% **2. 100 MW Wind** Foreign exchange saving of US$ 23 million /y. The above is based on the following assumptions: • Calorific Value of diesel: 40,000 kJ/kg • Price of Diesel: US$ 700/t (CIF) • Efficiency of Combined Cycle power plant: 60% • Annual Plant factor of Wind plants: 25%
Climate Change Mitigation Impacts	**1. 100 MW Solar** Mitigation potential of 58,391 tCO2/y based on the following assumptions: • Emission: 74.1 tCO2/TJ for diesel • Calorific Value of diesel: 40,000 kJ/kg • Efficiency of Combined Cycle power plant: 60% • Annual Plant factor of Solar plants: 15%. **2. 100 MW Wind** Mitigation potential of 97,318 tCO2/y based on the following assumptions: • Emission: 74.1 tCO2/TJ for diesel • Calorific Value of diesel: 40,000 kJ/kg • Efficiency of Combined Cycle power plant: 60% • Annual Plant factor of Wind plants: 25%.

Expected future target of employment	• Phase 1 (Capacity Building): 12 persons • Phase 2 (Construction &operation of Wind and Solar Power Plants): ▪ Construction of wind power plants (10 x 10 MW): 250 people ▪ Operation of wind power plants: 10 x 12): 120 people. ▪ Installation of 50,000 nos. of 2 kW Roof-Mounted Solar:1000 people. Maintenance of Solar system: 200 people
Other Environment Impacts	• Reduction of acidification due to lesser consumption of diesel fuel • Reduced demand for cooling water. Thus less pressure on water resources.

1.3.3 Barriers to the technology diffusion

List of key barriers and hierarchical classification is given in Table 1.12.

Table 1.12: List of key barriers and hierarchy classification for Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration

No.	Key Barriers Identified	Priority Rank	Category of Barriers
1.	Non-conventional renewable energy options are more expensive as all externalities are not internalized when costing	1	Economic and financial
2.	High capital cost	2	Economic and financial
3.	Difficulty to access finance	3	Economic and financial
4.	Economic viability not examined	4	Economic and financial
5.	Subject matter not integrated into the curricula of technical colleges and universities	5	Information and awareness
6.	Technology not freely available	6	Information and awareness
7.	Lack of experts in relevant institutions	7	Human skills
8.	Lack of adequate weather forecasts provided by the Department of Meteorology	8	Institutional and organizational capacity
9.	Weak infrastructure – electricity grid limitations, telecommunication, road and railway networks	9	Technical
10.	Complexity of technology	10	Technical
11.	Poor electricity load profile – high peak for short duration	11	Technical
12.	Inadequate coordination among institutions	12	Policy, legal and regulatory

1.3.4 Proposed Action Plans for Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration.

The Proposed Action Plan for the technology is provided in Table 1.13.

ENERGY SECTOR

Proposed Action Plan for the Technology 2

Table 1.13: Action Plan for Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration

Measure/Action 1: Integrate all indirect (impacts on health and agriculture etc.) and direct costs when costing technology options during generation planning.					
Justification for the action: Barrier – '*Non-conventional renewable energy options are considered more expensive as all indirect costs are not integrated when costing technology options during generation planning,* thus renewable energy based electricity technology is deemed more costly. This anomaly could be corrected by internalizing all indirect costs.					
Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding In US$**	**Indicators**
I. Internalize all externalities when costing technology options during generation planning.	V. High	Ministry of Power and Energy	2014-2017	US$ 150,000 International to study the cost of externalities	Commissioning of Renewable Energy Projects due to this activity. 2014:48 MW 2015: 35 MW 2016: 85 MW 2017: 5 MW
Measure/Action 2: (i) Review and reform Government taxes on imports, local fabrications and constructions related to Renewable Energy and Energy Efficiency Projects. (ii) Donor agencies to consider providing required funds on concessionary terms.					
Justification for the action: Barrier – '*High capital cost'.* To attract private sector investments in renewable energy and energy efficiency projects through reduced investment costs.					

Action No.	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding US$	Indicators
I. Consider tax concessions for imports, local fabrications and constructions related to Renewable Energy and Energy Efficiency Projects	V. High	Ministries of Power and Energy/ Industry/ Commerce/ Finance & Planning	To be effective from 2014 the latest	Local funds US$ 10 million. To be raised through a tax of fossil fuels	Gazette notification to the effect published and operational from 2014 .
II. Donor agencies to consider providing required funds on concessionary terms. sectors.	V. High	Sustainable Energy Authority/ Department of External Resources	2014-2017	local 2014:US$43 m 2015:US$35m 2016: US$85 m 2017: US$ 5 m	Commissioning of Renewable Energy Projects due to these activities: 2014: 43MW 2015: 35MW 2016:85 MW 2017:5 MW
Measure/Action 3: Sustainable Energy Authority to exercise the provision in the Act to impose a levy on all fossil fuels and constitute a fund for the development of renewable energy and energy efficiency projects. The magnitude of the levy should not adversely affect the economy in a significant manner.					
Justification for the action: Barrier – '*Difficulty to access finance*'. Presently the fossil fuel based energy projects are funded by international agencies. Such financing is not available for renewable energy and energy efficiency projects.					
Action No.	**Priority Rank**	**Responsibility**	**Time frame**	**Cost & Funding US$**	**Indicators**
I. Sustainable Energy Authority to exercise the provision in the Act to impose a levy on all fossil fuels and constitute a Fund for the development of renewable energy and energy efficiency projects.	High	Sustainable Energy Authority/ Department of External resources/Donor Agencies	2014-2017	local 2014:US$50m 2015:US$60 m 2016: US$70m 2017: US$ 80 m International:	Commissioning of Renewable Energy Projects due to these activities: 2014:48 MW 2015: 35 MW 2016: 85 MW 2017: 5 MW

				2014:US$48 m 2015:US$35mil 2016: US$85 m 2017: US$ 5 m Funding is based on US$2000/kW	
Measure/Action 4: (i) Relevant State Institutions to undertake feasibility studies and disseminate study results. (ii) Donor agencies to consider providing required funds for studies.					
Justification for the action: Barrier- '*Economic viability not examined*'. Financial and economic viability of the technology needs to be examined to encourage private sector to consider investing in this technology. As private sector institutions are finding it difficult to raise funds for these new technologies, donor agencies need to consider providing funds on concessionary terms to kick off such initiatives.					
Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US$**	**Indicators**
I. Relevant State Institutions to conduct feasibility studies and disseminate study results	High	Sustainable Energy Authority/	2014		Feasibility Report on this topic to be available before end of 2014 .
II. Donor agencies to consider providing required funds for studies.	High	Department of External resources	2014	US$150,000 International	Funds to be provided in 2014
Measure /Action 5: Technical Colleges and Universities to integrate related subject matter in study curricula.					
Justification for the action: Related barrier- '*Related subject matter is not integrated into the curricula technical colleges and Universities*'. The concept of Smart Grid is new to Sri Lanka and to the world. Furthermore uptakes of new technologies are very slow in Sri Lanka. Hence this subject need to be introduced at the Technical Colleges and Universities as soon as practicable.					

Action No	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding US$	Indicators
I. Technical Colleges and Universities to include related subject matter in study curricula	High	University Grants Commission/ Ceylon Electricity Board/ Sustainable Energy Authority	2014	local US$ 80,000	Topics included in the curricula in the Technical Colleges and Universities from 2015 .
Measure/ Action 6: Provide adequate exposure on such technologies to the relevant Officials					
Justification for the action: Since these technologies are new, relevant officials need to be exposed to such ventures in other countries in order to get familiarized with technology applications.					
Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US$**	**Indicators**
i. Relevant Officials should be exposed to such technologies	High	Ceylon Electricity Board/ Sustainable Energy Authority/ Meteorological Department	2014	International US$ 250,000	A total of 25 officials have gained practical knowledge on the technology by end of 2014
Measure / Action 7: Provide required training to relevant Officials to acquire expertise in such technologies					
Justification for action: In order to implement and ensure sustainability of these new technologies, building of local expertise will be imperative.					
Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US$**	**Indicators**
Relevant Officials should be trained as experts in such technologies	High	Ceylon Electricity Board/ Sustainable Energy Authority/ Meteorological Department	2014 - 2015	International US$ 250,000	A total of 5 officials have gained expert knowledge in technology by end of 2015

Measure /Action 8: Provide necessary resources to the Meteorological Department

Justification for the action: Related barrier is '*Lack of adequate weather forecasts provided by the Department of Meteorology*'. The smart grid technology to integrate wind, solar and small hydro power projects with the national grid requires very accurate weather forecast data on a regular basis. At present the Meteorological Department in Sri Lanka does not have adequate resources to provide such specific data. Therefore, the Meteorological Department needs to be adequately equipped with required hardware, software and human resources. In view of government's financial constraints donor funding may be explored for this purpose.

Action No	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding US$	Indicators
i. Provide necessary resources to the Meteorological Department	Medium	Department of Meteorology/ Ministry of Finance/Department of External Resources	2014	US$ 10 million International	More accurate and early predictions of weather relevant for renewable energy applications from 2015 .

Measure /Action 9: Necessary funds to be provided by the state or donor agencies to improve relevant infrastructure.

Justification for the action: Related barrier is '*Week infrastructure – Electricity grid limitations, telecommunication, road and railway networks'.* Improvements to the existing infrastructure will be a necessary pre-condition to ensure successful technology implementation. Donor funding in the form of grants may be explored for such infrastructural improvements.

Action No	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding US$	Indicators
i. Necessary funds to be provided by the state or donor agencies to improve relevant infrastructure such as enhancements of grid, telecommunication net work, road and railway networks.	Medium	Ministry of Finance/ Department of External Resources	2014 - 2018	US$ 100 million Local or International	Better Infrastructure Facility. Share of Renewable Energy in the national grid due to this action: 2015: 35 MW 2016: 85 MW 2017: 25 MW 2018: 100 MW

Measure /Action 10: Provide opportunity to the relevant officials to get familiarized with these technologies through exposure.

Justification for the action: Related barrier – '*Complexity of the technology*'. As these technologies are new, officials of the relevant institutions need to be given an opportunity to get familiarized with the technologies through exposure..

Action No	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding US$	Indicators
i. Provide opportunity to relevant officials to get familiarized with these technologies to enable understanding the technology	Medium	Ceylon Electricity Board/ Sustainable Energy Authority/ Meteorological Department	2014	US$ 250,000 International	A total of 25 officials from the relevant institutions have familiarized with Smart Grid Technologies by end of 2014, to enhance the share of Renewable Energy in the national electricity grid

Measure /Action 11: Modify daily electricity load profile by (a) introducing Smart Meters & cost reflective tariff (b) regulations to restrain low priority activities during peak load hours(c) introducing load shifting technologies such as charging of electric vehicles during off-peak hours and making ice during off-peak hours to be used as refrigerant during peak hours. The purpose of introducing Electric Vehicles is to flatten the load curve by providing suitable time of day tariff to charge the batteries. This approach would enable increasing the low load experienced in the early hours of the morning and decrease the high demand created by air conditioning in the evening hours by ice manufacture during the early hours and using the ice for air conditioning during the entire duration of day and night.

Justification for the action: Barrier- '*Poor electricity load profile – high peak for short duration*'. The daily electricity load profile in the national electricity grid has a sharp evening peak and prolonged low demand during the early morning hours. These features limit the share of NCRE technologies in the energy mix. By flattening the load profile, by actions such as smart meters-tariff, storage devices etc. the share of NRE could be significantly increased.

Action No	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding US$	Indicators
i. Modify daily electricity load profile by (a), (b) and (c) above.	Medium	Ceylon Electricity Board/ Ministry of Power and Energy/ Sustainable Energy Authority	Year 2015-2019	US$ 500 m International	Gradual flattening of the daily load profile. As at 2007, the average to peak ratio was 0.61.This should be improved to at least 0.55 by 2019.

Measure/ Action 12: Strengthen the coordination among relevant institutions					
Justification for the action: Barrier- '*Inadequate inter-agency coordination* '. There have been instances where regulatory measures have been taken without adequate prior stakeholder consultations hence causing impacts on other sectors. In future, arrangements should be made to strengthen the coordination in order to ensure such actions are not implemented without adequate consultation.					
Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US$**	**Indicators**
i. Strengthen inter-agency coordination	Medium	CEB/Department of Wildlife Conservation	From 2014	Insignificant	Procedure established to strengthen coordination among relevant institutions.
Total Cost for Technology 2				**Approx: US $ 1,210 million**	

1.4 Action plans for Technology 3: Building Management Systems

1.4.1 Description of the technology

The sub technologies considered under this technology are: (a) LED Lighting (b) Solar Assisted Air Conditioning.

a). LED Lighting

LED technology is advancing into new categories of white light applications, including surgical task lighting, where early indications suggest significant potential for energy savings and reduced maintenance.

The halogen lamps typically used in surgical task lights suffer from relatively low luminous efficacy (lumens of light output per watt of input power), which is further worsened by filters that must be used to reduce emission of non-visible radiation. LED surgical task lights typically do not require such filtering media, and their higher efficacy can allow for reductions in connected load of 50 percent or more, with potential for additional energy savings through constant-color dimming and reduced cooling load in the operating room. Furthermore, while halogen lamps are typically rated for just 1,000 to 3,000 hours and fail without warning, LED surgical task lights are generally rated for 25,000 to 40,000 hours and are expected to “fail” by gradually fading in brightness.

LED bulbs are presently marketed by few traders through the normal marketing channels which do not involve employing specialized personnel for the sale of LEDs. Hence the total number of people currently being employed in this sector may be considered as negligible.

b). Solar Assisted Air Conditioning

The Solar Assisted Air Conditioning system is a system that utilizes the sun as a heat source to generate energy needed to drive the cooling process of a typical air conditioning system which in turn contributes to reduce electricity usage to run the compressor.

Solar Assisted air conditioner has the potential for saving 30-50% of the electricity. It has a wide target market such as hotels, restaurants, hospitals, factories, schools, convention centres and high end residential units. It requires minimal direct sunlight exposure as heat from ambient and heat blown by the condenser is also utilized. There is minimum 30% saving if conventional AC unit is replaced by solar assisted AC. The estimated energy saving is about 6,785,100,000 kWh/year.

This technology has not been introduced into the country as yet. Hence the number of people employed in this sector should be taken as zero.

The 'Building Management Systems' has been considered a priority mainly due to following economic and environmental benefits arising from the technology;

a) **LED Lighting** is energy efficient, less weight, long lasting and reduce heat load of air conditioner. Lifespan of LED lighting is around 20 times that of the halogen lamps and is designed to "fail" gradually through fading in brightness.
b) **Solar assisted air conditioner** saves around 30 -50 % of electricity. It requires minimal direct sunlight exposure. The estimate energy saving is around 6,785,100,000 kWh per year.

(Please refer to Annex C - Technology Fact Sheets (TFS) in the TNA report (Report I) for further details)

1.4.2 Target for technology transfer and diffusion

The Tables 1.14 and 1.15 give the primary targets for transfer and diffusion of each technology together with expected economic benefits and lifetime of the technology including climate change mitigation impacts and other environment impacts.

Table 1.14: Primary targets of LED Lighting

Technology	LED Lighting
Primary target	1MW of LED Solar by 2018 (if project starts in 2014)..
Expected life time	20 years (Average 7 hours of lighting /day)
Expected economic benefits	Estimated annual energy saving: Rs. 1.08 million (US$ 7,467). The above is based on the following assumptions: • A 6 W LED lamp would replace a 60 W Incandescent lamp. • Average operation of lamps per day: 7 hours. • Average price electricity: Rs. 16 per kWh • Exchange Rate: 1 US$ = Rs.135
Climate Change Mitigation Impacts	Mitigation potential of 49.14 tCO2/y The above is based on the following assumptions: • Grid Emission Factor:0.78 kgCO2/kSWh • A 6 W LED lamp would replace a 60 W Incandescent lamp. • Average operation of lamps per day: 7 hours.
Expected future target of employment	Marketing of 167,000 nos of 6W LED lamps: 10 people.
Other Environment Impacts	• Reduction of acidification due to lesser consumption of diesel fuel • Reduction cooling water. Thus less pressure on water bodies.

Table 1.15: Primary targets of Solar Assisted Air Conditioning

Technology	Solar Assisted Air Conditioning
Primary target	Reduction in Air Conditioning load by 1MW with in 2018 (if project starts in 2014).
Expected life time	20 years
Expected economic benefits	Estimated annual energy savings: Rs. 28.8 million (US$ 210,000). The above is based on the following assumptions: • Average operation of Solar Heaters: 300 days/ y; 6 h/day • Average price electricity: Rs. 16 per kWh • Exchange Rate: 1 US$ = Rs.135
Climate Change Mitigation Impacts	Mitigation potential of 1,404 tCO2/y based on following assumptions: • Grid Emission Factor:0.78 kgCO2/kSWh • Average operation of Solar Heaters: 300 days/ y; 6 h/day
Expected future target of employment	• Installation: 8 people • Maintenance: 8 people
Other Environment Impacts	• Reduction of acidification due to lesser consumption of diesel fuel • Reduction cooling water. Thus less pressure on water bodies.

1.4.3 Barriers to technology diffusion

The barriers for successful implementation of the Technology and hierarchical classification is given in Table 1.16.

Table 1.16: List of key barriers and hierarchy classification for Building Management Systems

Technology Name: Building Management Systems			
No.	**Key Barriers Identified**	**Priority Rank**	**Category of Barriers**
1.	High capital cost	1	Economic and financial
2.	Difficulty to access finance	2	Economic and financial
3.	Economic viability not established	3	Economic and financial
4.	Consumers pay below marginal cost of generation for electricity	4	Economic and financial
5.	Subject matter not covered in the Technical Colleges and Universities	5	Information and Awareness
6.	Unavailability of technology related latest information.	6	Information and Awareness
7.	Technology not freely available	7	Information and Awareness

8.	Inadequacy of technicians to maintain equipment (eg. for Solar Assisted Air Conditioning)	8	Human skills
9.	Expected life time of LED lamps not ensured	9	Technical
10.	Lack of certification	10	Technical

1.4.4 Proposed Action Plans for the Technology.

The Proposed Action Plan for Building Management Systems is provided in Table 1.17.

ENERGY SECTOR

Proposed Action Plan for the Technology 3

Table 1.17: Action Plan for Building Management Systems

Measure/Action 1: (i) Review and reform Government taxes on imports, local fabrications and constructions related to Renewable Energy and Energy Efficiency Projects. (ii) Donor Agencies to consider providing adequate funds on concessionary terms to promote these sectors.					
Justification for the action: Barrier:' *High capital cost* '. To facilitate reducing the high implementation costs of renewable energy and energy efficiency projects in order to attract private sector investments.					
Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding In US$**	**Indicators**
i. Government to consider tax concessions for imports and local fabrications and constructions related to Renewable Energy and Energy Efficiency Projects.	V. High	Ministries of Power and Energy, Industry and Commerce and Finance & Planning	From 2014 the latest	None.	Gazette notification to the effect published and operational from 2014.
ii. Donor agencies to consider providing funds on concessionary terms for renewable energy and energy efficiency projects	V. High	Sustainable Energy Authority/ Department of External Resources	From 2014 onwards	International US $ 10 m from Year 2014 to 2018.	Donor agencies provide following funds during the time frame indicated; 2014:US$2 m 2015: US$2m 2016: US$2 m 2017: US$ 2 m 2018: US$ 2 m

Measure/ Action 2: Sustainable Energy Authority to exercise the provision in the Act to impose a levy on all fossil fuels and constitute a Fund for the development of renewable energy and energy efficiency projects. The magnitude of the levy should not adversely affect the economy in a significant manner.					
Justification for the action: Barrier: '*Difficulty to access finance*'. Presently the fossil fuel based energy projects are funded by international agencies. However, such funds are not available for renewable energy and energy efficiency projects.					
Action No.	**Priority Rank**	**Responsibility of Implementation**	**Timeframe**	**Cost & Funding US$**	**Indicators**
i. Sustainable Energy Authority to exercise the provision in the Act to impose a levy on all fossil fuels and constitute a Fund for development of renewable energy and energy efficiency projects.	V. High	Sustainable Energy Authority/ Ministry of Finance and Planning	2014 onwards	Local funds 2014:US$2 m 2015 :US$2m 2016: US$2 m 2017: US$ 2 m 2018: US$ 2 m The levy on fossil fuels will be used to meet a number of financial needs to promote renewable energy. For purpose of emphasizing each activity, it is segregated.	From levy on fossil fuels by end of 2014. Following funds provided from the levy 2014:US$2 m 2015:US$2m 2016: US$2 m 2017: US$ 2 m 2018: US$ 2 m

Measure/Action 3: (i) Relevant State Institutions to conduct feasibility studies and disseminate study results. (ii) Necessary funds for these studies to be explored from donor sources.

Justification for the action: Barrier: '*Economic viability not established*'. Financial viability of the technology needs to be made available to the private sector to consider investing in these technologies.

Action No.	Priority Rank	Responsibility	Time frame	Cost & Funding US$	Indicators
i. Relevant State Institutions to conduct feasibility studies and disseminate study results	High	Sustainable Energy Authority/	2014		Feasibility Report on this topic to be available before end of 2014.
ii. Donor Agencies to consider providing adequate funds for this study.	High	Department of External resources	2014	US$100,000 International	Funds to be provided in 2014

Measure /Action 4: Revise household electricity tariff structure based on marginal cost of generation including transmission and provide relief to targeted consumers only

Justification for the action: Barrier: '*Consumers pay below marginal cost of generation'.* Presently electricity to most of the household consumers is sold at below the marginal cost of generation and distribution. As a result, household consumers are not attracted to use energy efficient devices in order to reduce electricity consumption. By introducing a cost based tariff structure, consumers will be encouraged to use electricity efficiently. Relief could be provided only to those who deserve such assistance.

Action No	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding US$	Indicators
i. Revise household electricity tariff based on marginal cost of generation and distribution and provide relief to targeted consumers only	High	Ceylon Electricity Board/ Public Utility Commission	2014 onwards	Nil	- Revise household electricity tariff - Penetration of Light Emitting Diode lights due to this activity 2014 – 2018.

Measure /Action 5: Technical Colleges and Universities to include relevant subject matter in study curricula to provide exposure to relevant officials.					
Justification for the action: Barrier: '*Subject matter not integrated into the Technical Colleges and University curricula'.* The topic of Solar Assisted Air Conditioning is new to Sri Lanka and to the world. Therefore, subject matter related to this technology needs to be introduced at the Colleges to promote this technology.					
Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US$**	**Indicators**
i. Technical Colleges and Universities to include related subject matter in the curricula to expose relevant officials to the technology.	High	University Grants Commission/ Ceylon Electricity Board/ Sustainable Energy Authority	2014-2015	local US$ 80,000	Topics included in the curricula in the Technical Colleges and Universities from 2014.
Measure / Action 6: Update information on technology through appropriate media					
Justification for action: Barrier: 'Unavailability of *latest information related to the technology*'. Information on the two technologies considered is not readily available to the public and the stakeholders. Hence the authorities need to provide the latest technology related information through appropriate media.					
Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US$**	**Indicators**
i. Provide latest information on technology through appropriate media	High	Sustainable Energy Authority	2014	US$10,000 Local (Funds raised through levy on fossil fuels may be used for this)	Up to date Information on Light Emitting Diode Lamps and Solar Assisted Air Conditioners are available to the public and the stakeholders by 2014.

Measure / Action 7: The details, including the benefits and the means of accessing these two technologies should be publicized.					
Justification for action: Barrier: '*Technology not freely available*'. These two technologies are new to the country. Hence adequate publicity and promotion are necessary to disseminate these technologies quickly.					
Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US$**	**Indicators**
i. The details, including the benefits and the means of accessing the technologies should be publicized	Medium	Sustainable Energy Authority	2014	US$10,000 Local (Funds raised through levy on fossil fuels may be used for this)	Information on accessing Light Emitting Diode Lamps and Solar Assisted Air Conditioners are available to the public and the stakeholders by end of 2014.
Measure /Action 8: Train technicians at Technical Colleges and Vocational Training Institutions on the maintenance of Solar assisted Air Conditioning systems.					
Justification for the action: Barrier: '*Inadequacy of skilled personnels to maintain equipment'.* Skills required for the maintenance of Solar Assisted Air Conditioning is currently not available in the country. Therefore, prior to introducing this technology, the personnel presently engaged in servicing Air Conditioners need to be given adequate training on the new system to enable successful technology transfer.					
Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US$**	**Indicators**
I. Provide training to the technicians at Technical Colleges and Vocational Training Institutions on the maintenance of Solar assisted Air Conditioning systems.	Medium	Ministry of Labour and Skills Development	2014	Local Funding US$ 80,000	- Topics included in the vocational training institutions from 2015.
Measure /Action 9: Introduce legislations to ensure appropriate compensation to the consumers for failure of lamps before the guaranteed lifetime.					
Justification for the action: Barrier: '*Expected life time of LED lamps not ensured*'. LED lamps cost more than the conventional lamps. The LED Lamps carry a					

manufacturer's guaranteed lifetime of around 50,000 hours. The government needs to introduce legislations for consumer protection to enable obtaining relief in the event of any premature failure.					
Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US$**	**Indicators**
i. Introduce legislations to ensure consumer protection through appropriate compensation.	Medium	Ministry of Trade	2014	Local Funds US$ 80,000	- Legislation in place from 2015.
Measure /Action 10: Introduce a labeling/ certification scheme to guarantee product quality.					
Justification for the action: Barrier: '*Lack of certification'.* Energy/ Efficiency Labeling is an important tool practiced in many parts of the world to ensure product quality thereby encouraging purchase of such items taking into account the long term benefits. Similar system already existing in the country needs to be extended to LED lamps and Solar Assisted Air Conditioning systems to facilitate promoting the technology..					
Action No	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US$**	**Indicators**
i. Introduce a labeling/ certification scheme to inform the consumers of the product quality	Medium	Sustainable Energy Authority/ Sri Lanka Standards Institute	2013	International Funding US$ 1 million	- Light Emitting Diode Lableing Scheme in operation from 2014.
Total Cost for Technology 3				**Approx: US $ 21.36 million**	

CHAPTER 2

Technology Action Plan for the Transport Sector

2.1 Actions at sectoral level

The data presented in this chapter is mainly based on the Second National Communication (SNC) on Climate Change for Sri Lanka prepared by the Ministry of Environment in year 2012. The preparation of the GHG inventory for SNC required a large number of activity data from a wide range of sectors, coming under the purview of many ministries and government organizations.

2.1.1 Short sector description

Transport sector is considered as one of the major economic sectors in Sri Lanka. The main mode of transportation in the country is through the existing road network, which is supplemented by other means such as rail, air, and water transport. Out of land passenger transport, buses carry about 48 percent and railways carry about 4 percent of the passengers, while the rest of the passengers are carried by the other modes[5]. The existing railway network is 1447 km long[6]. Road transport accounts for about 96% of passenger transportation and 99% of freight transportation[1] while the railways accounts for 1% of freight transport. The existing road network is 113,094 km long. Sri Lanka has a high road density compared to other countries in the region. The current road density is 1.6 km of roads per square km; the highest road density in Sri Lanka is found in the Western Province, especially in Colombo District. The sector is significant in terms of a greenhouse gas (GHG) mitigation potential due to high level of GHG emissions from fossil fuel burning.

GHG Emissions Level and Trends: Currently; the transport sector utilizes petroleum fossil fuels *(LPG, Gasoline and Diesel, Coal, Aviation Gasoline, Aviation Turbine and Fuel Oil)*, contributing to significant amounts of carbon dioxide (CO_2) and other GHGs such as N_2O NO_x, CO, CH_4 and SO_2. The transport sector contributes to about 27% of the total GHG emissions in the country (Figure 2.1) and about 60% of the air pollution in Colombo City[7]. According to the national greenhouse gas inventory, CO_2 accounts for more than 95% of the transport related emissions[8]. Although the overall CO_2 emissions from transport sector are relatively low, given the size and population of the country, per capita CO_2 emission in Sri Lanka is more than three times that of any other country in the region. In addition, the transport sector is the second highest contributor of GHG emissions in the country (See Figure 2.1). Therefore, the transport sector has been

[5] Jayaweera, 2011

[6] Ministry of Transport, 2011

[7] AirMAC, 2009

[8] ME, 2011, Second National Communication on Climate Change, Ministry of Environment, Sri Lanka

identified as a priority sector to be considered for technology needs assessment and explore cleaner technologies to mitigate GHG emissions.

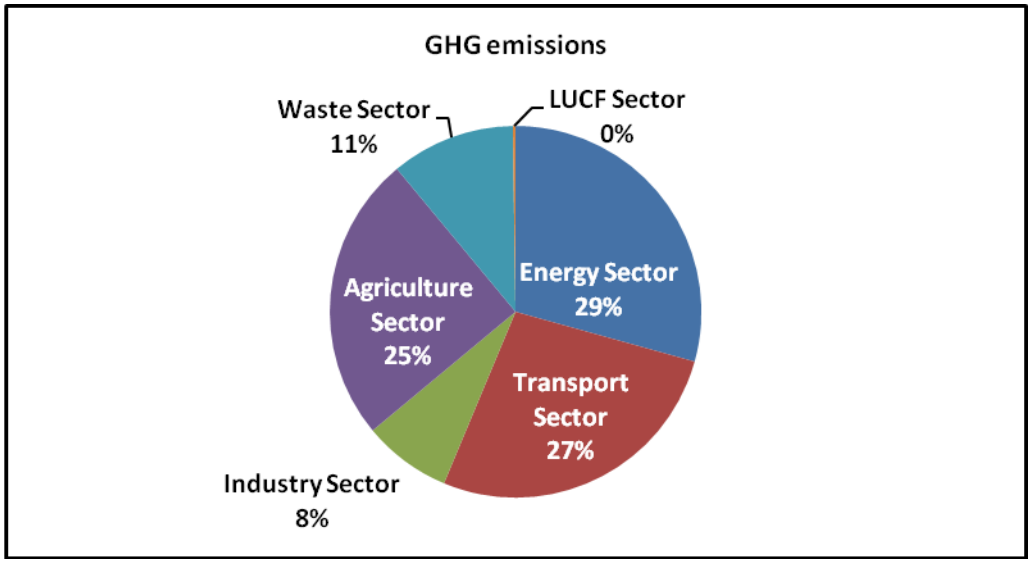

Figure 2.1: Contributions for GHG emissions from different sectors in Sri Lanka

A summary of the emissions from the Transport sector is provided in Table 2.1. The total CO_2 equivalent emissions from Transport sector is 5,084 $GgCO_{2Eq}$, which comprises of 5,058 Gg of CO_2 emissions, 10.$GgCO_{2Eq}$ of CH_4 and 16 $GgCO_{2Eq}$ of N_2O.

Table 2.1: Emissions of GHG and other gases from the Transport Sector

Sub-sector	Emissions (Gg)						
	CO_2	CH_4	N_2O	CO	NOx	NMVOC	SO_2
Road Transport	4,444.03	0.47	0.04	131.47	46.96	25.26	7.50
Railway Transport	80.46	0.01	0.00	1.09	1.31	0.22	0.15
Air Transport	496.99	0.00	0.01	0.70	2.10	0.35	0.16
Sea Transport	36.70	0.00	0.00	0.50	0.75	0.10	0.17
Total	**5,058.19**	**0.48**	**0.05**	**133.76**	**51.13**	**25.93**	**7.98**

Source: ME, 2011, Second National Communication on Climate Change, Sri Lanka

2.1.1.1 Existing Policies and Laws related to the Transport Sector's Development and Technology Development

The Existing Policies and Laws related to Transport Sector are given in Table 2.2 below.

Table 2.2: Existing Policies and Laws related to Transport Sector

Name of the Law/Policy	When Enacted/ Revised	Main Contents
Policies		
1.Draft National Transport Policy	2009; Pending Government approval	The policy lists fourteen key objectives; key functions of the agencies under the purview of the Ministry of Transport are given. Vision of the Draft National Transport Policy is To ensure a satisfactory access to and choice within a reliable, efficient and integrated system of transport modes and services that satisfies the diverse public and corporate needs for mobility for both goods and people.
Laws		
1. Motor Traffic Act 14 of 1951 and all subsequent Amendments.(altogether 26 Amendments until 2009)	1951 and 26 amendments until2009	Motor vehicles registration, construction and equipment of motor vehicles, revenue licenses, passenger carriage permits for omnibuses, goods carriage permits
2. Road Development Authority Act No. 73 of 1981; Road Development Authority (amendment) act, no. 37 of 2009	1981; 2009	Provision for the establishment of the road development authority (RDA), specifying the powers, duties and functions of the RDA; membership of the Authority and the Council
3. National Transport Commission (NTC) Act (No. 37 of 1991); National Transport Commission (Amendment) Act No, 30 of 1996	1991; 1996	Membership, functions and powers of the NTC, passenger service permits
4. Sri Lanka Transport Board Act (No. 27 of 2005); Sri Lanka Transport Board (Amendment) Act 2009	2005; 2009	Establishment of Sri Lanka Transport Board; its powers, finances, and regulations
5. National Thoroughfares Act No. 40 of 2008	2008	Advisory bodies, Regulations and user fees relevant to national highways, execution of works under the Act, protection of public roads and highways, use of expressways and restricted access highways

2.1.1.2 Selected Mitigation Technologies in the Transport Sector

The prioritized technologies for climate change mitigation in the Transport sector are;

1) Integration of Non- motorized transport methods along with regularized public transport system
2) Carpooling and park-and-ride systems
3) Electrification of the existing railway system

Brief descriptions of these technologies are provided in sections 2.2.1, 2.3.1 and 2.4.1.
The projected employment generations by the interventions related to these technologies is a minimum of 150 per major city, 40 per each park-and-ride location, and about 100 for the electrified railway system majority of which comprises the labor force.

2.1.2 General Barriers and Proposed Measures in the Transport Sector

The overall goal of these technological interventions is aimed at achieving the highest economic and environmental benefits, reducing the number of vehicles on the road and traffic congestion, promotion of public transportation, high occupancy vehicles, and non-motorized transportation. However, there are several barriers which need to be overcome for successful implementation of these technologies.

Although some barriers are technology specific, yet there are certain barriers which are common to all three technologies. The common general barriers are;

- Inadequate of finances
- Lack of knowledge on potential benefits and various other aspects related to the prioritized technologies
- Poor enabling policy and legal environment for promoting the prioritized technologies
- Lack of infrastructure and locomotives
- Lack of economic tools such as road pricing, taxes, and tariffs

Barrier: ***Inadequacy of finances:***

Inadequacy of finances is common to all three prioritized technologies. Sustainability of financial resources is an essential requirement for both implementation and continuity of the services expected from the technologies.

Proposed Measures: ***Ensuring appropriate financial mechanisms*** are imperative for successful implementation of all enabling measures proposed under the prioritized technologies and sustainability of such interventions. Government financing and appropriate public private partnerships are considered appropriate financing mechanisms for the sustainability of the technologies. These domestic financing arrangements need to be supplemented by donor funding given the extent of the measures to be involved.

Exploration of public private partnership appears to be the most promising arrangement in addition to the option of securing donor assistance.

Barrier: *Lack of knowledge on potential benefits and various other aspects related to the prioritized technologies:*

Lack of awareness among the general public on the potential health and environmental benefits of the prioritized technologies would jeopardized opportunities for that the public to enjoy such benefits from the interventions. On the regulatory aspects, both motorists and pedestrians need to be educated on the existing road rules and regulations. Awareness on novel approaches such as carpooling and park-and-ride is also lacking.

Proposed Measures: Awareness creation together with training is proposed as an important measure to overcome this barrier. Awareness creation would be very critical and essential prior to implementation of all proposed technologies. Public awareness on the benefits of these technologies is required in addition to ensuring road discipline through strict implementation of road rules and regulations. Therefore, awareness creation on existing road rules, regulations and benefits of the prioritized technologies is also needed. The use of mass media such as television could play an important role in promoting the use of carpooling and park-and-ride systems and a newly electrified railway system.

Barrier: *Poor enabling policy and legal environment for promoting the prioritized technologies:*

A national policy commitment is essential for promoting all three prioritized technologies. Therefore, review and appropriate reforms of the existing policies and legislation with the focus on the safety of non-motorized transportation and pedestrians is recommended. Enabling policy measures are also needed for proper and sustainable functioning of carpooling and park-and-ride systems.

Proposed Measures: Therefore, *an enabling policy and legal environment through appropriate policy and legal reforms* in the form of new regulations and amendments to the existing legislation will be required. Introduction of tariff barriers to discourage importation of too many personal vehicles and a tax system for single or low occupancy vehicles during the rush hours and on certain road sectors with heavy traffic congestion also need to be considered in this process. Automated fine systems help protect pedestrian rights. Direct management regulations for carpooling and shuttle transit are required with initiative action from the government agencies.

Barrier: *Lack of infrastructure and locomotives:*

Lack of the necessary infrastructure is also a general barrier common to all three technologies.

Proposed Measures: Provision of *improved facilities, amenities, and infrastructure* for the convenience of pedestrians and passengers of motorized transport are being recommended to overcome this barrier. Establishment of proper sidewalks, walkways, pedestrian crossings with prominent signposts is essential

requirements for Technology 01 (*Integration of non- motorized transport methods along with regularized public transport system)*. Need for safe parking lots with adequate security measures, ticketing facilities, information display measures, and high quality buses, etc are important elements for the success of carpooling and park-and-ride systems. Having market, restaurant, and communication facilities along with fuel stations are value added conveniences for potential users of the facility. Better tracks, signal systems, and other infrastructure, sufficient and better-quality locomotives and rolling stocks are still needed for a better, electrified railway system.

Barrier: ***Lack of economic tools such as road pricing, taxes, and tariffs:***

Lack of a proper system for penalizing the violators of rules and regulations is a barrier common to all three technologies.

Proposed Measures: Absence of an automated system to impose fines on motorists who violate the rights of pedestrians and bicyclists is a drawback for promoting non-motorized transportation. In certain busy roads of other countries (e.g. United States, United Kingdom), single or low-occupancy vehicles are taxed if take the option of travelling on the lanes designated for high occupancy vehicles. Introduction of such a system would discourage single or low-occupancy vehicles and will facilitate promoting systems such as carpooling and park and ride. Tariff concessions for buses to be used in park-and-ride systems will also be required for sustainability mass transportation.

2.1.3 Specific Measures Proposed for the Selected Technologies

The Table 2.3 provides specific measures recommended for the prioritized technologies in the transport sector. Please refer to the report on Barrier Analysis and Enabling Framework (Report II) for explanations of barriers and measures.

Table 2.3: Specific measures for Technology 1: Integration of Non- motorized transport methods along with regularized public transport system

No.	Recommended Measures
1.	Financial support from the Government or donors. All new and rehabilitation road projects to increase finances to provide pedestrian facilities
2.	Enabling policy and legal environment to recognize the need for developing pedestrian and other non-motorized transport facilities.
3.	Improvement of road discipline by law enforcement and other means and increased awareness among road users.
4.	Awareness creation on environmental and health benefits of non-motorized transport.
5.	Automated fine systems along with amendments to the Motor Traffic Act.
6.	Construction of walkways connecting sidewalks to main bus and railway terminals along with attractive pedestrian facilities such as benches and bicycle racks

7.	Well designed sidewalks and walkways and land acquisition, as appropriate.
8.	Provision of all required road furniture.

Table 2.4: Specific measures for Technology 2: Carpooling and Park-and-Ride systems

No.	Recommended Measures
1.	Sustainable financing arrangements through public private partnership.
2.	Introducing a tax system for single or low occupancy vehicles on designated lanes for high occupancy vehicles, as an incentive for the users of carpooling and park-and-ride systems
3.	Awareness creation through mass media.
4.	Registration system for regular users and maintenance of an operational database (e.g. driver/passenger information).
5.	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.
6.	Information Manual or Directory which contains basic information such as the rules and regulations pertaining to driver- passenger cost/credit sharing.
7.	Establishing useful amenities within a part of the carpooling and park-and-ride lots.
8.	Facility for on-line ticketing.
9.	Electronic information display related to bus transit (delays, on-time arrival, etc.) and establishment of proper signboards by the main road.
10.	Publishing an annual Directory containing information such as listing of responsible authorities and officials, while providing the same on the internet.
11.	Introduction of better vehicles and reduction of the importation taxes for public transport vehicles.
12.	Provide security measures such as security cameras and lighting systems, security personnel, and introducing insurance schemes for the parking lots.

Table 2.5: Specific measures for Technology 3: Electrification of the existing Railway System

No.	Recommended Measures
1.	Sustainable financing arrangements through donors and public private partnership
2.	Accommodate a Bus Rapid Transit (BRT) system within the existing rail road network
3.	Backup systems for uninterrupted power supply.
4.	Identify priority segments for electrification with the support from the Transport Ministry. .
5.	Exposure and training from countries with a similar railway system.
6.	Developing new tracks and signal systems.

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

2.2.1 Description of the Technology

The transport sector contributes a major portion of the overall GHG emissions in the country. With the current trend of increasing fleet of vehicles on the road, there is a urgent need to pay attention in exploring means of reducing congestion, especially during peak hours and at city centers. One option would be to promote more public transportation, in conjunction with non-motorized transportation, especially walking and bicycling in congested areas and city centers. The main objective of Technology 1 is the reduction of the existing traffic congestion in Sri Lanka, especially during peak hours and at city centers. Currently, bicycling has become a high risk mode of transport, especially due to disregard of road rules by majority of the drivers. Therefore, initial focus needs to be placed on strict enforcement with regard to road rules and facilitating walking as a better mode of non-motorized transport through improved pedestrian facilities.

Under this technology, priority has been given for improving pedestrian facilities to promote walking, as bicycling is still not a viable option given the large volume of traffic on busy roads and poor enforcement of road rules. Thus having pedestrian walkways, sidewalks, and proper electronic signaling and warning signposts at pedestrian crossings, etc., would be promoted under this technology. As these non-motorized modes could serve as means of proper access to public transport, promoting non-motorized transport will also help popularizing use of the public transportation. However, since non-motorized transport reduces speed of travel, the public transport need to be better regularized for proper time planning and to accrue desired benefits out of the combined public and non-motorized transportation. Non-motorized transport adds green benefits including the reduction of greenhouse gas emissions and overall pollution, while contributing to improve the health.

This technology option has prioritized in view of it is less expensive, ability to facilitate reducing traffic congestion, potential environmental benefits including greenhouse gas mitigation potential, low air pollution, reducing noise pollution, health benefits etc. Details on the technology could be found in the Annex C - Technology Fact Sheets, TNA Report (Part I).

2.2.2 Target for technology transfer and diffusion

Development of majority of the infrastructure (sidewalks, green walkways, signposts and signaling at pedestrian crossings, etc.) is proposed for the suburban areas within a radius of about 10 km of Colombo. Sidewalks and traffic lights at major pedestrian crossings in a road length of about 100 km, development of walkway fragments with pedestrian attractions and facilities, starting from public transport terminals for a total length of about 20 km, and warning signposts by yellow pedestrian crossings are recommended for roads with heavy traffic by 2016.

2.2.3 Barriers to the technology diffusion

Heavy traffic congestion at city centers result in high amounts of GHG emissions, while causing traffic delays as well. Promotion of public transportation, in conjunction with non-motorized transportation is seen as a better option for resolving this issue. Given the potential risks associated with bicycling as a non-motorized method of transport due to obvious reasons, initial focus will be on strict enforcement of road rules and facilitating walking through the improvement of pedestrian facilities. However, several potential barriers that would impede progress of technology implementation have been identified.

List of key barriers with and hierarchical classification is given in table 2.6.

Table 2.6: List of Key Barriers and Hierarchy Classification for Integration of Non- motorized transport methods along with regularized public transport system

Technology Name: Integration of Non- motorized transport methods along with regularized public transport system			
No.	**Key Barriers Identified**	**Priority Rank**	**Category of Barriers**
1.	Inadequate of finances	1	Economic and financial
2.	Absence of enabling policy and legal environment to promote the technology	2	Policy, legal, and regulatory
3.	Lack of interest towards non-motorized transport due to lack of road safety, especially on roads with heavy traffic.	7	Social, cultural, and behavioral
4.	Attitudinal indifference towards reverting back to non-motorized transportation by the public.	8	Social, cultural, and behavioral
5.	Negative public perception on non-motorized transportation as a primitive method.	3	Social, cultural, and behavioral
6.	Inadequate public awareness and poor enforcement of road rules.	6	Social, cultural, and behavioral
7.	No easy access to non-motorized transport facilities from the respective public transport terminals.	3	Other barriers
8.	Inadequate space to develop sidewalks and walkways.	4	Other barriers
9.	Lack of proper sidewalks and walkways.	4	Other barriers
10.	Lack of proper road furniture.	5	Other barriers

2.2.4 Proposed action plans for Integration of Non- motorized transport methods along with regularized public transport system

The Proposed Action Plan is provided in table 2.7.

The proposed actions are listed in table 2.3. Action 10 in the report II (Promoting better attitude towards non-motorized transport through awareness creation and developing attractive pedestrian facilities) is included along with the Action 5 and action 7. Action 11 in the report II (Construction of proper, attractive walkways and sidewalks) is included in action 7.

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Action plans for Technology 1

Table 2.7: Proposed Action plans for Technology 1: Integration of Non-motorized transport methods along with regularized public transport system

Measure/Action 1: Financial support from the Government or donors and all new and rehabilitation road projects to increase finances to accommodate the pedestrian facilities (i.e. traffic signals and construction of new sidewalks on main roads, as necessary)					
Justification for the action: Due to limited allocations currently available from the national budget, there is a need for enhancing Government financing and explore donor support.					
Action/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 1: **Sub action 1**. Establishing sidewalks and traffic signals at necessary pedestrian crossings in a road length of 100 km	V. High	Road development authority (RDA), Local authorities, Provincial road development authority (PRDA), Police	2014 - 2016	8.5 m Local or donors	- establishing sidewalks and traffic signals at necessary pedestrian crossings in a road length of 100 km by 2016,
Measure/Action 2: Review and reform existing policy and legal frameworks to promote developing pedestrian and other non-motorized transport facilities					
Justification for the action: In the absence of enabling policy and legal environment for promoting non-motorized transportation, there is a need to make the necessary adjustments to the existing draft national transport policy					

Action*/Sub Action No.	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source US $ millions	Indicators
Action 2: **Sub action 1**. Incorporate of provisions to provide better facilities and rights for pedestrians and non-motorized transportation and regularization of public transport in the draft national transport policy **Sub action 2.** Provisions to promote traffic signal synchronization	V. High	MoT, Ministry of private transport, Ministry of highways, UDA, National Physical Planning Dept, Police	2014 - 2016	0.01 Local	- Completion of the activities in sub action 1& 2 by 2016.
Measure/Action 3: Introducing automated fine systems along with amendments to the Motor Traffic Act					
Justification for the action: There is lack of public awareness on and poor enforcement of existing road rules requiring actions for having a proper penalty for violators of road rules.					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 3: **Sub action 1**. Amendment to the Motor Traffic Act to provide penalties for road rule violators, and subsequent gazette notification of such penalties, following the cabinet approval	High	MoT, Police	2014 - 2016	0.01 Local	- Amendment of the motor traffic act with relevant provisions by 2016.

Measure/Action 4: Improvement of road discipline through law enforcement and other means and increased awareness among road users including the drivers of different categories of vehicles					
Justification for the action: To overcome the barrier of low tendency towards using non-motorized transport due to lack of road safety, especially on roads with heavy traffic					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 4: **Sub action 1**. Quarterly workshops for Government and provincial Council Officials and monthly workshops for new licensees **Sub action 2**. Weekly TV and radio programs and advertisements	Medium	MoT, Police, RDA, Motor Traffic Department (DMT), National Council for road safety, University of Moratuwa, CMC, CETRAC, SLMA	2014 - 2016	US $ 0.1 m Local or donors US $ 1.9 m Local or donors	1. More than 90% of the workshops completed by 2016 with participation of over 80% of the anticipated participants. 2. Half-hour monthly TV programs- ~90% by 2016.
Measure/Action 5: Awareness creation on the health and cleaner air benefits and promotion of non-motorized transport					
Justification for the action: The current trend in the country is for increased motorized transport and to possess personal vehicles, and there is some reluctance to revert back to non-motorized transportation among the general public. Therefore, there is a need for awareness creation on the overall benefits of non-motorized transport					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 5: **Sub action 1**. Weekly TV and radio advertisements	Medium	MoT, Ministry of Health, Police, TV and radio	2014 - 2016	US $ 1.1 m Local/ Donors	1. Activities of sub section 1 completed by 2016

Sub action 2. Research and Development activities on vehicular emissions and health impacts		station/s of choice, and		US $ 1 m Local/ Donors	2. Activities of sub section 2 completed by 2016
Measure/Action 6: Construction of walkways connecting sidewalks to main bus and railway terminals together with attractive pedestrian facilities such as benches and bicycle racks					
Justification for the action: Currently certain major bus or train terminals in some cities do not have proper walkways, to continue the journey on foot. Therefore proper walkways with attractive pedestrian facilities such as benches, bike racks, shady trees, and small picnic tables starting from the public transport terminals need to be provided to promote walking/non-motorized transport.					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 6: **Sub action 1**. 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 **Sub action 2.** Provide pedestrian facilities (i.e. bike racks, benches, trees, sign posts, etc.) within the walkways	V. High	Urban Development Authority (UDA), RDA, Local authorities, Police	2014 - 2016	US $ 2 m Local /Donors US $ 0.3 m Local/ Donors	- Walkways of a total of 20 km length with pedestrian facilities, completed by 2016.
Measure/Action 7: Design and construction of better sidewalks and walkways and land acquisition, as appropriate					
Justification for the action: Due to heavy traffic and lack of space, certain sidewalks have become very narrow and close to the moving traffic requiring protective fencing or widening such sidewalks through land acquisition.					

Action*/Sub Action No.	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source US $ millions	Indicators
Action 7: **Sub action 1.** 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	High	RDA, PRDA, local authorities, Police	2014 - 2016	US $ 13 m Local/Donors	- All related work of the action 7 completed by 2016.
Measure/Action 8: Provision of all required road furniture					
Justification for the action: The number of fatal accidents on yellow pedestrian crossings has been increasing, and these crossing lines are hardly visible from distance especially at night; therefore advance warning in the form of signposts are required to be provided with pedestrian crossing. In addition, other prominent signposts are essential in some public places such as temples, hospitals, schools, etc., where there is high density of pedestrian movements.					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 8: Establish all required road furniture (i.e. proper yellow lines and yellow poles by pedestrian crossings for visibility at night; tactile tiles for visually impaired people)	High	RDA, Police	2014 - 2016	US $ 0.5 m Local/Donors	- All programs under Action 8 completed by 2016.
Total Cost for the Technology 1				**Approx: US $ 28.5 million**	

*- Action number is the corresponding number for each measure listed under Technology 1

2.3 Action Plan for Technology 2: Car Pooling and Park-and-Ride systems

2.3.1 Description of the Technology

The goal of this intervention is aimed at reducing congestion due to heavy traffic in the cities including the large number of single- and low- occupancy vehicles, reduced air pollution, enhancing fuel energy use efficiency, and promoting mass & non-motorized transportation all of which would finally contribute to reducing CO_2 emissions. In addition, park-and-ride systems will provide an opportunity of avoiding driving in the heavy traffic. The park-and-ride facilities will provide arrangements for parking private vehicles in which the commuters can leave their personal vehicles and transfer to a common shuttle or take the option of traveling together (carpooling) in one car for the rest of their journey. Cars or personal vehicles are parked in the facility throughout the day, and picked up when the commuters return at the end of the day. Such facilities are generally found in the suburban areas of many countries. Carpooling and park-and-ride options can be considered for roads where congestion is extremely high resulting in traffic delays and heavy pollution due to vehicular emissions. This system would be particularly applicable in industrial zones and busy city areas, and passengers should have secure facilities for parking personal vehicles during the day. In those countries having carpooling and park and ride system, both these options of transferring into a bus or train or carpooling arrangements are available.

The draft National Transport Policy of Sri Lanka which promotes park-and-ride systems in conjunction with public/mass transportation is yet to receive the government approval. The ultimate goal of having park-and-ride systems is to narrow down the number of vehicles on the road, from single- or low- occupancy vehicles to mass transit shuttles or cars with a larger number of people. More details on the technology is provided in Annex C - Technology Fact Sheets, Technology Needs Assessment Report (Part I).

2.3.2 Target for technology transfer and diffusion

Two park-and-ride systems are proposed for Gampaha or Colombo Districts and establishment of these facilities together the required features as provided in the action plans below is planned to be completed within three (03) years upon commencement of the Project.

2.3.3 Barriers to the technology diffusion

Despite its usefulness towards addressing traffic related issues such as road congestion and GHG emissions from fossil fuel combustion, certain barriers need to be overcome to promote this technology option in Sri Lanka. List of key barriers and hierarchical classification is given in table 2.8.

Table 2.8: List of Key Barriers and Hierarchy Classification for Car Pooling and Park-and-Ride systems

Technology Name: Car Pooling and Park-and-Ride systems			
No.	**Key Barriers Identified**	**Priority Rank**	**Category of Barriers**
1.	Inadequate finances.	1	Economic and financial
2.	Absence of economic tools including road pricing (tariff barrier) and innovative public transport facilities.	3	Economic and financial
3.	Lack of public awareness interest on a system of this nature.	4	Information and awareness
4.	Absence of a existing mechanism for sustainable operation of carpooling and park-and-ride systems.	5	Institutional and organizational capacity
5.	No existing public private partnership arrangement to promote such a mechanism.	8	Institutional and organizational capacity
6.	Unavailability of proper guidelines and regulations regarding possible driver- passenger cost/credit sharing.	6	Policy, legal and regulatory
7.	Lack of attractiveness to general public.	9	Social, cultural, and behavioral
8.	No easy access to ticketing facilities	11	Social, cultural, and behavioral
9.	Absence of a mechanism for providing real time information and location maps & direction boards to the parking spaces from the main road or highway.	10	Other barriers
10.	Absence of an information Directory of the responsible authorities and officials.	12	Other barriers
11.	Unavailability of attractive, more comfortable or high quality passenger transport buses.	2	Other barriers
12.	Lack of adequate and secure parking areas for further expansion into suburbs and other areas of the country.	7	Other barriers

2.3.4 Proposed action plans for Car Pooling and Park-and-Ride systems

The Proposed Action Plan is provided in table 2.9.

The actions/measures proposed for the technology 2 is provided in table 2.4.

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Action plans for Technology 2

Table 2.9: Proposed Action plans for Car Pooling and Park-and-Ride systems

Measure/Action 1: Appropriate financing arrangements through public private partnership for land purchase and clearance					
Justification for the action: In view of the limited allocation from the national budget and the need for involving the private sector, financial contribution from both the government and private sector is imperative for successful implementation and sustenance of the initiatives.					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action1: **Sub action 1**. Purchasing two land lots from suburbs of Colombo and Gampaha within a commuting distance of 20 km for establishing the Park and Ride systems	V. High	MoT, Ministry of Provincial Councils, Private sector	2014 - 2016	US $ 5.4 m Local or donors	Complete purchasing lands for Actions 1 by end of 2016.
Measure/Action 2: Introducing a tax system for single or low occupancy vehicles running on designated lanes for high occupancy vehicles, with a reduced rate for the vehicles run on cleaner fuel.					
Justification for the action: In order to promote innovative systems such as the park-and-ride and public transport, a penalty scheme in the form of tariff barriers or taxing of low occupancy vehicles, is considered to be effective.					

Action*/Sub Action No.	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source US $ millions	Indicators
Action 2: **Sub action 1.** Strict enforcement of an appropriate taxation system during the peak hours on roads with high congestion, and a point system to ensure driver discipline	V. High	MoT, Police	2014 - 2016	US $ 0.02 m Local	- Establishment of the tax system, by end of 2016.
Measure/Action 3: Awareness creation through mass media					
Justification for the action: Currently the majority of the general public either lack awareness or interest of having carpooling and park-and-ride systems.					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 3: Awareness creation through mass media	V. High	MoT, relevant TV and radio stations	2014 - 2016	US $ 2 m Local or donors	- Weekly advertisements and monthly programs on TV & radio-.90% to be completed by end of 2016.
Measure/Action 4: Establishment of a proper registration system for regular users and maintenance of an operational database with driver/rider information					
Justification for the action: An appropriate mechanism for registering the users along with relevant personal information is deemed critical for sustainable operation of carpooling and park-and-ride systems,					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 4: Establishment of an appropriate registration	High		2014 -	US $ 0.02 m	- Registration of drivers and

system for regular users and maintenance of an operational database.		MoT, Ministry of Provincial Councils	2016	Local	passengers -90% completed by end of 2016.
Measure/Action 5: The Transport Ministry in collaboration with the Ministry of Provincial Councils to introduce direct management regulations for carpooling and shuttle transit.					
Justification for the action: Currently there is no existing public private partnership arrangement to promote carpooling or park-and-ride systems and management regulations for sustained functioning of such a system is imperative.					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 5: Introduction of direct management regulations for carpooling and shuttle transit by the Transport Ministry in collaboration with the Ministry of Provincial Councils	High	MoT, Ministry of Provincial Councils	2014 - 2016	US $ 0.02 m Local	- Regulations related to the car pooling and park-and-ride systems completed by end of 2016.
Measure/Action 6: Preparation of a Manual or information Directory					
Justification for the action: Clear guidelines and regulations regarding driver- passenger cost/credit sharing are required.					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 6: Develop and publishing a Manual or an information Directory containing all relevant information	High	oT, Ministry of Provincial Councils	2014 - 2016	US $ 0.02 m Local	- 5000 Manuals/directories published by end of 2016.
Measure/Action 7: Establishment of useful infrastructure and amenities within the carpooling and park-and-ride facility					
Justification for the action: Since this is a novel concept for the country, the facility needs to be made attractive to the general public.					

Action*/Sub Action No.	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source US $ millions	Indicators
Action 7: Establish useful infrastructure and amenities within the carpooling and park-and-ride facility	Medium	MoT, Ministry of Provincial Councils, Private partners	2014 - 2016	US $ 2 m Local or donors	-All the amenities (e.g. Shopping center, bus shelters, fuel station/s etc) completed by end of 2016.
Measure/Action 8: Develop facilities to use a smart card and online ticket purchasing					
Justification for the action: To ensure customer convenience for availing services of the facility.					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 8: Develop a mechanism to enable using a smart card and online ticket purchasing	Medium	MoT and private partners	2014 - 2016	N/A	- Smartcard use and online ticket purchasing ability by end of 2016.
Measure/Action 9: Proper electronic information display related to bus transit (delays, on-time arrival, etc.) and establishment of directional signboards by the main road					
Justification for the action: Real time information providing facilities, proper location maps and directional sign boards of the parking space/s from the main road/ highway will be critical for smooth functioning of the system,.					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 9: Proper electronic information display related to bus transit (delays, on-time arrival, etc.) and	Medium	MoT, Ministry of Provincial Councils	2014 - 2016	US $ 0.04 m Local or donors	- Installation of 90% of the facilities corresponding to

establishment of appropriate signboards by the main road		(MoPC), and Private partners			Action 9 by end of 2016.
Measure/Action 10: Publishing an annual information Directory containing important information such as the responsible authorities and officials, while providing the same on the internet					
Justification for the action: : Currently there is no existing mechanism for accessing information on arriving and departing buses from any main bus station in Sri Lanka.					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 10: Publishing an annual information Directory containing useful information such as the responsible authorities and officials, while providing the same on the internet	Medium	MoT, MoPC, Private partners	2014 - 2016	US $ 0.01 m Local	- Publishing 5000 directories by end of 2016.
Measure/Action 11: Introduction of better vehicles, possibly run on greener fuel, and reduction of the importation taxes for public transport vehicles					
Justification for the action: Availability of comfortable and high quality buses for shuttle services would promote using a park-and-ride system.					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 11: Introduction of better vehicles, possibly run on greener fuel, and reduction of the importation taxes for public transport vehicles	V. High	MoT, private partners	2014 - 2016	US $ 1.5 m Local or donors	- Purchase of good quality shuttles by end of 2016.
Measure/Action 12: Establishment of security cameras and lighting systems, appointment of security personnel, and introducing insurance schemes for the parking lots					

Justification for the action: Security would be one of the major concerns of the commuters when leaving their vehicles in a parking lot for several hours. Therefore, the parking areas need to be made secured to garner confidence of the potential users.					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 12: Establishment of security cameras and lighting systems, appointment of security personnel, and introducing insurance schemes for the parking lots	High	MoT, Ministry of Provincial Councils, Private partners	2014 - 2016	US $ 0.02 m Local	- High quality security cameras and security personnel by end of 2016.
Total Cost for the Technology 2				**Approx: US $ 11 million**	

2.4 Action Plan for Technology 3: Electrification of the Existing Railway System

2.4.1 Description of the Technology

The existing railway network in the country is 1447 km long[9]. Although the railway network has been originally built only for transporting of plantation products, with increasing population and traffic needs, now the rail transport has become more passenger oriented. Railways accounts for about 4% percent of passenger transport and 1% of freight transport. The existing trains are diesel powered, and electrification is being proposed initially for one busy segment which represents nearly 5% of the railway network. Except when running at steady speed, the diesel powered electricity generator in the existing trains that drive the motors connected to the wheels remain idle most of the time. Once a train is electrified through the grid and when such trains brake or decelerate, these motors will perform the function of the generators producing electricity, which in turn will be returned to the grid for later use. In electrification of the railway system, the existing railway tracks could be used with electricity provided through overhead lines (25 kilovolt) drawn above the railway lines and loops[10].

This technology has been prioritized mainly in view of the following social and economic benefits arising from the technology.

a) Smooth and more sustainable transport with low energy inputs & cost, reduced travel time per unit distance with high energy efficiency.

b) Environmental benefits include low GHG emission, reduced environmental pollution and noise

2.4.2 Target for technology transfer and diffusion

Electrification is initially proposed for the suburban segments which covers about 5 percent of the existing 1,447 km long railway network within a project period of three (03) years.

2.4.3 Barriers to technology diffusion

The barriers for the Technology already identified and their hierarchical classification is given in table 2.9.

[9] Ministry of Transport, 2012

[10] IESL, 2008

Table 2.9: Key Barriers and hierarchy classification for Electrification of the existing railway system

Technology Name: Electrification of the existing railway system			
No.	**Key Barriers Identified**	**Priority Rank**	**Category of Barriers**
1.	Lack of finances	1	Economic and financial
2.	Lack of intermediate high density transport modes such as BRT for the nodal points identified for electrification links and other facilities relevant to non-motorized transportation	5	Network failures
3.	Lack of uninterrupted power supply.	3	Network failures
4.	Absence of transport network analysis to identify potential electrification links	2	Network failures
5.	Lack of research and studies on similar electrification experiences in other developing countries in the region	6	Social, cultural and behavioral
6.	Inadequate infrastructure	4	Other barriers

2.4.4 Proposed action plans for Electrification of the existing railway system

The Proposed Action Plan for Electrification of the existing railway system is provided in table 2.10. The actions/measures proposed during the barrier analysis and development of the enabling framework for the technology is provided in table 2.5.

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Action plans for Technology 3

Table 2.10: Proposed Action plans for Electrification of the existing railway system

Measure/Action 1: Providing required finances through public private partnership					
Justification for the action: The capital investment required for electrification is significantly high.					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 1: Mobilization of finances required for electrification of 5% of the existing railway system **Sub action 1.** Identification of the priority segments for electrification **Sub action 2.** Explore opportunities for public private partnerships for mobilizing required finances	V. High	Ministry of Transport (MoT), Sri Lanka Railways	2014-2016	Total preliminary cost US $ 48.5 m Including the costs of Actions 2-6. (US $ 0.75 million per km) Local or donors	- Electrification of about 5 percent of the existing railway system by end of 2016.
Measure/Action 2: Establish connectivity with **a multi modal system**					
Justification for the action: Having intermediate high density transport modes for the nodal points identified for electrification links is useful for maximizing benefits and sustainability					

Action*/Sub Action No.	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding Source US $ millions	Indicators
Action 2: Facilitate developing a multi modal system	Medium	MoT	2014-2016	N/A	Take the necessary initiatives to promote and incorporate a low-cost BRT system by 2016.
Measure/Action 3: Establish **backup systems for uninterrupted power supply**					
Justification for the action: In view of recurring power failures in the national grid, appropriate backup systems are imperative for ensuring uninterrupted power supply.					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 3: Install backup systems for uninterrupted power supply	High	MoT, Electricity Board	2014-2016	N/A	- Backup power supplied through the batteries by 2016.
Measure/Action 4: Identification of priority electrification links					
Justification for the action: There should be a transport network analysis to identify the electrification links					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 4: Secure services of the Transport Ministry to identify and prioritize electrification links	V. High	MoT, Sri Lanka Railways	2014-2016	N/A	- All the electrification links identified by 2016.
Measure/Action 5: Acquire **experience and training from countries with a similar railway system**					

Justification for the action: Since this initiative is a new experience for Sri Lanka and in view of the relatively low demand for passenger transportation by the railways, case studies on similar experiences from other countries will be beneficial for the success of this initiative.					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 5: Provide exposure to and training from countries with a similar railway systems	Medium	MoT, Sri Lanka Railways	2014-2016	US $ 0.3 m Local or donors	- Any required training and capacity building to be completed by end of 2016.
Measure/Action 6: Use appropriate new locomotives, rolling stocks, tracks (as needed) and signal systems					
Justification for the action: Up-gradation of tracks and development of other infrastructure facilities are deemed essential.					
Action*/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding Source US $ millions**	**Indicators**
Action 6: Procure new locomotives & rolling stocks as appropriate and install tracks & signal systems	High	Sri Lanka Rail ways, MoT	2014-2016	(US $ 47.3 million** (IESL, 2008)) Local or donors	- 75% of the programs planned under Action 6 to be completed by end of 2016.
Total Cost for the Technology 3				**Approx: US $ 48.8 million**	

CHAPTER 3

Technology Action Plan for the Industry Sector

3.1 Actions at sectoral level

The data presented in this chapter is mainly based on the Second National Communication (SNC) on Climate Change for Sri Lanka prepared by the Ministry of Environment in year 2012. The preparation of the GHG inventory for SNC required a large number of activity data from a wide range of sectors, coming under the purview of many ministries and government organizations.

3.1.1 Short sector description

Industry sector of Sri Lanka is not a high energy and resource consuming sector. For the purpose of this report, the industrial sector includes all energy consuming industries and industrial processes other than those industries identified under energy sector (energy industry and refinery operations). These industries fall under the industrial categories of traditional, technology intensive, small & medium enterprises and micro industries. Cement manufacture, lime production for construction industry and industries using $CaCO_3$ containing material and soda ash are some of the key industries contributing to GHG emissions within the industry sector. The other industries contributing to significant amounts of GHG emission are Glass manufacturing, Metal & Paper and Food & Beverage production. According to the Second National Communication of Sri Lanka (2012) the total CO_2 equivalent emissions from the industry sector is 1,447.4 $GgCO_{2Eq}$. This amounts to around 8% of the total GHG emissions in the country. The details of emissions from sub-sector within the industry sector are provided in Table 3.1.

Table 3.1: Summary of emissions from the industry sector for 2000

Sub-Sector	Emissions (Gg)						
	CO_2	CH_4	N_2O	CO	NOx	NMVOC	SO_2
Industry	**842.03**	**2.29**	**0.21**	**114.46**	**7.28**	**4.09**	**25.31**
Industrial Processes	**492.40**			**0.04**	**0.02**	**53.49**	**0.26**
A. Cement Manufacture	347.95						0.209
B. Lime Prod & Use	28.96						
C. Soda Ash Use	37.83						
D. Asphalt Use				0.002	0.004	14.083	0.005
E. Glass Manufacture						0.001	
F. Steel Rolling	77.66				0.002	0.001	0.002

G. Paper Rolling				0.038	0.010	0.025	0.048
H. Food and Beverage						39.38	
Total Industry Sector	**1334.43**	**2.29**	**0.21**	**114.5**	**7.3**	**57.58**	**25.57**

Local industrial sector has not expanded at large scale in the recent past due to high energy cost and several other external factors. Since fuel prices continue to increase, most of existing industries that use thermal energy have been converting their basic energy source from fuel oil to biomass. Even though Sri Lankan GHG emission is at very low level compared to the other countries, local industries have started improving their processes to reduce energy and resource consumption because of high cost of energy and other resource.

3.1.1.1 Existing Policies and Laws Related to the Industry Sector's Development

The Existing Policies and Laws related to Industry Sector are given in table 3.2 below.

Table 3.2: Existing Policies and Laws related to Industry Sector

Name of Policies/ Laws	Date of Enactment	Content
Policies		
1). National Cleaner Production Policy	2005	Integrate Cleaner Production concepts, policies and practices into all sectoral procedures with the goal of improving material and energy use efficiency by utilizing cleaner production methods. Policy objectives are reduce consumption pressure on the natural resources based on efficient use of raw materials; improve environmental performance by using ecologically sound practices in the production process, design and use of products and in the provisions and use of services; improve efficiency of water and energy consumption by minimizing wastage and excessive exploitation and use through improving the production process of better products and provisions of services; improve competitiveness in the local and global economy through environmentally sound practices and improve social responsibility towards sustainable development.
2). National Energy Policy and Strategies of Sri Lanka	2006	The policy objective is to ensuring energy security, promoting energy efficiency and conservation, enhancing energy sector management capacity, and enhancing the quality of energy services.

		The policy spells out the implementing strategies, specific targets and milestones through which the Government of Sri Lanka and its people would endeavour to develop and manage the energy sector in the coming years in order to facilitate achieving its millennium development goals.
3). The Development Policy Framework, Government of Sri Lanka (Mahinda Chnthana)	2010	Stated objective: Sustainable development in all direction with minimal effect on environment. Sectors involved: Poverty alleviation, sustainable development, agriculture, education, health, environmental protection, energy and transport policies, science and technology policies, nation building, shelter, water and sanitation with some others. Policies and targets for all sectors, including energy for 2010-2020 have been spelled out, but, there is no set time target for many, but generally there are many projects which are time bound.
Laws		
1). Public Utility Comission of Sri Lanka Act No. 35	2002	A multi-sector Regulator for certain physical infrastructure industries such as electricity, water and petroleum in Sri Lanka
2). Sri Lanka Sustainable Energy Authority Act No.35	2007	To provide to develop renewable energy resources, to declare energy development areas, to implement energy efficiency measures and conservation programs, to promote energy security, reliability and cost effectiveness in energy delivery and information management

3.1.1.2 An overview of the prioritized technologies

The proposed technologies for climate change mitigation in the industrial sector in order of priority are;

1) Energy Efficient Motors
2) Variable Speed Drives for Motors
3) Biomass Residue Based Cogeneration Combined Heat and Power (CHP)

All three technologies are categorized as capital goods.

Brief descriptions of these technologies are provided in sections 3.2.1, 3.3.1 and 3.4.1.

3.1.2. General Barriers and Proposed Measures

There are several barriers which need to overcome for successful implementation of the technologies prioritized. Barriers and measures of energy efficient motors and variable speed drive technologies are almost same, and there are a few barriers unique to biomass CHP technology. In addition to technology specific barriers some are common to all three technologies. Those common general barriers are;

1) High capital costs
2) Lack of financial resources and incentives
3) Insufficient legal provisions, regulatory framework and insufficient enforcement
4) Absence of and limited institutional capacity
5) Lack of skilled personnel for technology implementation and inadequate training for maintenance
6) Poor Operations and Maintenance facilities
7) Inadequate Standards, Codes and Certification
8) Inadequate information, awareness, feedback and difficulties in comprehending technical content

1). Barrier: ***High capital costs:***

High capital cost is a common barrier for all three technologies. Most of industries are reluctant to invest on new energy efficient technologies because of unstable global economic conditions. EEM and VSD related equipments are not locally manufactured.

Proposed Measures: ***Tariff concessions for high efficient and sustainable technologies:***

Tariff concessions in the form of reduced taxes on imported equipment will be an effective measure as economic inducements are likely to attract investments. Loss of revenue to the Government from tax concessions will be compensated through national level energy saving and low cost industrial outputs which could be more competitive in export market.

2). Barrier: ***Lack of Financial Resources and Incentives:***

This barrier is closely relaterd with the previous barrier and common to all the technologies but of particular relevance to Biomass CHP as cost of EEM and VSD can be brought down by reducing government taxes.

Measure (i): ***Availability of financial instruments such as credit schemes, tax concessions and subsidies:***

Credit schemes on concessionary terms and other appropriate financial instruments will be imperative to ensure access to financial resources. Industries need to be encouraged to improve their resource efficiency through such interventions.

Measure (ii): ***Set up a development Bank to provide concessionary credit facilities to promote Biomass CHP:***

In addition to providing such facilities, the industries may be provided with tax holidays during the initial stages of fuel switch to biomass as an incentive to encourage renewable energy resources.

3). Barrier: ***Insufficient legal provisions, regulatory framework and insufficient enforcement:***

Inadequate legal provisions, regulatory framework and insufficient enforcement is another barrier common to all three technologies. EEM and VSD are energy efficiency improvement technologies in industrial electrical energy applications while biomass CHP is a renewable energy generation technology for both electrical and thermal energy applications. Therefore, this barrier is seen as a hindrance to promote energy efficiency and increase the renewable energy share in the industrial sector.

Measure (i): ***Establish appropriate regulatory mechanisms to promote mitigation technologies***

Establishment of appropriate regulatory mechanisms to promote mitigation technologies would enable overcoming regulatory related constraints. Legal provisions and enabling regulatory framework need to be designed so as to encourage continuous improvement of resource and energy efficiency and increase contribution of energy generation from renewable sources.

Measure (ii): ***Set up appropriate regulatory mechanism to ensure sustainable supply of biomass***

Regulatory mechanisms will also be required to ensure sustainable supply of biomass for energy generation which will in turn contribute to promote mitigation technologies.

4). Barrier: Absence of and ***limited institutional capacity***

Existing institution either have limited capacity or lack capacity altogether to implement all the technologies and it is of more relevance to EEM and VSD. There appears to be some institutional capacity to promote biomass CHP technology.

Measure: ***Strengthen institutions through capacity building:***

Strengthening institutions through capacity building will address capacity constraints of relevant professional institutions to enable supporting technology implementation. Motivation through empowerment of employees at middle level and improving co-ordination among institutions, industries and Universities for enhancing knowledge are also other possible measures to overcome this challenge. Further, these institutes need to be made aware of climate change challenges and possible mitigation technologies.

5). Barrier: ***Lack of skilled personnel for technology implementation and inadequate training for maintenance:***

This also can be identified as a common barrier for EEM, VSD and biomass CHP but it is of more relevance

to the first two technologies. Shortage of skilled personnel for operation and maintenance of these technologies is a critical barrier to maintain efficiency level of technologies.

Measure: *Focus on technical education, awareness creation, training and development of skillst:*

Focus on technical education and awareness creation while providing skill development opportunities through overseas training, exchange of specialists are recommended to overcome this barrier. National standardization scheme for technicians will be an added element for personnel development.

6). Barrier: *Poor Operations and Maintenance Facilities:*

This is a common barrier for all new technologies. Most of new technologies are accompanied with sophisticated electronic and computer devices. Therefore, unavailability of proper operation and maintenance facilities, service providers and spare parts will be critical constraints to diffuse these technologies among industries.

Measure: *Set up factory level operation and maintenance management system with registered after sale service providers and spare parts suppliers:*

Proper operations and maintenance system is a vital requirement for new technology related equipments. Most of new technologies are accompanied with sophisticated computer control systems. Therefore, regular servicing and maintenance is an essential factor to maintain the desired efficiency level for a long period. In addition, availability of after sale services and spare parts are also very important for ensuring sustainability of equipments.

7). Barrier: *Inadequate Standards, Codes and Certification:*

Inadequate standards, codes and certification for EEM and VSD technologies are barriers to build industry confidence. A screening process to identify inferior products through standards or certification system to guarantee the efficiency level and potential savings by application of these technologies will contribute to confidence building among the investors in new technologies.

Measure (i): *Get the service from international certification to set up local institutions:*

Getting the service from international certification agencies to set up local institutes will be a sustainable and cost effective approach to overcome the barrier related to standards, codes and certification.

Measure (ii): ***Establish energy labeling and standards, create awareness on effectiveness of the technology through demonstration and pilot projects.***

Sri Lanka Sustainable Energy Authority has initiated development of energy labeling standards for selected consumer items. It is recommended to extend this energy labeling program to cover energy efficient and climate change mitigation technologies for industries as well. Awareness on the effectiveness of the proposed technology may be provided through demonstration and pilot projects and mass media. Effectiveness of the technology could be show cased by providing publicity to success stories and through seminars and exhibitions.

Promotion of technologies by Energy Associations and the relevant stakeholder institutions would help overcoming information gaps, lack of awareness and difficulties in comprehending technological details.

In view of the availability of range of products and models of different quality standards, it is recommended to introduce a product labeling procedure to provide guidance to the potential technology users.

8). Barrier: ***Inadequate information, awareness, feedback and difficulties in comprehending technical communication:***

This barrier is also common to all the three technologies. Effective diffusion of the technologies to the potential industrialists is likely to be affected by lack of available information on the technologies and their effectiveness.

Measure (i): ***Energy labeling and standards, promote awareness on effective of this demo projects, model programme with this technology:***

Same as 7(ii) above

Measure (ii): ***Promote Technology through Energy Associations, Industry Associations and Stakeholders:***

Promotion of technologies by Energy Associations and the relevant stakeholder institutions would help overcoming information gaps, lack of awareness and difficulties in comprehending technological details. Trade Associations also could play an effective role in facilitating networking among different stakeholder groups for information sharing. Sustainable Energy Authority needs to be strengthened to function as the nodal agency for networking.

3.1.3 Specific Measures Proposed for the Selected Technologies

The specific measures proposed for prioritized technologies in the Industry sector are given in Table 3.3. Details of barriers and proposed measures are provided in the Report on Barrier Analysis and Enabling Framework (Report II).

Table 3.3: Specific Measures for Technology 1: Energy Efficient Motors

No.	Recommended Measures
1.	Review and reform government tax policy aimed at reducing capital costs of energy efficient and environment friendly technologies.
2.	Develop financial instruments such as credit facilities, tax concessions and subsidies.
3.	Establish appropriate regulatory mechanisms to promote mitigation technologies.
4.	Institutional strengthening and capacity development.
5.	Focus on providing technical education and awareness creation, training and skill development.
6.	Set up factory level operation and maintenance management system with registered after sale services providers and spare parts suppliers.
7.	Establish local institutions with assistance from international certification agencies.
8.	Establish energy labeling procedures and standards; promote awareness on effectiveness through demonstration projects and pilot programs.

Table 3.4: Specific Measures for Technology 2: Variable Speed Drives

No.	Recommended Measures
1.	Review and reform government tax policy aimed at reducing capital costs of energy efficient and environment friendly technologies.
2.	Develop financial instruments such as credit facilities, tax concessions and subsidies.
3.	Establish appropriate regulatory mechanisms to promote mitigation technologies.
4.	Institutional strengthening and capacity development.
5.	Focus on providing technical education and awareness creation, training and skill development.
6.	Set up factory level operation and maintenance management system with registered after sale services providers and spare parts suppliers.
7.	Establish local institutions with assistance from international certification agencies.
8.	Establish energy labeling procedures and standards; promote awareness on effectiveness through demonstration projects and pilot programs.

Table 3.5: Specific Measures for Technology 3: Biomass Residue Based Cogeneration Combined Heat and Power (CHP)

No.	Recommended Measures
1.	Review and reform government tax policy aimed at reducing capital costs of energy efficient and environment friendly technologies.
2.	Set up a Development Bank to provide credit on concessionary terms to promote biomass CHP.
3.	Establish an appropriate regulatory mechanism to streamline sustainable supply of biomass.
4.	Establish appropriate regulatory mechanisms to promote mitigation technologies.
5.	Measures to build confidence of industrialists on new technologies and publish local success stories and role models.
6.	Promote next generation biomass over for the traditional biomass resources.
7.	Technology promotion through Energy Associations, Industry Associations and stakeholders

3.2 Action Plan for Technology 1: Energy Efficient Motors

3.2.1 Description of the technology

According to global energy surveys, two thirds of electrical energy in the industry is consumed by motors and hence ensuring high efficiency is imperative for overall energy efficiency of the industry. If each installation could contribute even by a fractional improvement of efficiency, the gross saving would be enormous. 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) has listed different efficiency bands for motors. The motors that have higher efficiency by 2% – 8% than the standard motors are categorized as "Premium Efficiency Motors". The efficiency classes in three groups viz; EFF1, EFF2 and EFF3 where EFF1 has the highest efficiency. For a 1.1kW motor, efficiency of EFF1 type is equal or more than 82.8%, EFF2 type is equal or more than 76.2% and any type with lower efficiency than EEF2 falls into EFF3 type. The efficiency values for 75kW motor are EFF1 $\geq$ 94.6% and, EFF2 $\geq$ 93.6%.

In addition to energy savings, the energy efficient motors have other benefits such as longer life time due to high quality insulation, magnetic circuits and bearings. These properties together with high quality manufacturing processes results in very low vibration and become more susceptible to voltage unbalances and overloading.

Efficient Energy Motor technology has been prioritized in view of its high potential for green house gas emission reduction in electricity power generation. This technology also helps in improving electrical energy efficiency particularly in industries and generally in the service sector.

3.2.2 Targets for Technology Transfer and Diffusion

It is proposed to replace 75% of existing motors with EEM by 2030. All the existing motors which ranges from small to large consume about 40% of total electrical energy used by the industries. The current level of employment for the technology is less than 50 and the estimated employment opportunities through technology implementation is 250 @ 10 per district. The estimated GHG emission reduction potential is about 130,192 tCO_2e and the electrical energy saving is 380,679 MWh over ten years which is valued at US$ 35,688,656. The life time of the motor is minimum ten years and the investment cost of EEM technology would be about 71,000 US$ per ton of CO_2 reduction.

3.2.3 Barriers to technology diffusion

The barriers likely to impact upon successful technology implementation and hierarchical classification is given in Table 3.6.

Table 3.6: List of Key Barriers and hierarchy classification for Energy Efficient Motors

Technology Name: Energy Efficient Motors			
No.	**Key Barriers Identified**	**Priority Rank**	**Category of Barriers**
1.	High capital costs	1	Economic and Financial
2.	Lack of financial resources and incentives	2	Economic and Financial
3.	Inadequate regulatory framework and insufficient enforcement	3	Policy, Legal and Regulatory
4.	Lack of professional institutions and limited capacity in existing institutions	4	Institutional and Organizational Capacity
5.	Lack of skilled personnel for technology implementation and inadequate training for maintenance	5	Human Skills
6.	Poor operations and maintenance facilities	6	Technical
7.	Absence of standards, codes and certification	7	Technical
8.	Inadequate information, awareness, feedback and difficulties in comprehending technical content	8	Information and Awareness

3.2.4 Proposed action plans

The Proposed Action Plan for Energy Efficient Motors is provided in table 3.7.

INDUSRTY SECTOR

Action plans for Technology 1

Table 3.7: Proposed Action plans for Energy Efficient Motors

Measure/Action 1: Review and reform Government tax policy to enable reducing capital costs of high energy efficient and sustainable technologies					
Justification for the action: Energy efficient motors (EEM) are costlier than low efficient motors. As EEM are not manufactured locally, in view of high import taxes there is a tendency to import low efficient motors. Therefore, it is required to introduce tax reform policies so as to reduce capital cost of high efficient technologies such as EEM.					
Action/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US $**	**Indicators**
i. Enabling policy to provide tariff concessions for investments in Carbon mitigation technologies for industries	V. High	Treasury/ MoFP	2014-2016	1500 Domestic	- Enabled tax policy by 2016.
ii. Include these technologies to government Strategic Investments plan	V. High	Treasury/ MoFP	2014-2016	1500 Domestic	- EEM included in priority technologies in the strategic investment plan by 2016.
Measure/Action 2: Ensure availability of financial instruments such as credit schemes,, subsidies and green credit lines					
Justification for the action: Financial resources available for investing in energy efficient technologies are limited and it takes long period to recover the investment in present financial market. Therefore, financial inducements in the form of access to credit on concessionary terms and green credit lines dedicated for clean technologies need to be made available to encourage energy efficient and mitigation technologies.					

Action/Sub Action No.	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding US $	Indicators
i. Low interest credit schemes	V. High	Treasury/ MoFP	2014-2016	50,000 Donors	- Availability of low interest credit schemes by 2016
ii. Mandatory provisions to ensure investing at least 5% of loan the facility on mitigation related technology implementation and developments.	V. High	Treasury/CBSL/ MoFP	2014-2016	10,000 Domestic	- Percentage of loans given to mitigation technology implementation by 2016
iii. Capacity building for banking sector on mitigation technologies and its benefits	V. High	Treasury/SLSEA/ MoFP	2014-2016	100,000 Domestic	- No. of officers trained on project appraisal on mitigation technologies by 2016
iv. Reimbursement of part of the investment through a grant	V. High	Treasury /MoFP	2014-2016	20,000 Donors	- % of money reimbursed per year
v. Promote development banking to encourage investments on mitigation technologies (eg: EEM, VSD, biomass CHP)	V. High	Treasury/MoFP	2014-2016	5,000 Donors	- Amount of credit disbursed by 2016
Measure/Action 3: Develop enabling regulatory mechanisms to promote mitigation technologies, EEM, VSD and CHP					
Justification for the action: There is no mandatory requirement for adopting climate change mitigation technologies. Therefore, appropriate legal provisions and regulatory framework will be imperative to promote application climate change mitigation technologies in industries.					
Action/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US $**	**Indicators**
i. Introduce legal reforms to enable developing an appropriate regulatory framework	High	CEA/ SLSEA/MoFP	2014-2016	25,000, Domestic	- Mitigation technologies promoting regulatory framework introduced by 2016
ii. Incorporate mandatory provisions for incorporating mitigation technologies whenever new investments	High	CEA/ SLSEA/MoFP	2014-2016	20,000, Domestic	- No. of institutions and no. of officers trained on regulatory mechanism by 2016

are made in designated industrial facilities.					
iii. Develop and Introduce market based instruments to promote selected mitigation technologies.	High	CEA/ SLSEA/MoFP	2014-2016	100,000, Domestic	- Introduced voluntary recognition schemes such as award schemes by 2016
Measure/Action 4: Institutional strengthening including private sector organizations and capacity development					
Justification for the action: Institutional capacities of existing institutions are not geared to provide services related to promoting and implementation of climate change mitigation technologies.					
Action/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US $**	**Indicator**
i. Strengthen, enforce and expand ESCOs & regulatory agencies.	High	SLSEA	2014-2016	100,000, Domestic	- Increased no. of ESCOs by 2016
ii. Strengthen public private partnerships through joint ventures among ESCOs, Universities, government institutes and private organizations.	High	SLSEA	2014-2016	100,000, Domestic	- No. of intellectual property rights recognized by 2016
iii. Register and assist Universities, institutions, suppliers and service providers to offer mitigation technologies.	High	SLSEA	2014-2016	10,000, Domestic	- Registration process for supplier and service providers introduced within 3 years - No. of suppliers and service providers registered by 2016
iv. Technical and financial assistance for institutional capacity development.	High	SLSEA	2014-2016	5,000 Donors	- No. of programmes conducted to develop in house capacity by 2016
Measures/Actions 5: Focus on technical education and awareness creation, training and skills development.					
Justification for the action: Lack of skilled personnel for installation and maintenance of mitigation technologies is identified as a major barrier for promoting					

mitigation technologies. Regular maintenance and precious running conditions are main requirements of high efficient technologies. Therefore, availability of trained and skilled personnel to install and maintain the equipment and machinery is an essential prerequisite for successful application of mitigation technologies.					
Action/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US $**	**Indicator**
i. Include mitigation technologies in vocational and technical education curricula. Establish partnerships with industries to facilitate internship training opportunities for undergraduates and students of vocational training institutes.	Medium	MoVT, MoHE, NERD, SLEMA, NCPC, SLITA	2014-2016	250,000 Domestic	- No. of teaching hours are allocated for mitigation technologies annually in each institute - No. of institutes teaching mitigation technologies
ii. Develop twining programs with other relevant institutions (foreign and local) to enable exchange of experience and acquire skills.	Medium	MoVT, MoHE, NERD, SLEMA, NCPC, SLITA	2014-2018	5,000 per Participants Donors	- No. of training programs are conducted per year; No. of trained personnel - No. of international and local exchanges
Measures/Actions 6: Set up factory level operation and maintenance management system with registered after sale services providers and spare parts suppliers.					
Justification for the action: Poor operation and maintenance systems at factory level will not be conducive for achieving desired results from the new technologies adopted. Therefore, establishment of factory level operations and maintenance system is essential to enable deriving the maximum benefits of mitigation technologies.					
Action/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US $**	**Indicator**
i. Facilitate training institutions to conduct training and re-training programs on operation and maintenance of the EEM, VSD, CHP technologies.	Medium	MoVT, MoHE, NERD, SLEMA, NCPC, SLITA	2014-2018	250,000 Donors	- No. of training programmes conducted by 2016; No. of trained personnel trained by 2016
ii. Strengthen manufacturing and streamline supply of components and maintenance material for the	Medium	MoVT, MoHE, NERD, SLEMA,	2014-2018	100,000 Domestic	- No. of new suppliers, service providers and components manufacturers in

selected technologies.		NCPC, SLITA			business by 2016.
Measures/Actions 7& 8: (7) Get the service from international certification agencies to set up local institutions. (8.1) Develop schemes for energy labeling and standards. Promote technologies through increased awareness using demonstration and pilot projects. (8.2) Promote technology through Energy Associations, Industry Associations and stakeholders.					
Justification for the action: National standards, codes and certification schemes for the proposed technologies are non existent. In addition, availability of information and awareness on the proposed technologies is inadequate due to lack of feedback from technology users and difficulties in comprehending technology related literature.					
Action/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US $**	**Indicator**
i. Expand the existing labeling program to the selected technologies	Medium	SLSI, SLSEA	2014-2016	50,000 Domestic, Donor	- No. of energy labels introduced for mitigation technologies by 2016
ii. Awareness programs on labeling to Energy Association, Industry Associations and Chambers through demonstration projects	Medium	SLSI, SLSEA	2014-2016	25,000 Domestic, Donor	- No. of awareness programmes conducted during last three years - No. of relevant associations participated by 2016
iii. Develop a national certification system for new mitigation technologies through Sri Lanka Accreditation Board (SLAB)	Medium	SLSI, SLSEA, SLAB	2014-2016	50,000 Domestic, Donor	- National certification system developed by 2016
Total Cost Estimate for Technology 1				**Approx: US $ 1.28 million**	

3.3 Action Plan for Technology 2: Variable Speed Drives for Motors

3.3.1 Description of the technology

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.

'Variable Speed Drives for Motors' technology is recommended because of its high green house gas emission reduction potential in electricity power generation. This technology helps to improve electrical energy efficiency and save electricity particularly in industries and in service sectors as well. Estimated annual electricity saving is about 151,109 MWh and the greenhouse gas reduction potential is about 51,679 tCO_2e per year. Estimated investment cost of variable speed drive technology is about 104,563 US$/$tCO_2$ reduction.

3.3.2 Targets for Technology Transfer and Diffusion

Primary target is to use VSD in all relevant industrial applications by 2030. It is assumed that the VSDs are applicable for about 40% of all the electric motor driven applications. Expected lifetime of this technology application is minimum 10 years. Estimated electricity saving for 10 years is about 1,511,088MWh and its cost saving is about US$141,664,500. Expected GHG reduction for 10 years is about 516,792 tCO_2e. Less than 50 personnel are being currently employed in the technology related activities and the employment generation potential is estimated to be around 250 @ 10 per district.

3.3.3 Barriers and Technology Action Plan for the Technology

The barriers and measures identified for '***Variable Speed Drives for Motors'*** and 'Energy Efficient Motors' are identical due to similarities in two technologies. Both technologies are used for improving efficiency of motors and their applications. Hence the barriers and proposed enabling measures are essentially the same. Therefore, the key barriers, hierarchical classification and technology action plan for 'Variable Speed Drives for Motors' are not repeated in this section for practical reasons (Refer to table 3.6 and 3.7).

3.4 Action Plan for Technology 3: Biomass Residue Based Cogeneration Combined Heat and Power (CHP)

3.4.1 Description of the technology

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 wood based industries. 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).

Generation of energy requirement of the rubber processing factories using saw dust is an example for application of CHP. Saw dust is a waste material from saw mills which has potential of creating several negative environment issues if not disposed off properly. The average thermal requirement of a rubber processing factory 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 combined heat and power (CHP) plant proposed under this technology will run at a constant load of 2250 kW electricity and the excess electricity generated can be fed into the national grid. Generation of steam will be at a constant rate of 3,375 kW and the excess steam generated will be either wasted or could be used for preheating 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). Attempts towards

lowering cost of energy generation through cogeneration systems could be a key to the survival of local industries in today's competitive environment.

'Biomass Residue Based Cogeneration Combined Heat and Power (CHP)' technology has been recommended due to its high green house gas emission reduction potential. This technology helps to improve electrical energy efficiency and contribute for saving electricity as well. The estimated greenhouse gas (GHG) emission reduction potential is about 11,300 t CO_2 per year whereas cost of investment would be around US$ 161,363 per tCO_2e reduction.

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

3.4.2 Targets for Technology Transfer and Diffusion

Primary target of Biomass Combined Heat and Power (CHP) technology is industrial sector applications such as rubber, tea and dairy industry with the GHG emission reduction potential of about 11,300 t CO_2 per year. Expected lifetime of the CHP plant is minimum 15 years.

Current employment in the technology related activities is less than 50. Estimated employment generation potential of the technology applications would be around 400. This includes operators and maintenance staff only.

3.4.3 Barriers to the Technology Diffusion

The barriers that is likely to impede successful application and diffusion of Biomass Residue Based Cogeneration Combined Heat and Power technology with hierarchical classification is given in table 3.8.

Table 3.8: Key Barriers and hierarchy classification for Biomass Residue Based Cogeneration Combined Heat and Power (CHP)

Technology Name: Biomass Residue Based Cogeneration Combined Heat and Power			
No.	**Key Barriers Identified**	**Priority Rank**	**Category of Barriers**
1.	High capital cost	1	Economic and financial
2.	Finance resource constraints and lack of incentives.	2	Economic and financial
3.	Legal constraints related to felling and transport of trees and obtaining permits.	3	Policy, Legal and Regulatory

4.	Inadequate legal provisions, regulatory framework and insufficient enforcement.		Policy, Legal and Regulatory
5.	Resistance to change and lack of confidence in new technologies.		Social, Cultural and Behavioral
6.	Reduction in cultivation of food crops and shift to alternative crops such as Gliricidia.		Social, Cultural and Behavioral
7.	Limited information, awareness, feedback and difficulties in comprehending Technical content.		Information and Awareness

3.4.4 Proposed action plans for the Technology

The Proposed Action Plan for Biomass Residue Based Cogeneration Combined Heat and Power is provided in table 3.9.

INDUSRTY SECTOR

Action plans for Technology 3

Table 3.9: Proposed Action plans for Technology3: Biomass Combined Heat and Power (CHP)

Measure/Action 1: Review and reform Government tax policy to enable reducing capital costs related to implementation of high efficient and sustainable technologies.					
Justification for the action: The existing general import tax policy for all the type of energy generation equipments is a disincentive for importing high efficient renewable resource based energy technologies. Therefore, it is required to introduce enabling tax policies aimed at reducing capital costs of high efficient renewable resources based technologies such as Biomass CHP.					
Action/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US $**	**Indicators**
i. Enabling tax policy including tariff concessions to attract investments in climate change mitigation related technologies in industries	Very High	Treasury	2014 - 2016	1,500, Domestic	- Total duty free concession (USD/3 years) (2) Energy saving (kWh/year) - No. of investments receiving tax holidays for CHP
ii. Integrate climate change mitigation technologies into government Strategic Investment plans	Very High	Treasury	2014 - 2016	1,500 Domestic	- CHP included in priority technologies in the strategic investment plan by 2016
iii. Tax concessions for Research and Development on green energies	Very High	Treasury	2014 - 2016	2,500, Domestic	- Investment on Research and Development (Rs/year) (only an output indicator)
Measure/Action 2: Establish mechanisms to provide credit facilities on concessionary terms to promote biomass CHP					
Justification for the action: Potential sources for accessing finances for investing on energy efficient technologies are inadequate. It takes long period to recover the investment in present financial market. Therefore, it is required to consider introducing credit schemes based on concessionary terms for financing energy efficient and GHG emission reduction technologies.					

Action/Sub Action No.	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding US $	Indicators
i. Low interest credit schemes	Very High	Treasury	2014 - 2016	50,000 Donors	- Availability of low interest credit schemes by 2016
ii. Make provisions for mandatory investment of minimum 5% of loan facility on mitigation technology implementation and developments.	Very High	Treasury/CBSL	2014 - 2016	10,000 Domestic	- Percentage of loans given to mitigation technology implementation by 2016
iii. Capacity building for banking sector on climate change mitigation technologies and related benefits	Very High	Treasury/SLSEA	2014 - 2016	100,000 Domestic	- No. of officers trained on project appraisal on mitigation technologies by 2016
iv. Reimbursement of a part of the investment in the form of a grant	Very High	Treasury	2014 - 2016	20,000 Donors	- % of money reimbursed per year
v. Promote development banking to encourage climate change mitigation technologies.	Very High	Treasury	2014 - 2016	5,000 Donors	- Amount of credit disbursed by 2016
Measure/Action 3: Set up appropriate regulatory mechanisms to promote mitigation technologies and streamline the biomass supply process.					
Justification for the action: There are no existing mandatory requirements for applying climate change mitigation technologies and to develop a supply chain network of renewable energy sources. Availability of appropriate legal provisions and regulatory mechanism to promote application of climate change mitigation technologies in industries would ensure increased industry participation in such initiatives.					
Action/Sub Action No.	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding US $	Indicators
i. Introduce reforms to existing regulatory framework	High	CEA, SLSEA	2014 - 2016	25,000, Domestic	- Mitigation technologies promoting regulatory framework introduced by 2016
ii. Grid connection facility with net metering system	High	CEA, SLSEA	2014 -	20,000,	- No. of CHP plants are connected to grid and No.

to supply excess electricity to national grid.			2016	Domestic	units (kWh) supply to grid by 2016
iii. Incorporate regulatory mechanism to incorporate energy generation related mitigation technologies as an obligatory requirement whenever new investments are made in industrial facilities.	High	CEA, SLSEA	2014 - 2016	100,000, Domestic	- Mitigation technologies as the minimum requirement whenever approve new investment by 2016
iv. Introduce new regulatory mechanism to streamline and strengthen the supply chain of biomass fuel	High	CEA, SLSEA	2014 - 2016	2,500, Domestic	- Increase area coverage and smooth supply of biomass fuel by 2016
v. Introduce market based instruments to promote application of mitigation technologies such as rewards, regulations, etc.,	High	CEA, SLSEA	2014 - 2016	5,000, Domestic	- Introduced market based instruments (awards scheme, recognition) by 2016
Measure/Action 4: Confidence building among industries in new technology applications through publishing local success stories and role models					
Justification for the action: Local industrialists lack of confidence in investing on renewable energy projects such as biomass CHP.					
Action/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US $**	**Indicator**
i. Demonstration projects for selected industries and industrial sectors.	High	SLSEA	2014 - 2016	2,000,000, Donors	- No. of industries successfully implemented biomass CHP by 2016
ii. Financial incentives for early adopters (eg. tax concessions and subsidies).	High	SLSEA	2014 - 2016	20,000, Domestic	- The percentage of reduction of cost on investment through concessions by 2016
iii. Exchange programs to get an exposure to successful projects implemented industries in other countries.	Medium	SLSEA	2014 - 2016	200,000, Donors	- No. of industries/ industrialist exposed to new technologies and technology applications by 2016
iv. Technical and financial support for institutional	Medium	SLSEA	2014 -	50,000,	- No. of ESCOs trained on CHP technologies and

capacity building.			2016	Donors	services by 2016
v. Technical capacity enhancement of suppliers and manufacturers of equipments.	Medium	SLSEA	2014 - 2016	50,000, Donors	- No. of suppliers trained by 2016
Measures/Actions 5: Promote next generation biomass in place of use of traditional biomass.					
Justification for the action: The food security of the country would be affected if the industrial and energy sector favors traditional biomass resources. Therefore, it is important to promote next generation biomass such as, agriculture and other residue biomass to alleviate any such risks.					
Action/Sub Action No.	**Priority Rank**	**Responsibility of Implementation**	**Time frame**	**Cost & Funding US $**	**Indicator**
i. Streamline the management of agro waste biomass	Medium	SLSEA	2014 - 2018	100,000, Domestic / donors	- Achieve maximum 30% dumping of residue biomass by 2018
ii. National Survey on the availability of biomass (both first generation and next generation)	Medium	SLSEA	2014 - 2016	30,000, Domestic / donors	- Information on next generation biomass availability for investors by 2016
iii. Information dissemination on suitability and availability of biomass agro waste for CHP.	Medium	SLSEA	2014 - 2016	50,000, Domestic / donors	- No. of publications available for promoters and investors by 2016
iv. Research and Development for improvements and adaptation of available technologies	Medium	SLSEA	2014 - 2016	200,000, Domestic / donors	- No. of research and development projects initiated by 2016
Measures/Actions 6: Promote technology through Energy Associations, Industry Associations and stakeholders					
Justification for the action: Biomass based energy generation technologies have not become popular among industries due to availability of limited information, lack of adequate awareness, user feedback and difficulties in comprehending technical literature.					

Action/Sub Action No.	Priority Rank	Responsibility of Implementation	Time frame	Cost & Funding US $	Indicator
i. Networking of relevant associations and professionals	Medium	SLSEA	2014 - 2016	5,000, Domestic / donors	- Prepare registry of network members by 2016
ii. Awareness creation and training programs by the members of the networks	Medium	SLSEA	2014 - 2016	100,000, Domestic / donors	- No. of training and awareness and no. of training hours by 2016
iii. Develop a compendium of potential technologies with technical fact sheets	Medium	SLSEA	2014 - 2016	20,000, Domestic / donors	- Publications of the compendium by 2016
iv. Develop a methodology to evaluate usefulness/ success of technologies based on United Nations Environment Programme (UNEP) SAT methodology	Medium	SLSEA	2014 - 2016	50,000, donors	-Development of technology assessment methodology by 2016
Total Cost Estimate for Technology 3				**Approx: US $ 3.22 million**	

CHAPTER 4

Cross-cutting Issues

Barriers to transfer and diffusion of climate change mitigation are unlikely to function independent of one another. The barrier analyses in different sectors show linkages between different barriers or existence of general/common barriers to the prioritized technologies. Although there are technology specific barriers yet, some general or common barriers and measures can be identified for some of the technologies in all the sectors. Therefore, it is useful to analyze such linkages and measures in order to maximize synergies and optimize the potential impacts of recommended measures.

The action plans provided in chapters 1-3 for implementation of proposed mitigation technologies in the different sectors, also recommend measures/actions to overcome the barriers in each sector. Although the respective barriers have been listed under different sectors, measures recommended to overcome such barriers are similar. While these measures/actions will facilitate development of the respective technologies, they will also influence overcoming barriers related to other technologies within the same sector or those in other sectors.

The aim of this section is to identify common or general barriers to technology transfer and diffusion that cut across all the three sectors, namely energy, transport and industry and to analyze possible cross-sectoral development measures/actions.

4.1 Identification of common barriers across the sectors

The general/common barriers and proposed measures for sectors have already been discussed in the Report II, 'Report on Barrier Analysis and Enabling Framework - Mitigation', as well. However, the major groups of common barriers across sectors are listed below for easy reference. These barrier groups are;

1. Finances
2. Information and awareness
3. Policies/laws
4. Institutional capacity
5. Technology Development

The cross sectoral common barriers falling under each of the Barrier Groups are provided in Table 4.1.

Table 4.1: The common barriers across the sectors

Barrier Group	Energy	Transport	Industry
1. Finances	High capital cost and difficulties to access finance	Inadequacy of finances	High capital cost
2. Information and Awareness	Economic feasibility not examined or not published	Lack of knowledge on the benefits and other aspects related to the technologies	Inadequate information, awareness, feedback and difficulties in comprehending technical content
3. Policies/laws	Not Applicable	Poor attention in national policies and legislation for promoting the technologies	Insufficient legal, regulatory framework and enforcement
4. Institutional Capacity	Not Applicable	Not Applicable	Capacity constraints of existing institutions
5. Technology Development	Technology not fully developed.	Not Applicable	Not Applicable

As shown in Table 4.1 above, the most critical barriers that cut across all the three sectors are inadequate finances, information & awareness and enabling policy & regulatory framework. However, inadequacy of finances appears to be the most critical issue across the sectors. Similarly, inadequate information & awareness is also a significant barrier for most of the technology developments. Lack of enabling policy and legal environment & poor enforcement of existing laws, and institutional capacity constraints appear to be next most significant barrier affecting the transfer and diffusion of technologies in transport and industry sectors. As far as the energy sector is concerned, insufficient institutional capacity and inadequate technology development can be considered as the most significant barriers.

Furthermore, information & awareness and institutional capacity related barriers are directly related with inadequate finances. Availability of adequate finance is imperative for timely dissemination of information and awareness creation on new technologies & technological advances, and institutional capacity improvements through required training.

4.2 The measures to overcome common barriers in sectors

The common measures proposed to overcome cross cutting barriers for the prioritized technologies can be summarized as follows;

- Establish proper financing mechanisms including appropriate tax concession policies.

- Awareness creation on potential benefits of technology applications and provide required technical education and training.
- Introduce appropriate enabling policies and regulations to promote the implementation of technologies.
- Institutional strengthening and capacity development of the officials on relevant technologies.
- Take appropriate steps to develop the technologies including marketing.

As these are common measures which will have impacts on transfer and diffusion of technologies in all three prioritized sectors, such measures/actions should be implemented on priority basis when implementing the technology action plans.

The proposed actions/measures to overcome the cross-sectoral barriers are summarized in Table 4.2.

Table 4.2: Proposed actions/measures to overcome the cross-sectoral barriers

Group of Measures	Energy	Transport	Industry	Common Measures to Overcome Barriers
1. Finances	(i).Consider providing tax concessions on local fabrications and constructions related to Renewable Energy and Energy Efficient projects. (ii). Activate the provision in the SEA ACT to establish a Fund for supporting Renewable Energy and Energy Efficient projects by imposing a cess on all imported fossil fuels.	Establish a financial mechanism conducive to promote recommended technologies.	Review and reform Government Tax Policy to enable reducing capital costs of high efficient and sustainable technologies	Establish a proper financing mechanism including appropriate tax concession policies.
2. Information and Awareness	Conduct economic feasibility studies on relevant renewable energy and energy efficient projects and publicize study findings.	Awareness creation on the potential benefits of the recommended technologies and establish a proper road discipline through implementation of road rules and regulations.	(i). Create awareness through demonstration and pilot projects. (ii). Focus on technical education, awareness creation, training and skill development	Awareness creation on potential benefits of the technology applications and provide required technical education and training.
3. Policies/laws	Not Applicable	Introduce enabling policies and regulations to establish tariff barriers to discourage importation of too many vehicles for personal use and a tax regime for single or low occupancy vehicles.	Establish enabling regulatory mechanisms to promote mitigation technologies.	Introduce appropriate enabling policies and regulations to promote the implementation of technologies.

4. Institutional Capacity	Provide opportunities to to ocal officials to get exposure to successful interventions in other countries.	Not Applicable	Institutional strengthening and capacity development.	Institutional strengthen and capacity development of the officials on relevant technologies.
5. Technology Development	Commercialize production and marketing of Glricidia leaves through supporting R&D.	Not Applicable	Not Applicable	Take appropriate steps to develop the technologies including marketing.

4.3 The measures that may have negative impacts on other technologies

There could be instances where the implementation of some of the above measures to overcome the cross cutting barriers would negatively impact upon the development of other technologies. For example, allocation of required finances for a particular technology could jeopardize implementation of another technology, success of which also dependent upon availability of adequate finances. This is applicable to other resources such as skilled human resource as well. Therefore, judicious allocation of scarce resources for prioritized technologies, both financial and human, on a need based approach would help avoiding such situations. Prioritizing the implementation of recommended measures for each technology as provided in Table 4.3 would ensure realistic allocation of resources for one activity without impacting upon the success of another.

Table 4.3: Level of priority of the measures that has the potential financial conflict in the energy sector

Technology	Measure	Priority	Implementation Timeframe
1. Conversion of Biomass and Waste to Energy	1. Feasibility studies by the relevant State institutions.	V. High	2014 (Year 1)
	2. (a) Consider providing tax concessions on local fabrications and constructions related to Renewable Energy and Energy Efficient projects. (b) Donor agencies to provide funds on concessionary terms.	V. High	2014 (Year 1)
	3. SEA to exercise provision in the Act by imposing a levy on fossil fuels and to use such proceeds to establish a Fund to provide low interest finance.	High	2014-2017
2. Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration	1. Integrate all externalities when costing technology options during generation planning.	V. High	2014-2017
	2. (a) Government taxes on imports and local fabrications and constructions for Renewable Energy and Energy Efficiency Projects be reduced or eliminated. (b) Donor agencies to provide funds at low interest rates.	V. High	2014-2017
	3. Relevant officials should be exposed to such technologies	High	2014 (Year 1)
3. Building Management Systems	1. (a) Consider providing tax concessions on local fabrications and constructions related to Renewable Energy and Energy Efficient projects.	V. High	2014 (Year 1)

	2. SEA to exercise provision in the Act by imposing a levy on fossil fuels and to use such proceeds to establish a Fund to provide low interest finance.	V. High	2014 onwards
	3. Revise household electricity tariff based on marginal cost of generation and distribution and provide relief to targeted consumers only	High	2014 onwards

As shown in the Table 4.3, measures 1 & 2 of all the three prioritized technologies for the Energy sector have very high priority and will be carried out during the same period from 2014 onwards. Considering the very high level of priority and overlapping period of implementation, these measures have a potential for financial conflicts when mobilization of financial resources under a limited resource environment. Therefore, in such cases resource allocation needs to be done very cautiously in consideration of the relative importance of the measure for development of the technology.

As the measure 3 of all the technologies has low priority when compared with measures 1 and 2, its implementation needs to be considered accordingly in order to avoid conflicts in mobilizing finances among these technologies.

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Annex I

List of Stakeholders Involved and their Contacts

ENERGY SECTOR

List of Stakeholders

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3.	Mr. A.H.S. Ariyasinghe	Senior Assistant Secratary Ministry of Petroleum Industries	Government	No. 80, Sir Ernest De Silva Mawatha Colombo 07
4.	Mr. N.R. Wickramasinghe	Deputy Manager Ceylon Petroleum Corporation	Government	No.609, Dr. Danister de Silva Mawatha, Colombo 09.
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8.	Mr. Nilantha Kumara,	Consultant Practical Action of Sri Lanka	NGO	5, Lionel Edirisinghe Mawatha Kirulapone, Colombo 5
9.	Mr. Parakkarama Jayasinghe,	President Bio Energy Association of Sri Lanka	NGO	465/1, Sunethradevi Rd, Pepiliyana, Boralesgamuwa
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13.	Mr. Nalin Edirisinghe	Director Public Utilities Commission of Sri Lanka	Government	6th Floor , BOC Merchant Tower, St. Michael's Road, Colombo 3

TRANSPORT SECTOR

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

INDUSTRY SECTOR

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