Ministry of Environment and
Renewable Energy
Sri Lanka

Technology Needs Assessment And Technology Action Plans For Climate Change Mitigation

Barrier Analysis and Enabling Framework

2012

Supported by

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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.

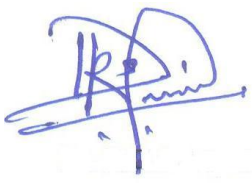
I wish to take this opportunity to express my sincere gratitude to Hon. Susil Premajayantha, Minister of Environment and Renewable Energy, Hon. Anura Priyadarshana Yapa, Former Minister of Environment, Mr. B.M.U.D. Basnayake, Secretary, Ministry of Environment and Renewable Energy and Mr. Gamini Gamage, 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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Stakeholder Participation

TNA Committee	– Annex A1
Workshop Participants	– Annex A2

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

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ABREVIATIONS

ADB	Asian Development Bank
BEASL	Bio Energy Association of Sri Lanka
BRT	Bus Rapid Transit
CDM	Clean Development Mechanism
CEB	Ceylon Electricity Board
CH_4	Methane
CHP	Combined Heat and Power
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	Green House Gas
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 mitigation in Sri Lanka focused on environmentally sound technologies that support Sri Lanka's economic development in a sustainable manner, in line with the National Development Policy Framework of the country ("Mahinda Chintana: Idiri Dakma" – Vision for a New Sri Lanka, 2010) and reducing the rate of greenhouse gas emissions whilst contributing to low carbon technology investments in the future.

The priority sectors identified for mitigation are Energy, Transport and Industry. Having identified the potential priority technologies for adoption in each sector, the next step of the TNA process involved with defining any barriers that is likely to impact upon successful transfer and diffusion of the technological interventions. The identification of barriers and enabling measures to overcome these barriers involved with stakeholder consultations, review of related literature and specialist inputs.

Energy Sector

The prioritized technologies for the sector are; **(1) Conversion of Biomass Waste to Energy (2) Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration** and **(3) Building Management Systems.** Specific interventions proposed under these technologies include; (a) Co-Firing of Biomass with Coal, (b) Compact Biogas Digester for Urban Households & (c) Waste to Energy, under the Conversion of Biomass Waste to Energy, (d) Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration, and (e) LED Lighting & (f) Solar Assisted Air Conditioning under the Building Management Systems.

Co-Firing Biomass with Coal involves biomass fuel combustion along with coal to generate high pressure and high temperature steam to drive turbo alternators to generate electricity. This technology contributes to reducing coal consumption thereby resulting in GHG emission reduction and foreign exchange saving. **Compact Biogas Digester for Urban Households** is aimed at helping the urban households to partially replace imported LPG used for cooking by biogas. Use of a compact biogas digester which could be accommodated in an urban household is recommended for this purpose. The feed stock for the biogas digester would be dried and powdered Gliricidia leaves to be made available in user-friendly packs from the grocery shops. **Waste to Energy** is an attempt to use Municipal Solid Wastes (MSW) as a source of energy by converting into pellets to be used as fuel along with coal in cement kilns. The high temperature resulting from the combustion of coal would crack any dioxin formed from the combustion of halogenated plastics found in MSW. In addition, the presence of calcium carbonate would absorb any remaining dioxin. AS combustion of these pellets in other applications is likely to cause environmental pollution, it is recommended for to be used only in cement manufacture.

The economic and financial barriers for **Conversion of Biomass Waste to Energy** are H*igh capital costs*, *Inadequate information on economic and financial feasibility* and F*inancing constraints*. The identified

non- financial barriers are I*nadequate private sector awareness*, *Externalities of coal firing not internalized*, *Supply constraints of biomass/waste*, *Technology not established at the scale envisaged*, *Absence of fully developed technology* and *Public apathy.*

The financial measures proposed to overcome barriers are (a) Feasibility studies by the relevant state institutions and dissemination of results (b) Consider tariff concessions for local fabrications and constructions; Explore donor funding on concessionary terms (c) Sustainable Energy Authority to consider a levy on fossil fuels to develop a Fund to finance Renewable Energy and Energy Efficiency projects. The non-financial measures are (a) Sri Lanka Sustainable Energy Authority to recognize "Co-firing" as a means of supplementing electricity for the grid, (b) Consider all externalities in generation planning and costing of technology options (c) Provide underutilized state lands for multipurpose agro-energy cultivation by private sector; Consider removing subsidies on fossil fuels; Ensure availability of MSW for RDF manufacture by the private sector, (d) Proactive State initiatives to demonstrate viability of co-firing and RDF technologies, (e) Actions by relevant State institutions to address technical issues related to compact biogas digester and (f) Public awareness to ensure public acceptance of compact biogas digesters.

The **Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration** together with superior forecasting technologies will enable increasing the share of varying outputs into the grid through the use of Solar PV and Wind energy. These resources are being underutilized as the outputs have frequent and rapid variations. The economic and financial barriers for this technology are; *Misconception of non-conventional renewable energy options being expensive*; *High capital cost*; *Difficulty to access finance*; *Economic viability not established*. The non-financial barriers include; *Related subject matter not included in formal education sector; Difficulties in accessing the technology*; *Lack of expertise*; *Inadequate weather forecasts*; *Weak electricity grid, telecommunication, road and railway infrastructure*; *Inherent complexity of the technology*; *Poor electricity load profile* and *Inadequate consultations when declaration of national reserves.*

The economic and financial measures to overcome barriers are; (a) Realistic costing of technologies in generation planning (b) Consider tariff concessions for local fabrications and constructions; Explore donor funds under concessionary terms (c) Sustainability Energy Authority to consider a levy on fossil fuels to support Renewable Energy and Energy Efficiency projects (d) Feasibility studies by relevant state institutions and dissemination of study results. The non-financial measures include (a) Include relevant subject matter in study curricula of Technical Colleges and Universities (b) Provide relevant officials with required exposure to such technologies, (c) Training opportunities for relevant officials. (d) Provide specific instrumentation and other resources for detailed weather forecasting by the Meteorological Department (e) Provide necessary funds for infrastructure improvement (f) Opportunities for familiarization with the technologies (g) Modify the load profile and (h) Ensure adequate inter agency consultations.

The technology on **Building Management Systems** includes activities related to **LED Lighting** and **Solar Assisted Air Conditioning**. The “Efficacy” and life time of LED lamps are much higher than th eordinary lamps. Gradual diminishing of LED lamps before failing is a desirable factor for certain Task applications such as surgical lighting. **Solar Assisted Air Conditioning** has the capability of saving 30 -50 % of electrical energy and has a wide target market including hotels, restaurants, hospitals, factories, schools, convention centres and high end residential buildings. As it requires minimal direct sunlight exposure, heat from ambient and heat blown by the condenser can also be utilized. The annual energy savings through this technology is estimated to be around 6,785,100,000 kWh/year.

The potential economic and financial barriers are *High capital cost*; *Difficulty to access finance*; *Economic viability not established*; *Existing tariff for electricity is below marginal cost of generation*. The non-financial barriers are; *Relevant subject matter not included in formal education*; *Unavailability of latest information*; *Difficulty in accessing technology*; *Lack of qualified technicians*; Uncertainty of guranteed *life time of LED lamps* and *Absence of certification*.

The economic and financial measures include (a) Consider tax concessions for local fabrications and constructions; Explore donor funds on concessionary terms (b) Sustainability Energy Authority to consider imposing a levy on fossil fuels to provide concessionary finances for Energy Efficiency projects; (c) Feasibility studies and dissemination of results; Provide funds adequate for such studies, (d) Consider introducing electricity tariff based on marginal cost and provide relief to targeted consumers only. The non-financial measures include (a) Integration of relevant subject matter in formation education curricula (b) Ensure availability of latest information through appropriate media, (c) Provide publicity through appropriate media, (d) Provide training opportunities for technicians, (e) Introduce legislations to compensate for failure during guaranteed lifetime of LED lamps, (f) Introduce certification by testing under more rigorous conditions.

Transport Sector

The recommended technologies for 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.**

Integration of Non- motorized transport methods along with regularized public transport system would facilitate reduction of congestion, especially during peak hours and at city centers. Promotion of non-motorized modes of transportation such as walking and bicycling in congested areas and city centers by providing pedestrian walkways, sidewalks, and overhead pedestrian bridges, and proper electronic signaling coupled with warning signposts at pedestrian crossings, etc., will be considered under this technology. In addition to reducing congestion, non-motorized transport adds green benefits including

the reduction of greenhouse gas emissions and overall pollution, while improving the human health.

The main economic and financial barrier likely to impact upon this technology is *Inadequate finances* while the non-financial barriers are; *Lack of public interest due to inadequate road safety*; *Attitudinal indifference of the public towards non-motorized transportation*; *Inadequate awareness of and poor enforcement of road rules*; *Poor policy and legal environment towards pedestrians over the motorists*; *Poor accessibility to non-motorized transport facilities from the public transport terminals*; *Lack of space to develop sidewalks and walkways*; *Lack of proper sidewalks and walkways* and *Lack of proper road furniture.*

The recommended economic and financial measure to overcome the barrier is to provide government financing and to explore donor support. The non- financial measures are (a) National policy and legislative reforms to recognize need for developing pedestrian and other non-motorized transport related infrastructure, (b) Adequate law enforcement to maintain road discipline and awareness creation among road users, (c) Awareness on health benefits of non-motorized transport, (d) Attitudinal changes through better awareness and developing attractive pedestrian facilities, (e) Legal amendments to to introduce automated fine systems, (f) Provide walkways from main bus and train stations, (g) Improved sidewalk and walkway designs and land acquisition, as appropriate, (h) Construction of proper, attractive walkways and sidewalks, (i) Provide all required road furniture.

Carpooling and Park-and-Ride systems envisages providing parking facilities at a central location for the commuters can leave their personal vehicles and transfer to a common shuttle service or take the option of traveling as a group in one car for the rest of their journey. Thus vehicles are parked in the facility throughout the day, and picked up on the return journey. Typically, such facilities are found in the suburban areas. Carpooling and park-and-ride options can be considered for roads where congestion is extremely high, causing traffic delays and heavy pollution due to vehicular emissions.

The economic and financial barriers for the technology are; *Inadequate finances*, and *Lack of economic tools including road pricing and innovative public transport facilities.* Non-financial barriers include; *Absence of a existing mechanism for operation of carpooling and park-and-ride systems*; *Lack of a public private partnership arrangement to promote the technology*; *Inadequate public awareness on the potential of this systems*; *Unavailability of guidelines and regulations for driver- passenger cost sharing*; *Lack of public interest*; *No remote ticketing facilities*; *Absence of real time information, location maps and sign boards of the parking spaces* ; *No directory of responsible authorities and officials*; *Unavailability of attractive, comfortable high quality buses*; *Inadequate potential parking areas in the suburbs for expansion*.

The economic and financial measures are; (a) Explore financing through public private partnerships and (b) Introducing a tax system for single or low occupancy vehicles. The non-financial measures are; (a) Awareness creation through mass media, (b) Establish a registration system for regular users and

maintenance of operational database, (c) Introduction of direct management regulations for carpooling and shuttle transit, (d) Prepare a information directory (e) Establish utility infrastructure and amenities within the carpooling and park-and-ride facility, (f) Facilities for on-line ticket purchasing, (g) Electronic display of information related to bus transit and signboards by the main road, (h) Introduction of better vehicles and reduction of the importation taxes for public transport vehicles, (i) Adequately secured parking areas with insurance.

Electrification of the existing railway system will aim at electrification of ~5 percent of the existing railway system, as it will save both energy and the maintenance cost, while providing sustainable transport. The main economic and financial barrier for this technology is *lack of adequate finances* and the non-financial barriers are; *Lack of existing intermediate high density transport modes such as BRT for the nodal points and facilities related to non-motorized transportation*; *Uncertainty of uninterrupted power supply*; *No transport network analysis to identify the electrification links*; *Lack of research studies on similar experience from other developing countries in the region;* and *Lack of required infrastructure*.

The economic and financial measure recommended to overcome the respective barrier is to explore financing through donors and public private partnerships. The recommended non-financial measures comprised of; (a) Establish a BRT system within the existing road network, (b) Provide backup power generation for uninterrupted power supply, (c) Solicit support of the Transport Ministry to identify electrification links, (d) Acquire experience and training from countries with a similar railway system, (e) Develop new tracks and signal systems.

Industry Sector:

Prioritized technologies for the energy sector are; **(1) Energy Efficient Motors, (2) Variable Speed Drives for Motors, (3) Biomass Residue Based Cogeneration Combined Heat and Power.**

Introduction of technology related **Energy Efficient Motors** is aimed at improving energy efficiency of motors. Energy efficient motors have other benefits such as longer life due to high quality insulation, magnetic circuits and bearings. The economic and financial barriers for transfer and diffusion of this technology include; *High capital cost* and *Lack of financial resources and incentives*. The non-financial barriers are; *Poor Operations and Maintenance Facilities*; *Inadequate standards, codes and certification*; Absence *of a regulatory framework and insufficient enforcemen*t; *Lack of professional institutions and capacity limitations in existing institutions*; *Lack of skilled personnel for technology implementation and inadequate training for maintenance*; and *Inadequate information, awareness, feedback and difficulties in comprehending technical contents.*

The enabling economic and financial measures are (a) Consider tax concessions to reduce capital costs and (b) Provide credit facilities, tax concessions and subsidies. The recommended non-financial measures are (a) Set up factory level operational and maintenance management system with registered

after sale services providers and spare parts suppliers, (b) Secure services of international certification agencies to establish local institutions, (c) Develop appropriate regulatory mechanisms to promote mitigation technologies, (d) Strengthen institutions through capacity development, (e) Focus on technical education and awareness creation, training and skill development and (f) Establish energy labeling and standards, promote awareness through demonstration projects.

Variable Speed Drives for Motors provide ability to adjust the speed using speed control to suit the respective application thereby saving energy as much as 60% depending on the nature of application. 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 very much less than that of a mechanical speed controller and also very compact. Various manufacturers provide other technologies to achieve fine improvements of motor operation to achieve more energy saving and optimizing the operation.

The barriers and measures for 'Energy Efficient Motors' and 'Variable Speed Drives for Motors' are similar due to similarities in two technologies as both the technologies are for improving efficiency of motors and their applications. Hence, barriers and proposed enabling measures are more or less identical. The economic and financial barriers include; *High capital costs;* and *Lack of financial resources and incentives*. The non-financial barriers are; *Poor Operations and Maintenance Facilities*; *Inadequate standards, codes and certification*;, *Absence of regulatory framework and insufficient enforcement*, *Lack of professional institutions and limited institutional capacities in existing institutions*; *Lack of skilled personnel for technology implementation and inadequate training for maintenance*; and *Inadequate information, awareness, feedback and difficulties in comprehending technical content*.

The economic and financial measures are; (a) Consider tax concessions to reduce capital costs, (b) Provide credit facilities, tax concessions and subsidies whereas, the non-financial measures are (a) Set up factory level operational and maintenance management system with registered after sale services providers and spare parts suppliers, (b) Secure service of international certification agencies, set up local institutions, (c) Establish appropriate regulatory mechanisms to promote mitigation technologies, (d) Institutional strengthening through capacity development, (e) Focus on technical education and adequate awareness, training and skill development (f) Establish energy labeling and standards, promote awareness through demonstration projects.

The technology related to **Biomass Residue Based Cogeneration Combined Heat and Power (CHP)** is aimed at converting biomass into useful forms of energy such as heat, electricity and liquid fuels. Biomass required for bio-energy generation comes either directly from the land, as dedicated energy crops, or from residues from the processing of crops for food or other products such as pulp and paper from the wood industry. Through this technology, GHG emissions could abe reduced by the equivalent of about 11,300 t CO2 per year. The reduced energy costs due to cogeneration could be a key to the

survival of local industries in today's competitive environment.

The economic and financial barriers for this technology are; *High capital costs* and *Financing constraints and lack of incentives*. The non-financial barriers are comprised of; *Legal issues related to felling and transport of trees*; *Inadequate regulatory framework and insufficient enforcement*; *Resistance to change and lack of confidence in new technologies*; *Negative impacts on food production due to shift to alternative crops such as Gliricidia*; *Limited information, awareness, feedback and difficulties in comprehending technical contents*..

The enabling economic and financial measures recommended are; (a) Consider tax concessions to reduce capital costs and (b) Set up development bank to provide credit facilities on concessionary terms .The non-financial measures include; (a) Establishing a regulatory mechanism to streamline biomass supply, (b) Regulatory mechanisms to promote mitigation technologies, (c) Measures for confidence building among industries and disseminate local success stories, (d) Promote next generation biomass and (e) Promotion of technology through energy associations, industry associations and stakeholders.

CHAPTER 1

ENERGY SECTOR

Sri Lanka's present primary energy supply is based mainly 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%, while the contribution to the electricity grid is about 4%[1]. The government plans to increase this ratio to 10% by 2015[2]. The National GHG inventory recognizes that CO_2 emissions from fossil fuel combustion being the major source of emissions and it has shown a growth from 5,447 Gg in the 1994 to 10,430 Gg for the year 2000 and the corresponding per capita CO_2 emissions were 304 and 545 kg, respectively.

The National Energy Policy and Strategies (NEPS) stipulate that the government will endeavor to reach by 2015, a minimum level of 10% of electrical energy supplied to the grid to be from Non-Conventional Renewable Energy (NCRE). According to the power sector mitigation scenario as described in the LTGE Plan (2009 – 2022) of the CEB, by 2020 150 MW would be generated from Upper Kotmale hydro power plant and 612.5 MW to be from renewable energy sources along with 2,260 MW from thermal power plants.

Sri Lanka has no petroleum oil or coal resources. Nevertheless, due to the geo-climatic conditions of Sri Lanka, the country is blessed with several forms of renewable energy resources. Some of them are widely used and developed to supply the energy requirements of the country. Others have the potential for development when the technologies become mature and economically feasible. Currently about 56.9% of the primary energy supply comes from renewable resources. Following are the main renewable resources available in Sri Lanka and their percentage share for the primary energy supply in the country:

- Biomass - 47.4%
- Hydro Power – 9.5%
- Solar & Wind – 0.04%

Process of identifying barriers:

Although potent technologies for the energy sector have been identified and prioritized during the Technology Needs Assessment stage, yet there are barriers to overcome to enable fulfilling the objectives of technology transfer and diffusion. Therefore, a barrier analysis was carried out through stakeholder consultations (see Annex II) supported by literature reviews specialist inputs. The barriers thus identified have been prioritized and ranked according to their significance

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

[2] MoPE, 2006, National Energy Policy and Strategies, Ministry of Power and Energy, Sri Lanka

1.1 Preliminary targets for technology transfer and diffusion

The mitigation technologies identified and prioritized for the energy sector using Multi Criteria Decision Analysis appear in Table 1.1. Two of the three technologies selected have sub-technologies ascomponents. Thus, the respective technologies and sub-technologies are (a) Co-Firing of Biomass with Coal, (b) Compact Biogas Digester for Urban Households and (c) Waste To Energy under Technology 1, (d) Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration under Technology 2 and (e) LED Lighting and (f) Solar Assisted Air Conditioning under Technology 3. The categorization of these technologies is shown in table 1.1.

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

No	List of Prioritized Technologies	Sub Technologies	Category of the Technology
1.	**Conversion of Biomass and Waste to Energy**	**a)** Co-Firing of Biomass with Coal	Publicly provided
		b) Compact Biogas Digester for Urban Households	Consumer
		c) Waste To Energy	Publicly provided
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	Other non-market good
3.	**Building Management Systems**	**a)** LED Lighting	Consumer
		b) Solar Assisted Air Conditioning.	Consumer

Table 1.2 below provides the primary targets for technology transfer and diffusion including expected life time, economic benefits and climate change mitigation impacts of sub-technology Co-firing Biomass with Coal under Technology 1.

Table 1.2: Primary targets of Co-firing Biomass with Coal

Technology	Co-Firing Biomass with Coal
Primary target	Substituting 30 MWe equivalent of coal with biomass in the 2 to 5 year period.
Expected life time	Minimum 30 years

Expected economic benefits	The annual economic benefit of replacing 30MWe equivalent of imported coal with indigenous biomass is US$ 75 million in terms of foreign exchange savings. This is based on the following assumptions: • Price of 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 for 30 years is about 6,180,000 tCO2e. This is based on the following assumptions: • Emission: 94.6 tCO2/TJ for coal • Calorific Value of coal: 26,000 kJ/kg • Annual operating hours: 7000 h/y • Specific fuel consumption: 0.4 kg/kWh

Table 1.3 below provides the primary targets for technology transfer and diffusion including expected life time, economic benefits and climate change mitigation impacts of sub-technology Compact Biogas Digester for urban households under Technology 1.

Table 1.3: Primary targets of Compact Biogas Digester for Urban Households

Technology	Compact Biogas Digester for Urban Households
Primary target	60,000 household units each replacing 0.4 kg LPG per day in 2 to 5 years.
Expected life time	10 years
Expected economic benefits	Savings of foreign exchange of US$ 34,133 /y based on the following assumptions: • Household consumption 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 based on following assumptions: • Emission factor for LPG: 63.1tCO2/TJ • Calorific Value of LPG: 46,100 kJ/kg • Household consumption 0.4 kh LPG per day

Table 1.4 below provides the primary targets for technology transfer and diffusion including expected life time, economic benefits and climate change mitigation impacts of sub-technology Waste to ener under of Technology 1.

Table 1.4: Primary targets of Waste to Energy

Technology	Waste to Energy
Primary target	50 tonnes/ day Residue Derived Fuel (RDF) manufacture from Municipal Solid Wastes (MSW) in 2 to 5 years
Expected life time	10 years
Expected economic benefits	Savings of foreign exchange of US$ 2,737,500 /y. This 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 based on the following assumptions: • Emission: 94.6 tCO2/TJ for coal • Calorific Value of coal: 26,000 kJ/kg • 1 kg of RDF = 1 kg of Coal

Table 1.5 below provides the primary targets for technology transfer and diffusion including expected life time, economic benefits and climate change mitigation impacts of sub-technology Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration under Coal of Technology 2.

Table 1.5: Primary 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	100MW of Solar and 100 MW of Wind Penetration in the next 2 to 5 years.
Expected life time	20 years

Expected economic benefits	**1. 100 MW Solar** Foreign exchange saving 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. 2. 100 MW Wind** Foreign exchange saving US$ 23 million /y. This 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 of 58,391 tCO2/y based on the following assumptions: • Emission: 74.1 tCO2/TJ for diesel • Calorific Value of diesel: 40,000 kJ/k • Efficiency of Combined Cycle power plant: 60% • Annual Plant factor of Solar plants: 15%. **2. 100 MW Wind** Mitigation of 97,318 tCO2/y based on 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%.

Table 1.6 below provides the primary targets for technology transfer and diffusion including expected life time, economic benefits and climate change mitigation impacts of sub-technology LED Lighting under Technology 3.

Table 1.6: Primary targets of LED Lighting

Technology	**LED Lighting**
Primary target	1MW of LED Solar in the next 2 to 5 years.
Expected life time	20 years (Average 7 hours of lighting /day)

Expected economic benefits	Annual savings of energy cost: 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 of electricity: Rs. 16 per kWh • Exchange Rate: 1 US$ = Rs.135
Climate Change Mitigation Impacts	Mitigation 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.

Table 1.7 below provides the primary targets for technology transfer and diffusion including expected life time, economic benefits and climate change mitigation impacts of sub-technology Solar Assisted Air Conditioning under Technology 3.

Table 1.7: Primary targets of Solar Assisted Air Conditioning

Technology	Solar Assisted Air Conditioning
Primary target	Reduction in Air Conditioning load by 1MW in the next 2 to 5 years.
Expected life time	20 years
Expected economic benefits	Annual savings of energy cost: Rs. 28.8 million (US$ 210,000). This 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 of 1,404 tCO2/y based on the following assumptions: • Grid Emission Factor:0.78 kgCO2/kSWh • Average operation of Solar Heaters: 300 days/ y; 6 h/day

1.2 Barrier analysis and possible enabling measures for Technology 1: Conversion of Biomass and Waste to Energy

1.2.1 General description of the technology

Following three sub technologies are considered under this technology.

(a) Co-firing Biomass with Coal

(b) Compact Biogas Digester for Urban Households

(c) Waste to Energy ie. Manufacture of Residue Derived Fuel (RDF) from Municipal Solid Waste (MSW)]

1.2.1.1 Co-Firing of Biomass with Coal

The proposed technology is intended to use biomass and coal together as fuels for power generation in coal fired power plants. Although several options are available for co-firing biomass with coal, the following option is recommended in view of the need to minimize the extent of tampering with the existing equipment at a coal fired power plant.

Use a separate biomass boiler to generate steam at the same temperature and pressure as that of the steam produced at the coal boiler. Steam produced in the biomass boiler is connected to a common steam header to drive the existing steam turbines.

Although this method is the most expensive option, it has the following advantages:

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

1.2.1.2 Compact Biogas Digester for Urban Households

Appropriate Rural Technology Institute of Pune, Maharashtra, India (www.arti-india.org) has developed a "Compact Bio Gas Digestor" to resolve issues of the conventional biogas digester. " The volume of this digester is 1.5 m3. It essentially consists of two plastic tanks. The research study carried out by the University of Moratuwa revealed that leaves of Gliricidia is the most effective material to be used for biogas production using this technology. Through this technology an average household could generate adequate biogas to meet the household requirements for cooking.

1.2.1.3 Waste To Energy

The major difficulty encountered when Municipal Solid Waste (MSW) is combusted to generate energy is the production of dioxin (a highly toxic substance). This toxic substance is generated when combusting halogenated plastic materials such as PVC found in the MSW. Use Plasma Gasification Technology is being explored to resolve this issue. However, this process is very capital intensive and incurs high operational costs. Therefore, up to date no such facility has been introduced in Sri Lanka.

In the technology proposed, Municipal Solid Wastes (MSW) is shredded, dried and separated into organic, plastic, paper, etc. While recyclable fractions are diverted, the remaining components are blended in appropriate proportions and compacted into pellets known as Residue Derived Fuel (RDF). These pellets could be used along with coal as fuel in cement kilns. The high temperature resulting from the combustion of coal would crack any dioxins formed from the combustion of halogenated plastics. In addition, the presence of calcium carbonate would absorb any remaining dioxins. It is important to to ensure that pellets manufactured in this process are used only in cement manufacture as

combustion of these pellets in other applications has the potential of environmental pollution. As such these pellets could replace coal in the cement manufacturing industry.

1.2.2 Identification of barriers for the Technology

A total number of ten (10) key barriers have been identified through stakeholder consultations by analyzing causal relations using root cause analysis and market map for Technology 1 b- Biogas Digester for Urban Households (Annex I) supported by review of literature and specialist inputs. These barriers include three (03) economic & financial barriers, one (01) information & awareness, two (02) policy, legal &regulatory, one (01) market failure, two (02) technical and one (01) social, cultural & behavioral barriers.

1.2.2.1 Economic & financial barriers

Following are the three economic & financial barriers identified.:

a) Inadequate awareness on Economic and financial feasibility of the technology

In the absence of fossil fuel deposits in the country, a large share of the foreign exchange earnings is spent on importation of fossil fuels. Conversion of biomass and waste to energy is found to be economically and financially feasible due to the prevailing economic and natural conditions of the country. This has been confirmed by research carried out by the Ministry of Science and Technology[3]. However, in view of inadequacies in dissemination of these research results no energy planning exercise has taken these facts into consideration[4].

b) High capital cost

All equipment and machinery required for the conversion of biomass and waste to energy need to be imported on commercial terms. As only the private sector institutions are expected to get involved in the implementation of these technologies, required finances have to be raised through commercial lending institutions at commercial rates[5]. Moreover, the Government of Sri Lanka has so far not supported such lending facilities with any form of government guarantees. Whereas fossil fuel based energy conversion projects implemented by government institutions obtain necessary finances at very concessionary terms with guarantees provided by the government. In addition, private sector institutions would be compelled to purchase required lands for these projects from private land owners at high prices. Another factor contributing to the high prices for this technology is the high cost of compensation payable to the

[3] CRI, 2008; CRI, 2005

[4] Ministry of Power and Energy, *National Energy Policies and Strategies*, 2005.

[5] Ministry of Power and Energy, *National Energy Policies and Strategies*, 2005.

community to mitigate potential impacts. Another contributory factor for high cost is the government taxes on local fabrications and constructions work carried out under this technology.

c) Difficulty to access finance

Financial institutions such as commercial banks in Sri Lanka are not familiar with biomass and waste based electricity generation projects as these technologies are new to this country. In respect of hydropower, wind power and solar power generation, the government took the initiative of demonstrating the respective technologies by sponsoring the initial projects. In the case of biomass and waste based projects, government has not initiated any such demonstration projects. Moreover, most of the biomass and wastes are generated as a byproduct from agricultural, industrial or municipal activities. Apart from municipal waste, all biomass fuels generated in Sri Lanka comes through out-grower model. As there are only few dedicated energy plantations, there is no guarantee of continuous supply of fuel to the project developers. In addition, these out-growers are likely to increase the price of biomass fuels and they are free to sell the produce to any party offering competitive prices. For these reasons, the commercial banks have not demonstrated a great enthusiasm in providing required finances for biomass or waste based energy conversion projects.

1.2.2.2 Non Financial barries

Information & awareness barriers

(d) Private sector not informed or not invited to participate

In respect of small hydro, wind, biomass based power generation, the electricity utility (Ceylon Electricity Board - CEB) and the state institution facilitating renewable energy projects (Sri Lanka Sustainable Energy Authority – SEA) has formulated and published specific Standardized Power Purchase Tariffs for each of these technologies. However, in respect of the *co-firing biomass with coal* project, neither such information is available nor the private sector has been invited to participate in this venture. No specific tariff has been formulated. If this technology option is promoted by the government, there will be a likelihood of some private sector parties actively participating in this technology.

Policy, legal and regulatory barriers

(e) Externalities of coal firing not internalized

Successive Long Term Electricity Generation Plans prepared by the Ceylon Electricity Board has clearly identified coal as the major source for the generation of electricity for the next few decades. (Figure 1.2: Energy sources for electricity generation 2011-2025)[6].

[6] Depart of National Planning, Introduction of Natural Gas to Meet Energy Needs of Sri Lanka, May 2011.

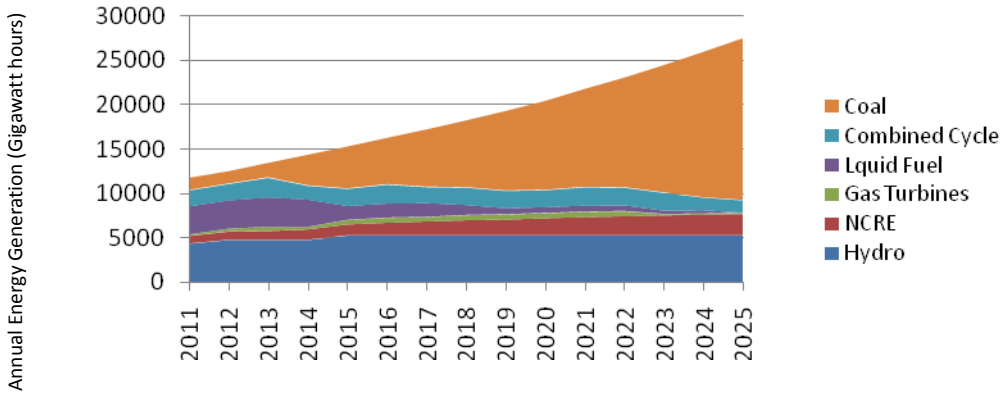

Figure 1.1: Energy sources for electricity generation 2011- 2025

The decision to use coal has been based on financial analysis carried out ignoring all externalities such as the effect on health of the population, damage to the agricultural land etc. If these costs are internalized, then the cost of generation of electricity using biomass would be very close to that of the electricity generated using coal.

Market failure

(f) *Adequate supply of biomass/waste not established*

The cultivation, harvesting, transporting and marketing of biomass fuels in Sri Lanka is carried out mostly in an informal manner. There is no state institution assigned to primarily address the issues of biomass fuels.

Although nearly 25% of the total land area in the country is classified as “Scrub Land”, and such lands remain underutilized, obtaining land for the cultivation of biomass fuels has been very rare[7].

For nearly two years, the price of furnace oil used by the industrial sector has been heavily subsidized by the state. This action resulted in the price of biomass fuels going down below the cost of collection and transport. Many private sector institutions engaged in the business of cultivation, harvesting and transporting biomass fuels have deviated from these activities to alternative ventures yielding better income.

In spite of the fact that cost of labor has been steadily increasing and non availability of required labor, the cultivation and harvesting of biomass fuels have continued to be dependent on manual labor. Mechanized form of cultivation or harvesting is not available Sri Lanka.

In respect of Municipal Solid Wastes (MSW), although the national daily production of MSW is around 2800 tonnes and the daily collection of MSW in the city of Colombo is over 1250 tonnes, access to MSW for energy generation has been very difficult. The bureaucratic process involved in securing the rights to

[7] Asia Pro-Eco Project. Land availability and land tenure. Silva, P. and Jayasinghe, J. August 2005.

use MSW for energy generation has proved to be pervasive. Although the Ministry of Power and Energy and the Sustainable Energy Authority has offered an attractive tariff for electricity generated from MSW, so far no single venture has been materialized.

In view of the above mentioned reasons, the availability of adequate biomass/ waste for energy generation has not been established yet.

Technical barriers

(g) *Technology not established at the scale envisaged (for co-firing and RDF):*

Although biomass has been used in the industrial sector for the generation of heat and steam and a few biomass based electricity generation units up to 10 MW have been established in Sri Lanka, co-firing of biomass and coal for electricity generation has not been demonstrated in the country. Similarly, the use of Municipal Solid Wastes (MSW) to manufacture and use Residue Derived Fuel (RDF) is also yet to be showcased.

As these technologies at the required scale of operation need heavy expenditure, interested parties need to be exposed to such facilities operating in other countries in order to garner confidence.

(h) Technology not fully developed (for Compact biogas digester)

A compact biogas digester developed based on the innovation of ARTI, India (www.arti-india.org) has been introduced to Sri Lanka. However, the technology to produce and market the feed material has not yet been developed. Although Gliricidia leaves are found to posses the desirable qualities to operate a compact biogas digester in an urban household, the technology to dry, powder and market Gliricidia leaf powder at an economically attractive price is yet to be developed. Research institutions too have not recognized the importance and national benefits of this technology. Unless these aspects of the technology are addressed, it would not be practicable to diffuse technology in any meaningful manner.

Social cultural and behavioral barriers

(i) Convenience to and acceptability by consumers not evaluated (for Compact biogas digester):

At present a private company has introduced a compact biogas digester made up of a pair of plastic vessels to be used at household level by utilizing food residues. Although kitchen wastes such as vegetable peelings also can be used as feed material, the use of such materials causes two difficulties. (a) Need to be first macerated using a device such as hand-operated meat mincer prior to feeding the digester. (b) Fibrous materials are slow to digest and take a longer resident time in the digester causing slowing down the digestion process resulting in inadequate gas generation. For the above two reasons, the uptake of this technology is very low.

Research carried out at the University of Moratuwa has shown that Gliricidia leaves in powdered form is a suitable feed material for compact biogas digester. It has been recommended to popularize this initiative by making the powdered Gliricidia leaves available in suitable packs (say in 1 kg packs) at

grocery stores. A housewife would need to feed 2 kgs of such powder per day to generate adequate biogas for cooking all meals required by an average family. However, this concept needs to be tested for consumer acceptability prior to commercialization.

1.2.3 Identified measures

The enabling measures to overcome barriers were identified through stakeholder consultations by using Logical Problem Analysis (LPA) methodology as described in the TNA Guidebook 'Overcoming Barriers to the Transfer and Diffusion of Climate Technologies' (please see Annex I). The measures identified to overcome barriers are given below.

1.2.3.1 Economic and financial measures

Barrier:

(a) Inadequate awareness on Economic and Financial feasibility of the technology

Measure: *Relevant state institutions should conduct feasibility studies and publicize study results.*

In order to address the above barrier, it is recommended that the relevant state institutions such as Ceylon Electricity Board, Sri Lanka Sustainable Energy Authority etc. conduct economic and financial feasibility studies of these technologies and make the study results available to the public and the decision makers. The task of conducting these studies may be entrusted to competent national officials. Technical and financial assistance for these studies may be sought from donor agencies. These studies should address all relevant externalities.

(b) Barrier*: High capital costs*

Measure (i)*: Reduce or eliminate Government taxes on local fabrications and constructions.*

The government imposes a tax on all local fabrications and constructions. Concessions in the form of tax reduction or waivers would be an incentive for easy diffusion of these technologies. The national economic benefits of introduction and propagation of these technologies offset any government revenue loss due to such concessions.

Measure (ii)*: Availability of donor funds on concessionaryterms for these sectors.*

Donor agencies having a mandate to promote these technologies in the developing countries need to consider providing funds to private sector institutions on concessionary terms to access these technologies. Such funding, if necessary, may be channeled through the government treasury and through commercial banks.

(c) Barrier: *Difficulties to access finance*

Measure (i)*: Sustainability Energy Authority (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 for*

Renewable Energy and Energy Efficiency projects.

The Sri Lanka Sustainable Energy Act, No. 35 of 2007 (Article 45) empowers this Authority to impose a cess (the amount to be decided by the Minister in charge and approved by the Parliament) on all fossil fuel products imported and the Article 46 of the Act empowers the Authority to utilize such cess for the purposes of subsidizing renewable energy and energy efficiency projects. Therefore, it is recommended that the Authority consider implementing this provision so as to promote these technologies.

1.2.3.2 Non financial measures

Measures to improve Information & Awareness barriers

(d) Barrier*:* **Private sector not informed or invited to participate**

Measure*: Sri Lanka Sustainable Energy Authority to include "Co-firing" as a technology option for generating electricity for the grid.*

Sri Lanka Sustainable Energy Authority has identified a number of technology options to utilize renewable energy resources for electricity generation. Electricity generated by these processes is to be fed to the national electricity grid and payment made by the Ceylon Electricity Board to the private sector developer who operates such a scheme. A technology dependent (and cost reflective) tariff for each of such technologies have been formulated. Some of these technologies are small hydro, biomass, wind, municipal waste etc. However, the option of co-firing has not been included in this scheme.

It is recommended that the Sri Lanka Sustainable Energy Authority invites the private sector to invest in this technology and operate such facilities. Further, a suitable tariff structure needs to be formulated to attract the participation of the private sector in this technology. As the this technology involves close collaboration with the Ceylon Electricity Board, adequate consultation between the private sector developer and Ceylon Electricity Board is imperative.

Co-firing could be carried out in a number of ways. The proposed technology is to install a separate biomass fired boiler to generate steam at the same temperature and pressure as that generated by the coal fired boiler. Steam generated by the biomass fired boiler could supplement the steam generated by the coal fired boiler. In this manner, least amount of tampering and interference with the coal burning facility would be required. Payment to the developer would be based on the amount (tones) of steam generated and fed into a common header.

Policy, legal and regulatory measures

(e) Barrier*: Externalities of coal firing not internalized.*

Measure: *During generation planning costs of technology options should include internalizing the externalities.*

Only the direct costs perceived by the Ceylon Electricity Board are taken into account during the planning stage for screening technology options for electricity generation. Externalities such as the

impacts on the human health due to particulate emissions, impact on agriculture due to acidification of agricultural land etc. are not included in the "costs" of generation. Costs of these externalities are either borne by the general public or by the government (such as the Department of Health). As these external costs are not considered, electricity generated from coal appears to be very much cheaper than that of renewable sources.

It is recommended that for comparison purposes, the costs of these externalities be included prior to screening the options. As the prices of fossil fuels used by the CEB and the consumer tariffs are controlled by the Treasury, a proper cost analysis incorporating the externalities would enable the Treasury officials to make an informed judgment beneficial to the national economy.

(f) Barrier: *Adequate Biomass/ waste supply not established*

Measure (i): *Underutilized state lands to be made available for multipurpose agro-energy cultivation by private sector.*

Although 25% of the total land area of the country amounting to over 1.6 million ha, remain under utilized[8], access to these lands for the cultivation of multipurpose agro-energy plantations has been denied. Research done by CRI and MOST has demonstrated the technical, financial and ecological sustainability of such agro-energy plantations. Therefore, it is recommended that government makes arrangements with the private sector to provide access to these lands for this purpose, without impinging upon any stipulated land tenure policies of the government.

Measure (ii): *Remove subsidy on fossil fuels.*

During the period from 2010 to 2011, the price of furnace oil sold to industrialists for the generation of heat has been highly subsidized. This subsidy has contributed to drop in the price of biomass fuels. Therefore, the private sector parties invested in biomass fuels production activities have diverted their resources to alternative ventures. Although this subsidy has been removed from early 2011, private sector investors are cautious in re-entering to this sector. However, sale of petroleum fuels for electricity generation remains heavily subsidized. Such subsidies give the wrong impression that the renewable resource based energy generation is more expensive than fossil fuel based generation.

In the case of coal, the legal duties and taxes imposed on imports are not exercised. This again distorts the picture, making it appear that electricity from coal is very cheap. Therefore, it is recommended that the government consider removing subsidies on imported fossil fuels…

Measure (iii): *Municipal Solid Wastes (MSW) to be made available for the manufacture of RDF by the private sector*

It appears that although substantial interest has been expressed by the private sector entrepreneurs for the generation of electricity from MSW, not a single project has made any tangible progress presumably due to lack of access to MSW. As stated in the relevant Technology Fact Sheet, conversion of MSW into

[8] Asia Pro-Eco Project. Land availability and land tenure. Silva, P. and Jayasinghe, J. August 2005.

RDF is a feasible project. If the government makes appropriate arrangements to ensure adequate and uninterrupted supply of MSW, it would be possible to constitute a consortium of private sector parties to invest in this project.

It is therefore recommended that the government creates an enabling environment through appropriate policy decisions to ensure availability of specified quantity of MSW for feasible projects to convert MSW into RDF.

Measures to address technical barriers

(g) Barrier: *Technology not established at the scale envisaged (for co-firing and RDF)*

Measure*: As done for small hydro, wind and solar technologies, the state should take initiatives in demonstrating viability of co-firing and RDF technologies*

As the technologies related to co-firing of biomass with coal and the conversion of MSW into RDF requires high degree of state patronage, it is important that the state sector plays a proactive role in promoting these two interventions. In fact, the state sector needs to demonstrate its commitment by announcing its intention to actively take part in these projects while soliciting the private sector collaboration in promoting these technologies.

(h) Barrier: *Technology not fully developed for compact biogas digester technology to a level of public acceptance*

Measure: *Relevant state institutions to develop and resolve all technical issues related to compact biogas digester.*

The technology to generate biogas from easily biodegradable biomass has been in Sri Lanka for many decades. Biogas digesters of various sizes and shapes have been operating for many years. It is proposed to introduce a compact biogas digester to be used in urban households with suitable feed material to generate adequate biogas to enable meeting the daily energy demand of an average family for cooking. A digester with a capacity of 1000 litres made of a pair of plastic water tanks has already been developed and introduced for using food leftover in households. But the amount of food left over in an average household is inadequate to generate the required amount of gas. Research has revealed that Gliricidia leaf powder is a suitable material to digest anaerobically[9]. However, a mechanism to ensure availability of powdered Gliricidia leaves in user friendly packs (eg. 1 kg bag) to the urban housewives is yet to be materialized.

Research institutions such as the NERD Centre, Universities, particularly UOM, SEA needs to take the initiative in developing a device / machine to produce Gliricidia leaf powder and market the packaged

[9] UOM, 2011, K.W.N. Dilnayana, P.G.Rathnasiri and A.A.P. De Alwis, Nov 2011.

product through grocery stores. It is important that the final price of the powdered Gliricidia leaves should not exceed Rs.25 to be price competitive with LPG.

Social, cultural and behavioral measures

(i) Barrier: *Convenience and acceptability of compact biogas digester by consumers not evaluated:*
Measure: Relevant state institutions should address issues to ensure public acceptance of compact biogas digesters.

The use of biogas to cook meals is not different to the use of LPG for the same purpose. The pressure of the gas in biogas generated in a digester is very much lower than the pressure of LPG. A simple adjustment at the burner would solve this problem. Biogas generated from Gliricidia leaves does not give any unpleasant smell. Hence there will be no resistance from the users on these two issues. However, an urban housewife may be reluctant to feed 2 kg of Gliricidia leaves daily into a digester, particularly, if the digester is kept outside the kitchen. As the price of LPG is continuously increasing, it is very likely that housewives would accept the little hassle of feeding Gliricidia powder into digesters.

This aspect need to be evaluated and appropriate action be taken to ensure that this technology is acceptable to the masses.

1.3 Barrier analysis and possible enabling measures for Technology 2: Smart Grid Technology for Wind, Solar and Small Hydro for Grid Integration

1.3.1 General description of the Technology

The potentials for wind based and solar PV based electricity generation in Sri Lanka are very large. Each of these technologies has the capability of generating many times the total electrical energy presently generated in the country. However, the development of these two technologies to meet grid-based electricity generation has not been satisfactory due to the reluctance on the part of the national electric power supplier due to the frequent and rapid variations in the level of outputs of power plants adopting these technologies. The cost of storing electricity generated by these sources to mitigate the fluctuations in outputs is prohibitively expensive.

Many developed countries have resolved this problem by adjusting the demand of energy in the system and output levels of hydropower plants to match the variations in the outputs of wind and solar PV power plants. Such adjustments are feasible only by incorporating Smart Grid/ Smart Meter technologies.

1.3.2 Identification of barriers for the Technology

A total number of twelve (12) key barriers which comprised of four (04) economical & financial barriers, two (02) information & awareness, one (01) human skills, one (01) institutional, three (03) technical and one (01) policy, legal & regulatory barriers have been identified.

1.3.2.1 Economic and financial barriers

Following are the economic and financial barriers identified:

(a) Non-conventional renewable energy options are perceived more expensive as externalities of conventional technologies are not internalized

Successive Long Term Electricity Generation Plans prepared by the Ceylon Electricity Board has clearly identified coal as the major source for the generation of electricity for the next few decades. The decision to use coal was on financial analysis carried out ignoring all externalities such as the effects on human health, damage to the agricultural land etc. If these costs are internalized, the cost of generation of electricity using non conventional renewable sources would be in par with the cost of electricity generated using coal.

(b) High capital cost

All equipment and machinery required for renewable based electricity generation are imported on commercial terms. Since it is expected of the private sector agencies to get involved in implementing these technologies (Ref. 3: MPE, 2005), these institutions are expected to raise necessary finances through lending institutions on commercial terms. Moreover, the Government is yet to support such borrowings with any form of government guarantees. However, the fossil fuel based energy conversion projects implemented by government institutions are able to secure necessary finances at very concessionary terms under the guarantees provided by the government. In addition, private sector institutions have to rely on individual land owners when land is required for such projects where land costs are prohibitive. High costs of compensation payable to the community to mitigate potential perceived impacts also contribute to the high prices related to this technology. Another reason for the high cost is the government taxes levied on local fabrication and construction activities coming under this technology.

(c) Difficulty to access finance

Renewable energy based electricity generation projects such as wind, solar and small hydro projects require large capital investments. Since the local banks have already committed to many such projects, they appear to be very reluctant to provide further finances for new renewable energy based electricity generation projects.

Another reason for the reluctance of the local banks is that the rate of return from these projects

is much lower than some of the other projects such as tourism or trading. Moreover, the bankers appear to have reluctance to consider project itself as the co-lateral for the loan and insist on immovable property such as land or building as co-lateral.

(d) Economic viability not examined

The economic viability of integrating wind, solar and small hydro power projects with the national grid using smart grid technologies with the view to enhance the share of renewable energy in the energy mix has not been carried out. Hence the utility and developers have an apathy towards investing in these ventures.

1.3.2.2 Non financial barriers

Information and awareness barriers

The following two barriers have been identified under this barrier category;

(e) Related subject matter is not introduced in the formal education sector

The use of smart grid technology to integrate solar, wind and small hydro power projects with the national grid is a new topic in Sri Lanka. Young professionals entering the power sector do not have any previous knowledge of or exposure to this technology. In the absence of this subject being taught at respective formal education institutions, it is incumbent upon them to enhance their knowledge on the subject on their own initiatives.

(f) Technology not freely available

The use of smart grid technology to integrate wind, solar and small hydro power with the national grid is new to many countries in the world. None of the neighboring countries have adopted this technology yet. Even many developed countries have ventured into this field only in the recent past. Hence decision makers in the energy sector appear to have lack of confidence on this technology as it is not widely practiced.

Human skills barriers

Only one barrier has been identified under this category.

(g) Lack of experts in relevant institutions

As this technology is yet to be implemented in Sri Lanka or even in any other neighboring countries, expertise on this technology is not available in the energy sector institutions. Hence initiating projects of this nature would be extremely challenging.

Institutional and organizational capacity barriers

(h) Inadequate weather related information

The weather related information generated by the Department of Meteorology are aimed at catering to the routine forecasting aspects. In order use smart grid technology to integrate wind, solar and small hydro power projects with the national grid, more detailed and accurate data are required. The energy sector needs continuous and very much updated data. Unless the resources of this Department are enhanced such vital information cannot be generated on behalf of the energy sector.

Technical barriers

(i) Weak infrastructure – electricity grid limitations, telecommunication, road and railway networks

The infrastructure facilities in the country need to be strengthened for the introduction of this technology. The existing national electricity grid is not designed to absorb larger share of inputs from locations where such renewable resources are available. Hence the entire national grid needs to be suitably strengthened in order to increase the share of renewable energy in the system. This would entail strengthening the lines, the circuit breaker capacities, protective equipment, substation capacities, reactive power compensators etc.

For the introduction of smart grid technologies, the telecommunication network also needs to be suitably enhanced to enable accessing information very quickly.

Increasing the share of renewable energy in the system would require the construction and operation of new renewable energy based power projects in the locations where these resources are available. This would involve transporting of heavy machinery to these locations. To facilitate these activities, the road and railway networks need to be enhanced.

(j) Complexity of technology

The use of smart grid technology would involve many inter connected issues. At any given instance the rate of total energy generation in the system should be equal to that of the total energy consumed from the system. If this balance is not maintained, the stability of the system would be seriously affected. As there are many generators many more consumers, It requires a complex operational procedure to maintain the required stability in view of the existence of many generators and the consumers operating in tandem. To optimize the contribution from renewable sources in the system, many inter related parameters need to considered and decisions taken to adjust these parameters appropriately.

Introduction of many small renewable energy based generators having constantly fluctuating outputs would greatly increase the complexity of the operations. Personnel presently involved in handling the system are yet to experience such a complicated system. Therefore, this aspect needs to be taken into consideration when introducing this technology.

(k) Poor electricity load profile – high peak for short duration

The daily load profile of the electricity system in Sri Lanka is shown in Figure1. 3 below.

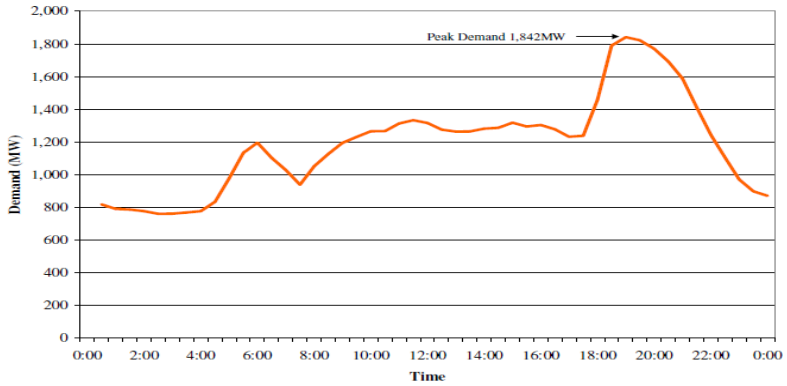

Figure 1.3: Daily load curve of the electricity system in Sri Lanka

There are two important features that should be taken noted of in this regard. Firstly, the problem of the peak needs to be addressed. At around 6 p.m. the demand starts to increase very rapidly where within a short period of 30 to 45 minutes the demand increases from around 1200 MW to over 1800 MW. This high demand does not last long and after around 9 p.m. the demand quickly drops to around 800 MW. The system experiences the highest strain during this period from around 6 p.m. to 9 p.m. All the generating resources in the system are either fully utilized or are kept ready to be able to provide the required energy if the need arises. As the system losses are proportional to the square of the current flowing, the highest system losses are also experienced during this period.

Second problem associated with the daily load profile is the very low load of around 800 MW experienced from around midnight to around 5 a.m. As some of the hydro power plants do not have any storage facility, it is the preferred option to operate the generators at full capacity when the rate of the water is high. Similarly, the outputs of wind power plants cannot be controlled as the output is decided by the wind speed available at any given time. The hydro power plants with storage facility are usually operated by giving priority for irrigation requirements. These restrictions result in partial off loading of large thermal power plants such as the 300 MW coal plants, which is not a desirable feature.
The integration of more and smaller wind power plants into the system would further complicate these problems.

Policy, legal and regulatory barriers:

(I) Inadequate inter agency coordination

In the recent past, some of the land areas earmarked for electricity transmission lines have been declared as Wildlife Protected Areas without adequate prior consultations. Such decisions sans proper consultation and coordination cause serious operational problems to the electricity operators.

Ensuring inter agency coordination would facilitate resolving such issues at the appropriate time.

1.3.3 Identified measures

The identification of required measures to overcome key barriers has been carried out through a stakeholder consultation and by using Logical Problem Analysis (LPA) methodology as described in the TNA Guidebook 'Overcoming Barriers to the Transfer and Diffusion of Climate Technologies'.(please see Annex I). The enabling measures thus identified are given below.

1.3.3.1 Economic and financial measures

(a) Barrier: *Non-conventional renewable energy options are perceived more expensive as externalities of conventional technologies are not internalized*

Measure: *Costs of technology options should include the externalities during generation planning*

When screening technology options at the planning stage only the direct costs perceived by the Ceylon Electricity Board are taken into account. Externalities (indirect costs) such as the impacts on the human health due to particulate emissions, impact on agriculture due to acidification of agricultural land etc. are not integrated into the "costs" of generation. However, costs of this nature are either borne by the general public or by the government (such as the Department of Health). As CEB does not include these costs, electricity generated from coal appears to be very much cheaper than electricity from renewable sources. Therefore, it is recommended that for comparison purposes, the costs of these externalities should be included prior to screening the options. As the prices of fossil fuels used by the CEB and the consumer tariffs are controlled by the Treasury, a proper and logical cost analysis incorporating the indirect costs would enable informed decisions by the Treasury officials on the net benefit to the national economy.

(b) Barrier*: High capital cost*

Measure (i)*: Government taxes on local fabrications and constructions to be reduced or eliminated*

In order to increase the contribution by wind, solar and small hydro projects, the capital costs of these projects needs to be low enough to attract private sector investments in these projects.

One option available for reducing the high capital costs would be for the government to consider providing incentives in the form of reduced or no taxes on the construction and fabrication of these power plants. The government may consider increasing the taxes imposed on fossil fuel based power plants in order to offset the loss of revenue.

Measure (ii): *Donor agencies to consider providing adequate funds on concessionary terms*

Donor agencies having mandate to promote these technologies in the developing countries need to consider providing required funds on concessionary terms to private sector institutions enable accessing these technologies. Such funding, if necessary, may be channeled through the government treasury and through commercial banks.

(c) Barrier: *Difficulty to access finance*

Measure (i)*: Sustainability Energy Authority 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 finances for Renewable Energy and Energy Efficient projects.*

The Sri Lanka Sustainable Energy Act, No. 35 of 2007 (Article 45) empowers this Authority to impose a cess (the amount to be decided by the Minister in charge and approved by the Parliament) on all fossil fuel products imported. Article 46 of the Act empowers the Authority to utilize such proceeds for the purposes of promoting renewable energy and energy efficiency projects.

Measure (ii): *Donor agencies to consider providing adequate funds on concessionary terms.*

Donor agencies having a mandate to promote these technologies in the developing countries need to consider providing funds on concessionary terms to private sector institutions to access these technologies. Such funding, if necessary, may be channeled through the government treasury and through commercial banks.

(d) Barrier*: Economic viability not examined*

Measure (i)*: Relevant state institutions should conduct feasibility studies and publicize study results.*

In order to address this above barrier, it is recommended that the relevant state institutions such as Ceylon Electricity Board, Sri Lanka Sustainable Energy Authority etc. conduct economic and financial feasibility studies of these technologies and make the study findings available to the public and to the decision makers. The task of conducting these studies may be entrusted to competent national officials.

Measure (ii)*: Necessary funds should be provided to conduct such studies.*

Seek technical and financial assistance from the donor community for these studies which should include all relevant externalities of the technology concerned.

1.3.3.2 Non financial measures

Measures to improve Information and awareness

(e) Barrier*: Related subject matter is not introduced in the formal education*

Measure: *Technical Colleges and Universities to include related subject matter in the curricula.*

The smart grid technology is a novel concept in Sri Lanka. Past experiences in the field of hydro and biomass based power generation indicates that the gestation period for a new technology is around 25 years. This is particularly because of the professionals lack early exposure to such technologies in their carrier. Hence the infusion of required knowledge needs to commence along with the technical college or university education.

Therefore, it is recommended that the concept of Smart Grid Technology be introduced into the curricula of the technical colleges and universities.

(f) Barrier *: Technology not freely available*

Measure*: Provide opportunities to the relevant officials for exposure to such technologies*

Currently, Ceylon Electricity Board (CEB) and Lanka Electricity Company (LECO) are the only service providers who could make use of Smart Grid Technologies. Although the smart grid technology has already been introduced in many other countries, it is a totally new concept in Sri Lanka. Hence, the subject of Smart Grid Technologies is yet to be introduced to the officials of these organizations. This barrier related to lack of awareness and knowledge could be addressed through bilateral arrangements with selected countries on a Government to Government basis. Once these officials are equipped with adequate knowledge on these technologies, these institutions would be in a position to explore potential options to implement these technologies.

Measures to improve human skills:

(g) Barrier: *Lack of experts in relevant institutions*

Measure: *Provide required training for officials of relevant institutions.*

This measure is identical to measure proposed under barrier (e) above.

Although already introduced in many other countries, the smart grid technology is a novel concept in Sri Lanka. One of the prior requirements for introducing this technology is to provide an adequate exposure to all relevant officials. This could be arranged through bilateral arrangements with selected countries on a Government to Government basis.

Measures to improve institutional and organizational capacity

(h) Barrier: *Inadequate weather related information*

Measure: *Meteorological Department to be provided with specific instruments and other resources to provide required weather related information to the energy sector.*

The smart grid technology requires accurate weather related information and forecasts on an uninterrupted basis. At present the Meteorological Department in Sri Lanka does not possess the resources required to provide data of this nature. Therefore, the Department of Meteorology needs to be strengthened by providing required hardware, software and skills. As neither the government nor the CEB has the financial capacity to provide these resources, donor assistance be sought to enable accessing these resources.

Measures to address technical barriers

(i) Barrier: *Week infrastructure facilities – Electricity grid limitations, telecommunication, road and railway network.*

Measure: *Provide necessary funds to improve relevant infrastructure facilities.*

Infrastructure facilities such the electricity grid, telecommunication, road and rail network should

be adequately improved as a prerequisite for implementation of this technology. This would entail large capital investments. As the financial position of the CEB is very unsatisfactory at present and the government financing is scarce to for such investments, the donor assistance need to be explored.

(j) Barrier: *Complexity of technology*

Measure: *Provide adequate exposure to relevant officials to get familiarized with these technologies*

Since this technology has many different interlinked components it is generally viewed as a complex one. In order to understand the technology involved, it is necessary to identify individual tasks of the process and provide an exposure to the relevant officials on these components. Most of these tasks have been performed only in some selected countries[10].

It is recommended to identify suitable officials from the CEB and LECO and arrange them to undertake familiarization visits to the countries where this technology is already being implemented.

(k) Barrier: *Poor load profile with high peak for short duration*

Measure: *Modify the load profile by appropriate methods*

The daily electricity load profile in Sri Lanka is awkward in two respects. Firstly, there is a very high peak demand for a short time in the evening and secondly very low demand for over five hours in the early morning hours. During the peak period the resources in the system are fully stretched to ensure uninterrupted supply and also the rate at which the load increases during this period is very steep. This necessitates the need for quick responding power plants. The low demand during the morning hours causes the problem of the need for partly off loading some of the large steam power generators. Large steam power plants are not supposed to subject to rapid change of load on regular basis. This would be a major issue when attempting to integrate small renewable energy technologies such as wind, solar and hydro plants as these small facilities are not able to cope up with the variations in the load. Therefore, it is necessary to find ways to increase the load during the Low Load period and reduce the load during Peak Load period.

Wind, solar and small run-off-the-river hydro power plants have the inherent weakness of their inability to provide steady and predictable outputs. For this reason, this type of plants is called “non-dispatchable” power plants as the system operator is not in a position to demand a specific output from these plants at any given time. When the share of such plants increases, it becomes more and more difficult for the system operator to balance energy generation with the demand. In the event of the non-dispatchable plant begins to reduce the output during peak time, the system operator would be in a precarious situation as he needs to increase the output from other power plants, which may be already at their maximum output levels.

[10] IEA, Wind Task 24, 2011

During the low demand period, the system operator would like to reduce the output of as many plants as possible because some of the power plants such as hydro power plants attached to irrigation schemes are not allowed to reduce their outputs as irrigation water need to be supplied at the desired level. During this low demand period, as the outputs of non-despatchable plants cannot be reduced, the system operator is compelled to reduce the outputs of large steam power plants by acting contrary to the manufacturers' recommendations.

Hence it is essential to manage to load profile of the system in such a manner that the demand during peak time is reduced (peak lopping) and increase the demand during off-peak time (trough filling).

Measure (i)*: Appropriate time based tariffs with appropriate meters.*

One effective method of achieving this objective is through market based tariff system. Under this scheme, the price of electricity consumed during high demand period (peak time) is much higher than electricity consumed during low demand period (off-peak time). Therefore, the electricity meters are designed to record the amount of electricity consumed during these specific periods separately.

In few countries this scheme is being implemented successfully with smart grid and smart meters to selected consumers who will permit the system operator to shut down some of their non-critical loads.

Consumers coming under these schemes are discouraged the use of electricity during peak times and encouraged to use more electricity during off-peak times. The introduction of electric vehicles with the provision with concessionary tariff during off-peak time would encourage electric vehicle owners to charge their vehicles during off-peak times.

Measure (ii): *Impose regulations to reduce electricity load during peak time.*

In addition to market based mechanism, it is possible to change the load profile in a favorable manner through regulatory mechanism. One option would be to to prevent the operation of TV transmission during peak time. It will be useful for the government to declare the peak time period of 6.30 p.m to 9.30. p.m as "Religious / Educational" time. To facilitate the practice of meditation/ prayer for those inclined to do so and for school children to concentrate on their home work, all TV transmission stations could be prohibited from operating their services. Moreover, places of entertainment such as cinema theaters, night clubs, casinos, bars where alcohol is consumed could be prohibited from operating during peak times. This action would be in line with the government policy of "Mathata Thitha" – Stop to Alcoholism.

Policy, legal and regulatory measures

(I) Barrier: *Inadequate inter agency coordination*

Measure: *Strengthening the inter agency coordination*

There had been instances where authorities have declared certain areas as national reserves without any prior consultations with stakeholders. Thus areas earmarked for transmission lines and substations have been declared as national reserves. Actions of this nature would be detrimental for wind, solar and small hydro power development. Therefore, it is recommended that such declaration be carried out with

proper prior consultations to avoid costly relocation of power plants/ transmission lines and substations.

1.4 Barrier analysis and possible enabling measures for Technology 3: Building Management Systems

1.4.1 General Description of the Technology

Following two sub technologies are considered under this technology option;

(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 generally 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 the amount of non-visible radiation they emit. LED surgical task lights 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 catastrophically (sudden and 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. The U.S. Food and Drug Administration (FDA), which grant marketing clearance for medical devices, has issued product testing guidance in 1998 for surgical task lights.

(b) Solar Assisted Air Conditioning

The Solar Assisted Air Conditioning system is a system that utilizes the sun as a heat source to assist the energy needed to drive the cooling process of a typical air conditioning system which in turn reduces the electrical consumption required to run the compressor.

Solar Assisted air conditioner saves up to 30 -50 % of electricity. It has wide target market including hotels, restaurants, hospitals, factory, school, convention centre 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% energy saving if conventional AC unit is replaced by solar assisted AC. The saving of energy is about 6,785,100,000 kWh/year.

1.4.2 Identification of barriers for the Technology

A total number of ten (10) key barriers have been identified through stakeholder consultations and by analyzing causal relations using root cause analysis and market maps for technologies. In addition, the identification process has been supplemented by literature reviews and expert inputs. The barriers are comprised of include four (04) economic & financial, three (03) information & awareness, one (01) human skills and two (02) technical barriers.

1.4.2.1 Economic and financial barriers

(a) High capital cost

The two sub technologies identified under this main technology group (ie. LED Lighting and Solar Assisted Air Conditioning) are relatively new technological advancements. As such the capital costs involved with these items are very high all over the world including Sri Lanka. The situation in Sri Lanka has further complicated by the recent rapid depreciation of local currency and the heavy taxes levied on local fabrications and constructions.

(b) Difficulty to access finance

Unlike a Renewable Energy project or a large Energy Efficiency project, the technologies covered in this category are essentially consumer goods. Unlike common consumer capital goods like TV or refrigerator, LED Lights or Solar Assisted Air Conditioners are not sold on hire purchase or credit schemes thereby owners of homes, buildings, factories etc. are compelled to raise their funds on their own to purchase equipment.

(c) Economic viability not examined

The economic viability of LED Lighting and Solar Assisted Air Conditioning has not been assessed. As these equipments are relatively expensive and the economic viabilities of these technologies have not been well established, the prospective consumers are reluctant to make investments in these ventures.

(d) Consumers pay below marginal cost of generation

The electricity tariff for the household sector is not based on market conditions but is based on social and political considerations. The householder is primarily responsible for the evening peak load. During the peak load the utility uses generators with the most expensive operating cost, primarily diesoline based gas turbines. Hence the marginal cost of energy consumed by the lighting loads in households is very high. However, the household consumers are charged well below the average cost of generation. Hence ordinary households have no compulsion to adopt energy efficient technologies.

1.4.2.2 Non financial barriers

Information and Awareness barriers

(e) Concept is not integrated into the formal education system

The concept of Solar Assisted Air Conditioning or LED Lighting is not integrated into the study curricula of Universities and Technical Colleges. Therefore, young professionals entering this sector do not possess any knowledge on this technology. In the absence of adequate knowledge among the professionals, there is the general industry apathy in promoting such advanced technologies in the market.

(f) Non accessibility to latest information.

Latest information on these technologies is not available in the public domain. Since this is being a new technology, professionals lack confidence in recommending the technologies due to inadequate information available.

(g) Technology not freely available

These two technologies are new to many countries in the world. None of the neighboring countries have adopted this technology as yet. Even many developed countries have started venturing into this field only in the recent past. Hence decision makers in this sector are reluctant to accept this technology as it is not freely available.

Human skills barriers

(h) Lack of technicians to maintain equipment

This technology being a relatively new innovation, the country lacks qualified trained technicians for equipment maintenance. Hence the technology will be less attractive to the ordinary customer.

Technical barriers

(i) Expected life time of LED lamps not assured

LED lamps claimed to have a life time of 50,000 hours (nearly 100 years assuming usage of 3 hours per day). The price tag for LED lamps are based on this claim. But in practice, there are no ways of verifying this claim. Hence the public intends to buy this item have to assume a much shorter lifetime.

(j) Lack of certification

As the price payable by the public for these technologies are relatively very high, the public expects some state institution to provide a quality assurance on the performance of the equipment.

1.4.3 Identified measures

The required measures to overcome key barriers have been identified through a stakeholder consultation and by using Logical Problem Analysis (LPA) methodology as described in the TNA Guidebook 'Overcoming Barriers to the Transfer and Diffusion of Climate Technologies' (please see Annex I).
The enabling measures identified to overcome barriers are given below.

1.4.3.1 Economic and financial measures

(a) Barrier*: High capital cost*

Measure (i)*: Consider reduction or elimination of Government taxes on local fabrications and constructions*

In order to facilitate introduction of these technologies, the capital investment costs should be low enough to attract private sector investors in project implementation. One option for reducing the high investment costs would be for the government to consider reducing or elimination of the taxes imposed on local fabrication and construction of these power generation facilities. The government may increase the taxes imposed on fossil fuel based power plants as a means of offsetting the loss of revenue.

Measure (ii): *Availability of donor funding on concessionary terms.*

Donor agencies having a mandate to promote these technologies in the developing countries may consider providing funds on concessionary terms such as low interest to the private sector institutions to access these technologies. Such funding, if necessary, may be channeled through the government treasury and through commercial banks.

(b) Barrier: *Difficulty to access finance*

Measure (i)*: Sustainability Energy Authority 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 for Energy Efficiency projects.*

The Sri Lanka Sustainable Energy Act, No. 35 of 2007 (Article 45) empowers this Authority to impose a cess (the amount to be decided by the Minister in charge and approved by the Parliament) on all fossil fuel products imported. Article 46 of the Act empowers the Authority to utilize such proceeds for the purpose of subsidizing renewable energy and energy efficiency projects,
It is recommended that this provision in the Act be implemented so as to promote the proposed technologies.

Measure (ii): *Availability of donor funding on concessionary terms.*

Donor agencies having a mandate to promote these technologies in the developing countries may consider providing funds on concessionary terms such as low interest to private sector institutions to access these technologies. Such funding, if necessary, may be channeled through the

government treasury and through commercial banks.

(c) Barrier: *Economic viability not examined*

Measure (i)*: Feasibility studies by the relevant state institutions and dissemination of study results to the general public.*

It is recommended that the relevant State institutions such as Sri Lanka Sustainable Energy Authority conduct economic and financial feasibility studies of these technologies and make the study results available to the public and the decision makers. The task of conducting these studies may be entrusted to competent national personnel.

Measure (ii): *Ensure availability of required funds to conduct such studies.*

Explore donor assistance in the form of technical and financial assistance for these studies. These studies should include all relevant externalities.

(d) Barrier: *Consumers pay below marginal cost of generation :*

Measures: *Revise householder tariff while keeping marginal cost as the baseline and provide relief only to targeted consumers.*

The present structure of the electricity consumer tariff and the subsidy granted to the CEB with respect to fossil fuels appear to be irrational and unsustainable. For sustainability of the industry, the tariff should be based on marginal cost of generation, transmission and distribution to a specific location at a specific time. This may be too complicated and may not be politically appealing in a country like Sri Lanka. However, as a compromise the consumer may be charged on a cost based tariff while considering relief to selected consumers who need such assistance.

1.4.3.2 Non financial measures

Measures to improve information and awareness

There are three barriers under this category.

(e) Barrier*: Subject matter is not integrated into the formal education curricula*

Measure*: Technical Colleges and Universities should include these topics in the curricula.*

These technologies are totally new to Sri Lanka and students are not exposed to related subject matter either in the Universities or Technical Colleges. Unless the professionals are adequately equipped with the relevant subject matter, promotion of the technology will become extremely difficult. Therefore, it is recommended that these technologies are integrated into the relevant study curricula of the Technical Colleges and Universities.

(f) Barrier: *Inadequate access to test information*

Measure: *Update information through appropriate media*

In view of these technologies are relatively new to the energy generation industry, accessibility to all

relevant information on the technology and its advancements need to be improved through appropriate media.

(g) Barrier: *Technology not freely available*
Measure: *Provide publicity through appropriate media.*
As the proposed technologies are being considered as latest technological innovations, adequate public awareness need to be created through appropriate means.

Measures to improve human skills

(h) Barrier: **Lack of technicians to maintain solar assisted A/C equipment**
Measure*: Train technicians at state owned technical and vocational training institutions.*
Prior to the introduction of this new technology, action should be taken to train required technicians in the state vocational training institutions on the maintenance of the equipment.

Measures to address technical barriers:

There are two barriers in this category.

(i) Barrier*: Expected life time of LED lamps not assured*
Measure*: Introduce legislations to ensure compliance with manufacturers' warranty by the retailers.*
LED lamps are claimed to have a lifetime of over 50,000 hours. Thus, on an average of 3 hours per day, a LED light should last over 50 years. As the public has been given this assurance by the manufacturers, it should be made mandatory upon the vendors to appropriately compensate the public in the event a lamp fails within the specified guarantee period.

(j) Barrier*: Lack of certification*
Measure*: Introduce quality certification by testing under more rigorous conditions*
An appropriate methodology needs to be developed to test samples of lamps under more stringent conditions with the view to judge the estimated life time of the lamps. The testing institution shall be required to introduce a suitable quality assurance scheme based on such test results.

1.5 Linkages of the barriers identified

Although the nature of the technologies varies from one another, some barriers have commonalities irrespective of the type of technology. Such barriers are designated as broader or common barrier. Such linked barriers are discussed below.

1.5.1 High capital cost and difficulties in accessing finance

High capital costs and difficulties in accessing required finance will be the most significant barrier common to all the renewable energy and energy efficient projects in the country. A number of factors that contribute to high capital costs has been identified and these factor include *inter alia* government taxes on local fabrications and constructions and recent steady depreciation of Sri Lankan Rupee resulting in escalation of prices of imports.

Difficulties in accessing finance for these projects are mainly due to saturation of lending portfolios of the banks in the energy sector. Hence the banks are keen in diversifying into other lucrative sectors such as tourism where the return on investment is much higher. The reluctance of the banks to get involved in biomass and wastes based energy projects appears to be due to the uncertainty of fuel supply and price stability.

These two dual barriers could be resolved by appropriate policy interventions including policy reforms and implementation of existing provisions. As the country at present is generating over 60% of the electrical energy using imported petroleum fuels, which in turn is sold to CEB at a huge subsidy, the government is due to benefit in the long term by lowering or removing the taxes as an incentive to promote energy production based on renewable sources for obvious reasons. The SEA could assist in generating funds needed for renewable energy development and energy efficient projects by imposing a cess on all imported fossil fuels as provided in the SEA Act. Funds so collected could be given for these projects at low interest sans external collaterals.

1.5.2 Economic feasibility not properly assessed

This barrier is common to the sub projects of (a) Co-firing of biomass with coal, (b) conversion of MSW into RDF, (c) compact biogas digester for urban households, (d) smart grid technology and (e) use of LED for task lighting and for the solar assisted air conditioning projects. The feasibility studies related to these technologies need to address the issues related to: (1) Externalities of all alternatives (2) Subsidies granted for fossil fuel based electricity generation. (3) Cross subsidies built into the tariffs applicable to various consumer types (4) Groth prospects under no subsidy scenario in electricity marketing

It is recommended that a team of economists/ engineers be assigned to conduct this study in a transparent manner in consultation with relevant stakeholders. The results of the feasibility studies should be made available to the information of the general public.

1.5.3 Technology not established at the proposed scale or technology not fully developed.

This barrier is applicable to the technologies of: (a) Co-firing of biomass with coal, (b) Manufacture of RDF from MSW, (c) Compact biogas digester for urban household and (d) Smart grid technology.
Co-firing of biomass with coal and the manufacture of RDF from MSW is practiced in large scale in many parts of the world. Efforts be made to get the local officials familiarized with the technology by undertaking visits to these sites. The compact biogas digester for urban households needs further R&D activities with regard to commercializing production and marketing of Gliricidia leaf power in the form acceptable for urban housewives. The smart grid technology is being practiced in a few countries such as Norway, Finland, Netherlands and Canada etc. Familiarization visits to these countries would enable appreciating and assessing the merits of the technology.

1.6 Enabling framework for overcoming the barriers in the Sector

Common barriers and their enabling framework:
The common barriers already identified can be broadly categorized into: (1) High capital cost and difficulties to access finance, (2) economic feasibility not properly assessed and (3) technology not established at the proposed scale or technology not fully developed.
The enabling framework for the common barriers is given under Table 1.8 below;

Table 1.8: The enabling framework for the common barriers

No	Broad/common barriers	Enabling framework	Technology
1.	High capital cost and difficulties to access finance	**(i)** Consider reducing or removing all taxes on local fabrications and constructions in respect of Renewable Energy and Energy Efficiency projects. **(ii)** Implement the provision in the SEA ACT towards creating a Fund for Renewable Energy and Energy Efficiency development by imposing a cess on all imported fossil fuels. (The quantum of this levy should not significantly affect the other sectors of the economy)	1(a), 1(b), 1(c), 2, 3(a) and 3(b).
2.	Economic feasibility not properly assessed	Assign a team of economists and engineers to conduct economic feasibility studies on relevant Renewable Energy and Energy Efficiency projects and publicize the study results.	1(a), 1 (c), 2, 3 (a) and 3 (b)

3.	Technology not established at the proposed scale or technology not fully developed.	(i) Commercialize the production and marketing of Glricidia leaves through R&D activities. (ii) Expose local officials to get familiarized with the relevant technologies already being practiced in other countries.	1 (a),1(b), 1(c), 2 and 3(b)

Enabling framework for common barriers in detail:

(1) Consider reducing or removing all taxes on local fabrications and constructions for Renewable Energy and Energy Efficiency projects.

The main reason for the slow p[progress in undertaking Renewable Energy and Energy Efficiency projects in Sri Lanka is the high capital cost due to the taxes imposed on local fabrications and constructions. Removal 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 national expenditure on the imports of fossil fuels leading to significant foreign exchange savings to the government. .

(2) Create a Fund for Renewable Energy and Energy Efficiency by imposing a tax (cess) on all imported fossil fuels as provided by the SEA Act.

Another major reason for the slow development of Renewable Energy and Energy Efficiency sector in the country is the general reluctance of local banks in providing credit facilities for these projects. This constraint could be overcome by establishing a special fund to provide finances at concessionary terms to the project developers. The Sri Lanka Sustainable Energy Act, No. 35 of 2007 empowers the SEA to create a fund to support projects of this nature by raising the necessary capital by imposing a cess on all fossil fuels imported into the country. A significant amount of funds could be generated to facilitate promoting these technologies by implementing these provisions of the Act.

(3) Assign a team of economists and engineers to assess economic feasibility of relevant Renewable Energy and Energy Efficiency projects.

Economic feasibility studies have not been done for some of the Renewable Energy and Energy Efficiency projects identified under this TNA. Such feasibility studies would facilitate informed decisions by the responsible authorities towards implementing such projects. As there are many issues that need to be considered in a feasibility study of this nature, a team of experts consisting of economists and engineers should be constituted to undertake this study. The study findings should be made available to the potential private sector investors.

(4) R & D activities to commercialize production and marketing of Glricidia leaves for urban households.

The production and marketing of Gliricidia leaves have not reached a commercial status for the viability of Compact Biogas Digester for Urban Households. Therefore, this intervention requires

further R&D activities. NERD Centre and the relevant Universities could be involved in such R & D activities.. It is important to develop a technology to produce powder from Gliricidia leaves so as to facilitate the bacterial fermentation and user friendly. The research should ensure that the cost of producing Gliricidia leaf powder is kept within comfortable limits of the potential customer. An average family consumes 12.5 kg of LPG per month for cooking and this works out to 400 grams of LPG a day. At current prices, the LPG costs over Rs. 75 per day (Cost of LPG cylinder is SL Rs 2400.00). Research studies indicate that 2 kg of dry Gliricidia leaves are required to generate the equivalent of 400 grams of LPG. Hence it is preferable that the total cost of production of biogas is kept below Rs. 75 per day.

(5) Expose local officials to get familiarized to the technologies already being adopted in other countries.

The energy sector stakeholders are of the view that the local officials are not familiar with some of the technologies proposed and suggested actions for familiarization programs through study visits to the countries where relevant technologies already being implemented.

CHAPTER 2

TRANSPORT SECTOR

Transport sector is a major greenhouse gas (GHG) emitting sector in Sri Lanka. About 60 percent of air pollution (especially in Colombo City) comes from the transport sector[11]. The main mode of transportation is through the existing road network, which is supplemented by rail, air, and water transportation. Road transport accounts for about 96% passenger and 99 percent of freight transportation. Contribution by the railways is about 4% percent passenger and 1% freight transport. Currently, the transport sector in Sri Lanka utilizes petroleum fossil fuels *(LPG, Gasoline and Diesel, Coal, Aviation Gasoline, Aviation Turbine and Fuel Oil)* leading to significant amounts of carbon dioxide (CO_2) and other GHG emissions (N_2O, CH_4, CO, NO_X, NMVOC and SO_2).

In Sri Lanka, the transport sector contributes to 27% of the total GHG emissions in the country. The total CO_2 equivalent emissions from transport sector in the year 2000 was 5,084 $GgCO_{2Eq}$. According to the national greenhouse gas inventory, CO_2 accounts for more than 95% of the transport related emissions[12] 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. Therefore, the transport sector has been identified as a priority sector for climate change mitigation towards exploring cleaner technologies for the transport sector.

Process of identifying barriers

Although potent technologies have been identified and prioritized for the transport sector during the Technology Needs Assessment (TNA) stage, yet there are barriers to overcome to enable meeting the objectives of technology transfer and diffusion. Therefore, the barrier analysis has been carried out through stakeholder consultations (see Annex II) supplemented by literature reviews and expert inputs. The barriers thus identified were prioritized and ranked according to their significance followed by hierarchical classification and analysis of causal relationship between barriers.

2.1 Preliminary targets for technology transfer and diffusion

The Technology Needs Assessment (TNA) has identified the following three technologies in their order of priority.

(1) Integration of Non- motorized transport methods with regularized public transport system,

(2) Carpooling and park-and-ride systems

[11] Air MAC, 2009. Clean Air 2015, Air Resource Management Centre, Ministry of Environment & Natural Resources

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

(3) Electrification of the existing railway system.

The categorization of these technologies is given in Table 2.1.

Table 2.1: Categorization of the prioritized technologies – Transport Sector

No.	List of Prioritized Technology	Category of the Technology
1.	Integration of Non- motorized transport methods with regularized public transport system,	Publicly provided goods
2.	Carpooling and park-and-ride systems	Publicly provided goods
3.	Electrification of the existing railway system	Publicly provided goods

The technologies have been prioritized with the view to improve economic and environmental benefits while targeting a better transport system to help reducing traffic congestion and delays due to large number of low occupancy vehicles and promote use of public and non-motorized transportation. In order to achieve these targets at least in some parts of the country in a sustainable manner, a proper mechanism for technology deployment and diffusion is required.

Suburban areas of Colombo District with heavy traffic will be targeted to promote non-motorized transport while carpooling and park-and-ride initiative will initially target commuters from two or three remote cities in Gampaha or Colombo District. The current length of the railway network of Sri Lanka is 1447 km (Ministry of Transport, 2012). Initially, electrification is proposed for only about 5 percent of this length.

So far none of these prioritized technologies have been implemented due to several constraints including some inherent barriers which need to be overcome for successful implementation of the proposed technologies. Hence identification of significant barriers that will impact upon successful implementation of the technologies is imperative. Therefore a barrier analysis along with the identification of enabling measures has been undertaken through expert and stakeholder consultations.

2.2 Barrier analysis and possible enabling measures for Technology 1: Integration of non-motorized transport methods with regularized public transport system

2.2.1. General description of the Technology

The main mode of transportation in Sri Lanka is through the road network, which is supplemented by rail, air, and water transport means. Of the passenger transport, buses contribute to about 50% and railways about 4%, while the rest of the passengers are carried by other means. Road transport accounts for

about 96% of passenger transportation and 99% of freight transportation[13]. Currently, the transport sector in Sri Lanka utilizes petroleum-based fossil fuels, resulting in significant amounts of CO_2 and other GHG emissions (e.g. N_2O, CH_4). The total CO_2 equivalent emission from transport sector of Sri Lanka in year 2000 has been 5,084 $GgCO_{2Eq}$[14].

With the increased fleet of vehicles on the road, there is an urgent need for reduction of congestion, especially during peak hours and at city centers. One way of resolving this issue is to promote more public transportation, in conjunction with non-motorized transportation, especially walking and bicycling in congested areas and city centers. Currently, bicycling has become a risky mode of transport, especially due to reckless driving. Therefore, initial focus needs to be placed on strict enforcement of road rules, in addition to promoting walking as a better mode of non-motorized transport by improving pedestrian facilities.

Thus provision of pedestrian walkways, sidewalks, and overhead pedestrian bridges, and proper electronic signaling and warning signposts at pedestrian crossings, etc., will be promoted under these technological interventions . As the non-motorized means could serve as access modes for public transport, promoting non-motorized transport also would help increased use of the public transportation. However, since non-motorized transport could sometimes reduce the speed of travel, provision of regular public transport will be important for proper time planning and to yield optimum benefits from the combined public and non-motorized transportation. Non-motorized transport adds green benefits including the reduction of greenhouse gas emissions and overall pollution, while improving the human health.

Since this technology hardly has the properties associated with any market goods[15] and also contributes to providing benefits to general public, it is considered under the category of publicly provided goods.

2.2.2. Identification of barriers of the Technology

A total number of ten (10) key barriers have been identified through a stakeholder consultation and by analyzing causal relations using root cause analysis supplemented by literature reviews and expert inputs. The key barriers classified into hierarchical categories which include one (01) economic & financial barrier, one (01) policy, legal & regulatory, four (04) social, cultural & behavioral, and four (04) "Other" barriers.

2.2.2.1 Economic and financial barriers

a) Lack of finances

[13] Jayaweera, 2011

[14] ME, 2011, Second National Communication on Climate Change in Sri Lanka

[15] Boldt et al., 2012

Lack of finances is identified as a key barrier affecting the implementation of this echnology. As a developing country, Sri Lanka is faced with budgetary limitations for publicly provided goods, and some of the development and economic targets in the country have been achieved through donor funding such as from the World Bank, Asian Development Bank (ADB), other foreign assistance and public-private partnerships. Lack of finances to improve the existing infrastructure and promote non-motorized transport needs is a key obstacle that needs to be overcome for the sustainability of the technology.

2.2.2.2 Non financial barriers

Following from Boldt et al. (2012), several categories of barriers were considered under non-financial barriers for implementation of non- motorized transport methods along with regularized public transport system. These categories included Policy, legal, and regulatory barriers, Social, cultural, and behavioral barriers, and other barriers.

Policy, legal, and regulatory barriers

b) Poor attention and concern in the national policy and legislation towards pedestrians compared to motorized vehicles

A national policy commitment is critical for promoting non-motorized transport in the country. Motor Traffic Act, Draft National Transport Policy, and Clean Air 2015 are the existing main policy and legislations related to the transport sector. Motor Traffic Act deals only with motor vehicles and their use on highways Although non-motorized transport is listed as a sub sector in the Draft National Transport Policy, it mostly deals with certain planned action for bicyclists, and focus on pedestrians is limited to providing separate infrastructure facilities for pedestrians on selected urban roads and designated regional roads. Though popularization of bicycling is recognized as a need, proper implementation of existing road rules is an essential prerequisite as the existing bike lanes are mostly occupied by motor bicycles and 3-wheelers.

The Clean Air 2015 also does not recognize the need for improving non-motorized transport as a means of greening the air, though it focuses mostly on cutting down emissions from the existing modes of motorized transport.

Social, cultural, and behavioral barriers

The following are recognized as key barriers under Social, cultural, and behavioral category:

c) Low tendency towards non-motorized transport due to lack of road safety, especially on roads with heavy traffic.

Road safety has been a great concern in Sri Lanka during the last few years due to heavy volume of vehicles per road segment, lack of safe pedestrian facilities, reckless driving, and low respect to pedestrian rights. Road accidents and deaths of pedestrians are reported daily. Crossing the road

at the designated yellow lines that are meant especially for pedestrians has become a threat, as some of the pedestrian killings have occurred at such places, due to lack of concern and respect to pedestrians. During the first quarter of 2011, 1283 accidents had been reported in the Western Province alone, due to the failure of the motorists to stop at pedestrian crossings; the highest number was reported in February 2011 with 513 accidents[16]. The death toll of pedestrians due to road accidents is still on the rise, and walking has become a risky activity, especially on congested roads with no proper sidewalks.

d) Initial unwillingness to move back to non-motorized transportation by the public. Importation and purchase of motor vehicles have increased during the past few years, as vehicles have became more affordable due to recent reduction of vehicle importation taxes. The current trend has been to move from mass or non-motorized transport to personal vehicles, and not vice versa. Lack of a regularized, convenient public transport system has also been a recurring issue over many decades.

e) Perception of non-motorized transportation as a primitive method.

Non-motorized transport was the traditional way of transport for majority of the people during the early part of the last century, and currently it is still not uncommon in rural areas of Sri Lanka. Due to increased tendency towards owning a private vehicle, some people have a wrong perception that using public or non-motorized ways of transport is primitive in a more technology oriented society. This societal trend has been a barrier in promoting walking and bicycling, especially in urban areas, where promoting non-motorized transportation is mostly needed due to various issues related to traffic congestion.

f) Lack of awareness among the general public and poor enforcement of road rules.

Although there are some pedestrian and bicycle friendly road rules existing in the country, there is lack of awareness among the general public on such provisions. Overall there is poor enforcement of road rules, especially those related to non-motorized transport. Although there are bike lanes on certain main roads, these lanes are mostly used by motor bicycles or three-wheelers, hardly leaving any space for bicyclists. Currently there are random checks by the police on road rule violators with regard to speeding and lane crossing, etc.; however, it does not occur on a regular basis, and violation of the road rules continues unabated. Therefore strict law enforcement for violating the rights of pedestrians and bicyclists is a timely need.

Other barriers

g) No easy access to non-motorized transport facilities from the terminus of public transport.

Availability of walkways and flyover bridges located close to the final destinations of public transportation could facilitate smooth movement of pedestrians. Although the public transport terminals in certain metropolises have direct access to walkways or sidewalks, there are hardly any such pedestrian facilities

[16] Thambiah, 2011

available at most other places. Therefore lack of pedestrian facilities directly from the final destination of public transport mode is considered a barrier for promoting non-motorized transportation.

h) Non availability of adequate space to develop sidewalks and walkways.

Certain barriers are interconnected. One reason for lacking pedestrian facilities in the metropolises could be unavailability of unoccupied land for acquisition for developing infrastructure such as sidewalks and walkways. Some roads in Sri Lanka are narrow in width (less than 6 m) and no further space is available for developing shoulders or sidewalks, and this has also adversely affected the road safety of pedestrians.

i) Lack of proper sidewalks and walkways.

Even though there are sidewalks and walkways on some roads, pedestrian safety has been an issue due to no proper paving or fencing and sometimes too narrow and located close to the moving traffic. Even though there are some walking spaces available close to main supermarkets, etc., often such facilities are being occupied by motor bicycles, three wheelers, and other utility vehicles thereby increasing the risk for pedestrians.

j) Lack of proper road furniture.

In Sri Lanka, pedestrian crossings are mostly marked with yellow lines on the road. However, some of those are hardly visible from distance especially at night. If there are no traffic signals at the pedestrian crossing, the zebra crossings are hardly visible at night when there are no street lamps. Therefore having proper road signage to indicate the pedestrian crossings is an immediate need, especially in view of the common occurrence of road accidents on the crossings.

2.2.3 Identified measures

Identification of appropriate measures to overcome the barriers has done through a stakeholder consultation along with Logical Problem Analysis (LPA) methodology and expert inputs. (please see Annex I). The enabling measures thus identified are discussed below

2.2.3.1 Economic and financial measures

a) Barrier: *Lack of finances*

Measure: Adequate financing from domestic *or donor sources.*

The highlights of the recent developments in the transport sector has been the expansion of the road network in the country through the development of major highways such as Colombo-Katunayake expressway, Outer Circular Highway, and Colombo-Matara expressway. Some of such infrastructure developments including rail transport have been undertaken with domestic and bilateral and multilateral funding sources including the World Bank, ADB, Japan, China, Korea, Kuwait, India and few other

bilateral sources. The improvement of provincial and rural road network has been mostly done through National Budget supports. Feasibility of having alternative financial mechanisms such as public private partnerships (PPPs) has also been explored for the construction work of certain roads (Department of National Planning, 2010).

Adequate financing from the government or donors has been identified as the key measure yp overcome the financial barrier for promoting non-motorized transport along with regularized public transport. It is also recommended that, all new road constructions and rehabilitation projects ned to consider increasing the investments to accommodate the pedestrian facilities.

2.2.3.2 Non-financial measures

Policy, legal, and regulatory measures

b) Barrier: *Poor attention and concern in the national policy and legislation towards pedestrians compared to motorized vehicles.*

Measure: *National policy and legal reforms to recognize the need for developing pedestrian and other non-motorized transport facilities as a matter of priority.*

Appropriate policy and legal reforms is considered essential to provide due recognition to the rights of the pedestrians and non motorized vehicle users. Therefore, appropriate amendments are required to be introduced to the existing transport related policies and legislations. All reforms will be required to address the need for ensuring safety of pedestrians and bicyclists while providing suitable punitive provisions against the violators

Social, cultural, and behavioral measures

The following measures are proposed to overcome the social, cultural, and behavioral barriers;

c) Barrier: *Low tendency towards non-motorized transport due to lack of road safety, especially on roads with heavy traffic.*

Measure: *Improvement of road discipline through law enforcement and by other means and increase awareness among road users.*

This is measure is aimed at increasing the interest for non-motorized transport by improving road safety, especially on roads with heavy traffic. Driver training and awareness programs for both drivers and pedestrians, and other stakeholders including the traffic police officers are proposed to ensure road discipline. This will also address the issues related to lack of understanding on and enforcement of road rules.

d) Barrier: *Initial unwillingness to move back to non-motorized transportation by the public*

Measure: *Awareness creation on the health benefits of non-motorized transport.*

The general public lacks awareness on need for air pollution control including greenhouse gas

emissions and the potential health benefits thereof. Given the stressful life with bad food habits and lack of physical exercise, the health of the overall population is on the decline. Therefore public awareness creation on environmental and health benefits of the non-motorized transport would facilitate increasing the public interest for non-motorized transportation.

e) Barrier: *Perception of non-motorized transportation as a primitive method.*
Measure: *Promoting better attitude towards non-motorized transport through awareness creation and developing attractive pedestrian facilities.*
Attracting the pedestrians through awareness creation and development of appealing sidewalks and walkways, etc., would help alleviating wrong perceptions non-motorized transportation as a primitive way of transport. Since the use of non-motorized transport is on the rise in most of the developed countries in Europe, North America, and Asia, examples from such countries could be used in promoting such initiatives in Sri Lanka. Giving more attention to pedestrian comforts and needs, such as planting trees along the walkways for shade and installing benches for occasional resting, could help attract more people.

f) Barrier: Inadequacy of *knowledge and enforcement of road rules.*
Measure: *Automated fine systems along with amendments to the Motor Traffic Act.*
Automated, camera-based fine systems can help isolate reckless drivers who have no concern about moving pedestrians. Appropriate amendments to the Motor Traffic Act will be required to impose such penalties.

Other measures:

The following measures are recommended to address barriers classified under the "Other" category.

g) Barrier: *No easy access to non-motorized transport facilities from the public transport terminals.*
Measure: *Construction of walkways starting from main bus stations and train stations.*
In order to reduce emissions from fossil fuel burning in vehicles, there is a need to promote both non-motorized transport and public transport. However, lack of walkways from the terminals of public transport is a major barrier to promote this mode of transportation. Therefore, provision of well demarcated walkways from main train and bus stations is an essential requirement.
One reason for the low use of public transport on certain road fragments is the lack of regularity and proper time schedules based on passenger needs. Therefore, regularization of public transportation is also essential, along with the development of pedestrian infrastructure for facilitating non-motorized transport.

h) Barrier: *Lack of adequate space to develop sidewalks and walkways*
Measure: *Better sidewalk and walkway designs and land acquisition, as appropriate.*
Acquisition of lands by making appropriate compensations to the land owners for road infrastructure

development is proposed for very narrow road segments in order to facilitate construction of.well designed walkways. However, due to high population density in metropolitan areas, there are hardly any unused lands available for further infrastructure development. In the absence of suitable lands for acquisition, well designed sidewalks with safety measures such as fencing will be required, especially on narrow roads where pedestrian movements have limitations.

i) Barrier: *Lack of proper sidewalks and walkways.*

Measure: *Construction of proper, appealing walkways and sidewalks.*

Construction of proper and appealing walkways and sidewalks is an essential approach to overcome thia barrier. When the new sidewalks and walkways are built, provision of proper structure, pavement, appropriate shade, and fencing, etc will be required to achieve the desired objectives of such structures. Walkways with adequate greenery for providing shade sans motorized traffic movement should help promoting non-motorized transportation in the cities.

J) Barrier: *Lack of proper road furniture.*

Measure: *Provision of all required road furniture.*

More electronic signal systems and sign posts are required for passenger crossings. Enhancing the prominence of pedestrian crossings where traffic signals are not available is an urgent need, as it would avoid any accidents, especially at night. Therefore, establishment of appropriate road furniture such as bright warning sign posts/poles or similar easy-to-detect road furniture at pedestrian crossings is proposed at locations where traffic signals are not available.

2.3. Barrier analysis and possible enabling measures for Technology 2: Carpooling and park-and-ride systems

2.3.1 General description of the Technology

Park-and-ride systems involve providing parking facilities where the commuters can leave their private vehicles in such places and transfer to a public shuttle service or several commuters could opt to travel in one vehicle for the rest of their journey by means of car pooling. Cars or any other personal vehicles are kept parked in the facility throughout the day, and picked up by the commuters on their return trip. Typically, such facilities are found in the suburban areas. 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. Availability of these facilities will require adequate publicity and awareness. This system would be ideal in industrial zones and busy city areas, and passengers should have secure parking facilities.

The draft National Transport Policy of Sri Lanka, which is yet to receive the government approval, contains provisions to promote park-and-ride systems in conjunction with public/mass

transportation. The overall objective 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.

2.3.2 Identification of barriers for the Technology

A total number of twelve (12) key barriers have been identified through a stakeholder consultation supported by literature reviews and expert inputs. The barriers classified into hierarchy of categories include two (02) economic & financial barrier, one (01) Information & awareness, two (02) Institutional & organizational capacity, one (01) policy, legal & regulatory, two (02) social, cultural & behavioral, and four (04) "Other" barriers.
The following are the key barriers identified.

2.3.2.1 Economic and financial barriers

The following barriers have been identified as important economic and financial barriers:

a) Lack of finances.

As described under Technology 1, currently transport sector in Sri Lanka is funded by bilateral and multilateral funding sources and national budget supports. In view of it is being a new initiative, to date there has not been any budgetary provisions for this technology related activities. Therefore, as in the most of other potential technologies, financing is expected to be a constraint for this intervention as well.

b) Lack of economic tools including road pricing and innovative public transport for utilizing such a system.

In certain developed countries, road pricing is enforced on fragments of roads with heavily congested traffic, as a means of congestion management. Such a concept would essentially be something new to Sri Lanka. However, recently road pricing has been introduced on Southern Expressway, the first toll road in the country. Other than that, there is no road pricing enforced in any city areas. If such a mechanism could be implemented based on the occupancy rate of the vehicles, it would promote the use of public transport, carpooling or park-and-ride systems.

2.3.2.2 Non-financial barriers

Several barriers have been identified under non-financial category as discussed below.

Information and awareness barriers

c) Inadequate public awareness on the technology.

Since car pooling and park-and-ride has not been practiced in Sri Lanka the general public lacks any

awareness on such s systems and its potential benefits. Although once there had been an attempt to introduce a park-and-ride system it has been aborted as a result of poor planning particularly with regard to public awareness. Therefore, advance public awareness on its benefits in terms of economical and environmental aspects is critical.

Institutional and organizational capacity barriers

d) Lack of an existing mechanism for sustainable operation of the system.

Although there are several policies and legislations encompassing the transport sector, they are not being properly implemented especially because it falls under the purview of several government agencies (e.g. Ministry of transport, Sri Lanka Railways, Ministry of Local Government and Provincial Councils, Ports and Highways Ministry). Since carpooling and park-and-ride are is a new initiative in the country a well defined institutional framework for management and adequate planning will be essential to ensure its success. Since any of the existing legislations do not have provisions for such a institutional mechanism enabling legislation will be an essential prerequisite.

e) No proper public private partnership to promote such a mechanism.

In Sri Lanka, bus transport is functioning through well-established public-private partnerships. However, there has not been any felt need for such partnership arrangement for obvious reasons. As public-private partnerships are seen as effective means of providing important services such as transport against a state monopoly, it will be incumbent upon the government to explore and promote such an approach for the sustainability of the proposed technological option.

Policy, legal and regulatory barriers

f) Unavailability of proper guidelines and regulations regarding possible driver- passenger cost/credit sharing.

In countries with well-established carpooling and park-and-ride systems, there are set guidelines and rules for promoting the use of those systems as sustainable transport options. Driver-passenger cost/credit sharing is an appropriate action towards promoting carpooling. Therefore, proper guidelines and regulations are required to address cost sharing among the riders so as to give more benefit to drivers in relation to the passengers.

Social, cultural, and behavioral barriers

g) Lack of attractiveness to general public.

In the transport sector of Sri Lanka, so far the main concern has been to fulfill the travel needs of the general public. However very little attention has been given to improve the outlook of the service in terms of quality of service provided so as attract more users. In order to encourage potential users and

to build trust on carpooling and park-and-ride options, it has to be associated with some privileges and facilities for their convenience and operation through a stable public private partnership. Therefore appropriate promotional measures would be needed for carpooling and park-and-ride to be attractive to people.

h) Absence of existing ticketing facilities for common shuttles.

The users of the Park-and-ride services would prefer to purchase short term or long-term travel passes. Although this could be done within the vehicle or at a designated kiosk within the parking lot, the ability to purchase tickets prior to the travel date/time using the internet could facilitate speedy and convenient travel. Currently there is no online ticketing facility available in Sri Lanka for public transportation. Similarly the ability to purchase it at any other place than the origin of travel is absent.

"Other" barriers:

Several important barriers fall under the "Other" category:

i) Lack of real time information providing facilities and proper location maps and sign boards of the parking spaces from the main road or highway.

At present real time information of departure and arrival of buses are not displayed at any main bus station in Sri Lanka. In order to attract people towards park-and-ride systems, in addition to available any other public transport, a digital system providing real time information on the availability of buses and sign boards displaying how to access the park-and-ride and carpooling lots from the main roads or highways are essential , as currently there are no such existing facilities.

j) No proper and adequate access to the responsible authorities and officials for information.

Currently there is no mechanism for the general public in distance places to contact and get the information on arriving and departing buses at any main bus station in the country. There is no directory with all the information (i.e. contact details) available either online or published which is easily accessible to someone in outstations. Having such a system promotes and facilitates more passenger friendly public transport options.

k) Unavailability of attractive service with comfortable or high quality buses.

In order to promote park-and-ride and carpooling options, the public transport service need to be made attractive and preferred than using personal vehicles. To provide such an added value to a carpooling and park-and-ride system, it has to maintain quality in its infrastructure, vehicles, and road discipline, while providing the expected comforts to the riders. Therefore availability of high quality, comfortable buses would be important for the success of this new initiative.

l) Lack of proper and secure parking areas for expansion into the suburbs of Colombo and other areas of

the country.

The trust of passengers is essential for the sustainable and large scale operation of a newly introduced technology. Sri Lanka does not have many secure parking areas and the vehicle owners are often warned to park at their own risk. For park-and-ride systems and carpooling to operate from remote areas, there should be safe parking lots providing adequate security to the vehicles parked therein. l.

2.3.3 Identified measures

The identification of enabling measures to overcome key barriers has been carried out through a stakeholder consultation

The measures thus identified are discussed below.

2.3.3.1 Economic and financial measures

The measures identified to overcome the economic and financial barriers are as follows;

a) Barrier: *Inadequate finances.*

Measure: *Proper finances through public private partnership.*

For establishment and continued operation of the park-and-ride and carpooling systems, ensured availability of funds will be very critical. Therefore, initial costs for infrastructure development, vehicles, and planning should be mobilized through public private partnership arrangements. Continued operation of the system may be funded through the user fees.

b) Barrier: *Lack of economic tools including road pricing and innovative public transport for utilizing such a system.*

Measure: *Introducing a tax system for single or low occupancy vehicles.*

Currently the majority of the private vehicles on the road during rush hours are single or low occupancy vehicles. In order to discourage such vehicles and to promote carpooling or park-and-ride system, it is necessary to introduce legal modalities such as penalties

2.3.3.2 Non financial measures

Non-financial measures include actions related to information & awareness, institutional & organizational capacity, social, cultural, & behavioral measures, and “Other” measures.

Measures to improve information and awareness

c) Barrier: *Inadequate public awareness on the technology.*

Measure: *Awareness creation through mass media.*

Awareness creation is an integral component of novel initiatives of this nature. Unless the potential users and the general public at large is made well aware of the rationale and the benefits, there will be

inevitable oppositions to the proposed system Currently there is hardly any discussion fora for transport related issues either in the public domain or mass media. Such for a need to be made established through television and radio stations, so that interactive dialogues could be undertaken with regard to the proposed carpooling and park-and-ride system. People should be made aware of all possible economic, environmental, and other benefits through such fora and advertisements on television, newspapers, and other mass media.

Measures to improve institutional and organizational capacity

The following measures need to be taken to avoid the institutional and organizational capacity barriers identified above:

d) Barrier: *Lack of an existing mechanism for sustainable operation of the systems.* Measure: *Proper registration system for regular users and maintenance of a database of operational details such as, driver/passenger information etc.*

Establishing a proper registration procedure for the current and potential users of the systems, including their preference, whether to be a passenger or a driver, is proposed. More privileges, including incentives, need to be considered to the regular or frequent users.

e) Barrier: *No proper public private partnership to promote such a mechanism*

Measure: *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.*

In order to overcome the barrier of non availability of a proper public private partnership to promote carpooling or park-and-ride systems, the proactive intervention of the respective government agencies such as the Ministry of Transport and the relevant Ministry of the Provincial Councils would be imperative. Initial partnership between the respective Ministry and the private sector partners will ensure the sustainability, and trust and confidence of the public on the system once come into operation.

Policy, legal and regulatory measures:

f) Barrier: *Unavailability of proper guidelines and regulations regarding possible driver- passenger cost/credit sharing.*

Measure: *Publishing a manual or directory with all the rules and regulations.*

Publishing a manual with all the rules and regulations about the overall functioning of the system is proposed for overcoming this barrier. Having well-established rules and regulations and easy access to such information will enable building public trust and user confidence of the system.

Social, cultural, and behavioral measures

g) Barrier: *Lack of attractiveness to general public.*

Measure: *Establish useful infrastructure and amenities within the premises of the facility for the behefit of the users.*

In order to enhance the attractiveness of the services provided, provisions of essential features such as markets, restaurants, and communication facilities along with fuel stations within the premises would be useful to attract people towards using them frequently. However, awareness creation is essential along with the establishment of all such infrastructure and amenities.

h) Barrier: *Absence of existing ticketing facilities.*

Measure: Facilities for *on-line ticket purchasing for shuttles starting at the park-and-ride lots*

On-line ticket purchasing ability is proposed as the suitable measure to provide easy access to ticketing facilities. The public should be able to purchase the required tickets at their convenience for the shuttle services to enable accessing shuttle services from any designated parking lot. Therefore, availability of a online ticket purchasing facility would be useful in this regard. This will enhance the sustainability of the operation of park-and-ride systems, while improving the overall efficiency.

"Other" measures

i) Barrier: *Lack of real time information providing facilities and proper location maps and sign boards of the parking spaces from the main road or highway.*

Measure: *Electronic display of information related to bus transit (delays, time of arrival, etc.) and establishment of proper signboards by the main road.*

This measure needs to be adopted to overcome the barrier of not having real time information providing facilities, proper location maps and sign boards of the parking space/s from the main road/ highway. These facilities are available in some developed countries in the region, and will attract more users to the system as such information makes it easier to decide the time-to-drop or time-to-pickup passengers for the bus transit.

j) Barrier: *No proper and adequate access to the responsible authorities and officials for information*

Measure: *Publishing an annual directory containing the information of the responsible authorities and officials, while providing the same information online.*

This measure is proposed to ensure that up-to-date information regarding the responsible authorities and officials with relevant contact details are made available to the general public. Publishing an annual directory with the relevant information will enable interested individuals to access relevant by directly contacting appropriate officials, or online. Availability of such a mechanism would help improving the efficiency and attracting more people.

k) Barrier: *Unavailability of attractive service with, more comfortable or high quality buses.*

Measure: *Introduction of better vehicles and reduction of the importation taxes for public transport vehicles.*

In order to make the bus transit at park-and-ride lots are more attractive to the public, those vehicles should be more passenger friendly, attractive and comfortable, compared to other regular buses used in public transport. Therefore deploying comfortable buses would be useful in this regard. Importing high quality buses can be facilitated through reducing the import tariffs.

l) Barrier: *Lack of proper and secure parking areas for expansion into the suburbs*
Measure: *Establishment of security cameras and lighting systems, appointment of security personnel, and introducing insurance schemes for the parking lots.*
Safety of the vehicles at the designated parking lots for carpooling and park-and-ride systems is a genuine concern of the public. Since most of these systems would be operating from the suburbs of Colombo and other major cities, there is a need to ensure adequate security at these parking lots. Therefore, need for proper and secure parking areas has been identified as an important aspect to enable further expansion into suburbs of Colombo and other areas of the country. Enhanced security measures such as security cameras and lighting systems, deploying adequate security personnel, and introduction of appropriate insurance schemes for the parking lots would be useful in this regard.

2.4 Barrier analysis and possible enabling measures for Technology 3: Electrification of suitable segments of the existing railway network

Electrification of suitable segments of the existing railway network has also been identified as a publicly provided good. The barriers and measures to overcome the barriers have been identified through stakeholder consultations supplemented by expert inputs…

2.4.1 General description of the Technology

The existing railway network in the country is 1447 km long[17]. The railway network in Sri Lanka has been originally built and used only for transporting export plantation products, and with increasing population and traffic needs, rail transport has become more passenger oriented. The existing trains are diesel powered, and electrification of one sector of the railway network (Nearly 5% of the existing railway network) has been proposed by IESL (2008).
Electrification of some segments of the railway network will save both energy and the maintenance cost, while providing sustainable transport. The diesel powered electricity generator in the existing trains that drive the motors connected to the wheels, remain idle most of the time, except when running at steady speed. When the train is electrified through the grid, there is no such wastage of fuel and when the train brakes or decelerates, the motors will transform into generators, producing electricity, which will be returned to the grid for later use. In electrification of the railway system, the existing railway tracks could

[17] Ministry of Transport, 2012

be used (with zero voltage) with electricity provided through overhead lines (25 kilovolt) drawn above the railway lines and loops (IESL, 2008).

2.4.2 Identification of barriers for the Technology

A total number of six (6) key barriers have been identified for the technology through stakeholder consultations followed by hierarchical categorization. Accordingly, the barriers include one (01) economic & financial, three (03) network failure, one (01) social, cultural & behavioral and one (01) "Other" barrier.

2.4.2.1 Economic and financial barriers

a) Lack of finances

Although the conversion from diesel to electric power is more economical in the long run, there is a higher capital cost associated with the conversion compared to the other two technologies already discussed, due to the need for new infrastructure and other necessities. Thus lack of a concrete financing mechanism will be a critical barrier.

2.4.2.2 Non financial barriers

The barriers identified fall under the following categories of Network failures, Social, cultural, and behavioral barriers, and other barriers as described in Boldt et al. (2012)[18]:.

Network failures:

b) Lack of intermediate high density transport modes such as Bus Rapid Transit (BRT)[19] for the nodal points identified for the railway electrification links and facilities relevant to non-motorized transportation.

The electric trains become more efficient and beneficial with the higher frequency of use. Therefore, more busy sectors with a large volume of passengers and frequent trips would generate the highest amount of benefit out of this technological option. In order to ensure sustainability and the use of

[18] Boldt et al, 2012

[19] Bus Rapid Transit (BRT) is a public transport system using buses to provide faster, more efficient service than an ordinary bus line. This is achieved by making improvements to existing infrastructure, vehicles and scheduling. BRT system is often useful to establish connectivity from nodal points of the railway electrification links to other mass transport modes and pedestrian or non-motorized transport facilities.

electrified trains to be economical, there should be enhanced connectivity with the other mass transport modes and pedestrian or non-motorized transport facilities.

c) Lack of uninterrupted power supply

The technology will be unsustainable if there are frequent interruptions in the power supply. Therefore, uninterrupted power supply is an essential and critical requirement for continued operation of electrified railway systems. However, power failures are common in Sri Lanka. Hence availability of the backup generation would be crucial for the success of electrification of the railway system.

d) Lack of transport network analysis to identify the electrification links.

Proper electrification links are essential for more economical use of transport technologies of this nature. Electrification of railway system is beneficial in terms of saving power and maintenance costs. However, it involves high initial capital costs. Therefore careful analysis needs to be done in choosing the appropriate railway links, so as to maximize the benefits in the long run.

Social, cultural and behavioral barriers

e) Lack of research and studies on similar experiences from other developing countries in the region

Often electrified railway systems are found only in cities with heavy populations. In the local context, there are no heavy populations as such and only segments of the railway line is proposed tol be electrified (Around 5% of the existing railway network). However, neither in Sri Lanka nor in any other developing country in the region has any similar previous experiences, and there are not many research studies done on similar situations.

Other barriers

f) Lack of infrastructure

The existing infrastructure including the communication and signaling systems need to be updated. Sufficient and strong enough tracks and signal lights, etc., are needed for proper and efficient functioning of an electrified railway system. The system also needs more better-quality locomotives and rolling stock. Therefore a major part of the initial investments will be required to be made on infrastructure development.

2.4.3 Identified measures

The identification of required measures to overcome key barriers has been done through a stakeholder consultation and the enabling measures thus identified are discussed below

2.4.3.1 Economic and financial measures

a) Barrier: *Lack of finances*

Measure: *Secure finances from donors and through public private partnership.*

It is recommended to explore required funding from donors and through public private partnerships. In order to ensure sustainability of the operation, it is proposed to provide government support and also to seek private sector funding in addition to donor support.

2.4.3.2 Non financial measures

Non-financial measures fall under network failures, social, cultural, & behavioral and "Other" categories.

Network failures

b) Barrier: *Lack of intermediate high density transport modes such as Bus Rapid Transit (BRT) for the nodal points identified for the railway electrification links and facilities relevant to non-motorized transportation*

Measure: *Explore possibilities of a Bus Rapid Transit (BRT) system within the existing road network.*

A BRT system originating from the nodal points will attract more passengers to use the electrified railway system. Linking with another mode of public transport always increases the sustainability of the train system, making it more economical. In the event the country decides to have an economical BRT system on a highly used road sector within the existing road network, linking the same to the electrified railway system would enhance the efficiency of the overall public transportation system.

c) Barrier: *Lack of uninterrupted power supply.*

Measure: *Introduction of backup systems for uninterrupted power supply.*

Suitable backup systems are proposed as a solution to prevent any interruption of services due to power failures. Power failures are quite common in Sri Lanka, due to maintenance requirements or natural or other reasons. In such a situation, backup generation should be available to at least move the trains to the nearby railway station.

d) Barrier: *Lack of transport network analysis to identify the electrification links.*

Measure: *Get the support from the Transport Ministry to identify electrification links.*

Identification of suitable electrification links should be addressed through a collaborative program between the responsible government agencies. Both the Railway Department and the Ministry of Transport need to work in close collaboration in order to identify potential links for electrification.

Social, cultural and behavioral measures

e) Barrier: *Lack of research and studies on similar experiences from other developing countries in the region.*

Measure: *Gaining experience and training from countries with a similar railway system.* Capacity building for maintenance requirements and proper and smoother operation of the electrified railway system can be acquired from the experiences of other countries having similar railway systems. Technical and technological training also will have to be sourced from foreign expertise. This two pronged approach would enable to fill the void due to absence of research studies from other countries having similar situations

Other measures

f) Barrier: *Lack of infrastructure.*

Measure: *Developing new tracks and signal systems.*

Developing new tracks and signal posts are necessary with the proposed transformation Infrastructure development is imperative to maintain a optimally functioning system including avoidance accidents on level crossings. Presently, certain railway crossings have poor signaling systems requiring replacement or up gradation.

2.5 Linkages of the barriers identified

Certain barriers which can be considered as linked and common to all three technologies have been identified and are described below.

2.5.1 Lack of finances

The lack of finances is common to all three prioritized technologies. So far adequate financial resources have not been made for promoting and improving non-motorized transportation related facilities. Therefore, at least the initial investment from government sources will be required from the government sources for the technology on *Integration of non- motorized transport methods along with regularized public transport system.* Since the other two technologies would require substantial financial investments compared to the Technology 01, opportunities for external funding will have to be explored. Public private partnership would be of vital importance for all three technologies in addition to exploring opportunities for potential donor funding.

2.5.2 Lack of knowledge on the benefits and other concerns related to the prioritized technologies

Lack of awareness on potential health and environmental benefits accruable by shifting to the prioritized technologies will remain a major constraint for promoting these initiatives. Also, given the extent of

violation of road rules by both motorists and pedestrians, there is a need for concerted efforts by the authorities in persuading public to be cognizance of the existing road rules and regulations. Also there is lack of awareness on novel concepts such as carpooling and park-and-ride. Therefore advance awareness creation is of paramount importance for the success of all the three technologies.

2.5.3 Lack of provisions in national policies and legislation for promoting the prioritized technologies

Policy commitment is essential for promoting all three prioritized technologies. Amendments to the existing policies and legislation with emphasis on the safety of non-motorized transportation and pedestrians is required.. Proper policy environment will be essential for proper and sustainable functioning of carpooling and park-and-ride systems.

2.5.4 Lack of infrastructure and locomotives

Lack of the necessary infrastructure is also a barrier common to all three technologies. For Technology 01, proper sidewalks, walkways and prominent signposts for easy identification of passenger crossings are needed. For carpooling and park-and-ride systems, there is a need for safe parking lots with all the relevant security measures, ticketing facilities, information display measures, and high quality buses, etc. Better tracks, signal systems, tracks and other infrastructure, sufficient locomotives and rolling stocks are vital infrastructure for a better, electrified railway system.

2.5.5 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. For instance, lack of an automated fine system for motorists who disregard the rights of pedestrians and bicyclists is a bottleneck for promoting non-motorized transportation. Similarly, absence of a system to penalize low-occupancy vehicles will be a barrier for promoting systems like carpooling and park and ride. Tariff concessions for imported buses to be used in park-and-ride systems will contribute for the sustainability of this initiative.

2.6 Enabling framework for overcoming the barriers in Transport Sector

Although these technologies are different from each other, they have been identified based on the economic and environmental considerations. While the overall objectives of the technologies are to mitigate climate change impacts by reducing GHG emissions, all of them have a common approach which aims at reducing the volume of low-occupancy vehicles on the road by promoting public (or mass) and non-motorized transportation.

In view of the continuous increase in the volume of vehicles on the road, the transport sector is called upon to take appropriate measures to ease traffic congestion through reducing the number of single or low occupancy vehicles, especially during the rush hours. However, this is not an easy task, given the personal preference of the people to use their own vehicles. Therefore a well-planned transportation strategy is imperative to facilitate promoting the three prioritized technologies while overcoming the barriers already dealt with for their successful diffusion and dissemination. Following consolidated enabling framework for the diffusion of prioritized technologies is thus proposed Based on the measures already identified.

The overall objective of the proposed technologies is being the reduction of traffic congestion and greenhouse gas emission through reduction of low occupancy vehicles by promoting public transportation, the Technology 1 is aimed at promoting non-motorized transportation in conjunction with public transportation whereas, the remaining technologies aims at promoting the use of mass transportation. In persuading the general public towards a larger shift from personal vehicles to a public or mass transport system, they should be made well aware of the benefits of the shift. Therefore,, one of the most important measures proposed is actions for adequate public awareness including training**.** Awareness creation needs to include potential benefits of the technologies and various aspects related to rules and regulations so as to improve road discipline. The use of mass media such as television will be essential in promoting the use of carpooling and park-and-ride systems and a newly electrified railway system.

At the same time, provision of improved ***facilities, amenities, and infrastructure*** will also be critical for attracting the public to use the proposed technologies. Development of proper sidewalks and walkways with greenery providing shade would help promoting non-motorized transportations. Availability of markets, restaurants, and communication facilities along with fuel stations within a park-and-ride facility for the convenience of the users would attract people for regular use. Better-quality locomotives, rolling stock, and tracks are required for popularizing electric railway system.
Similarly, road discipline, respect to pedestrians' rights and compliance with road rules are essential in promoting these technologies, especially the non-motorized transportation. Thus appropriate ***policy and legislative reforms*** including new regulations would be required as appropriate. Introduction of tariff barriers to discourage importation of too many vehicles for personal use and a tax system for single or low occupancy vehicles during the rush hours and on certain road sectors with heavy traffic congestion will be conducive for promoting the proposed technologies. Introduction of automated systems to impose penalties to protect pedestrian rights is also proposed.

Convenience and safety measures are also major concerns of the public, and availability of related services and measures will facilitate more people taking advantage of the proposed public and non-motorized transport technologies. Establishing linkages with other mass transportation modes such as BRT systems would facilitate popularizing the use of electrified railway system. Setting up pedestrian

facilities from train or bus terminals is needed to help promote the integration of non-motorized transport. Security and conveniences such as online ticket purchase will enable attracting more users to the park-and-ride facilities. Safe sidewalks, walkways, traffic signals and signposts for pedestrian crossings will ensure trust and security of pedestrians towards promoting non-motorized transport. However, ensuring safety of bicyclists will remain to be challenging unless the drivers on the road comply with road rules and respect their rights in the dedicated bike lanes.

Finally, and most importantly, a ***proper financial mechanism*** is critical towards successful implementation of all the enabling measures. Adequate funding from the government, and appropriate public private partnerships is required for ensuring the sustainability of the technologies. In addition, there is a need for supplementary donor funding as well. .

Summarized enabling framework by measure category and technology

The enabling framework for each technology is provided in Figures 2.1 to Figure 2.5 below..

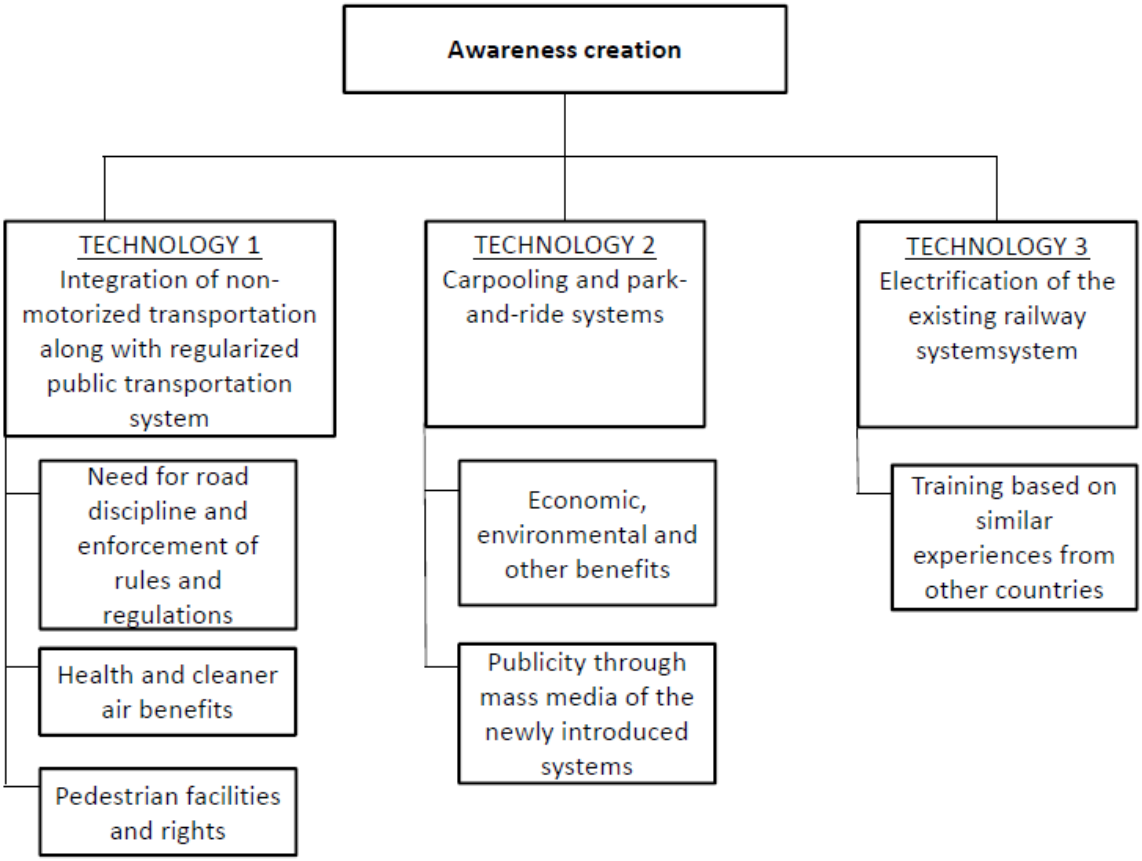

Figure 2.1: Awareness creation for Technologies 1 – 3.

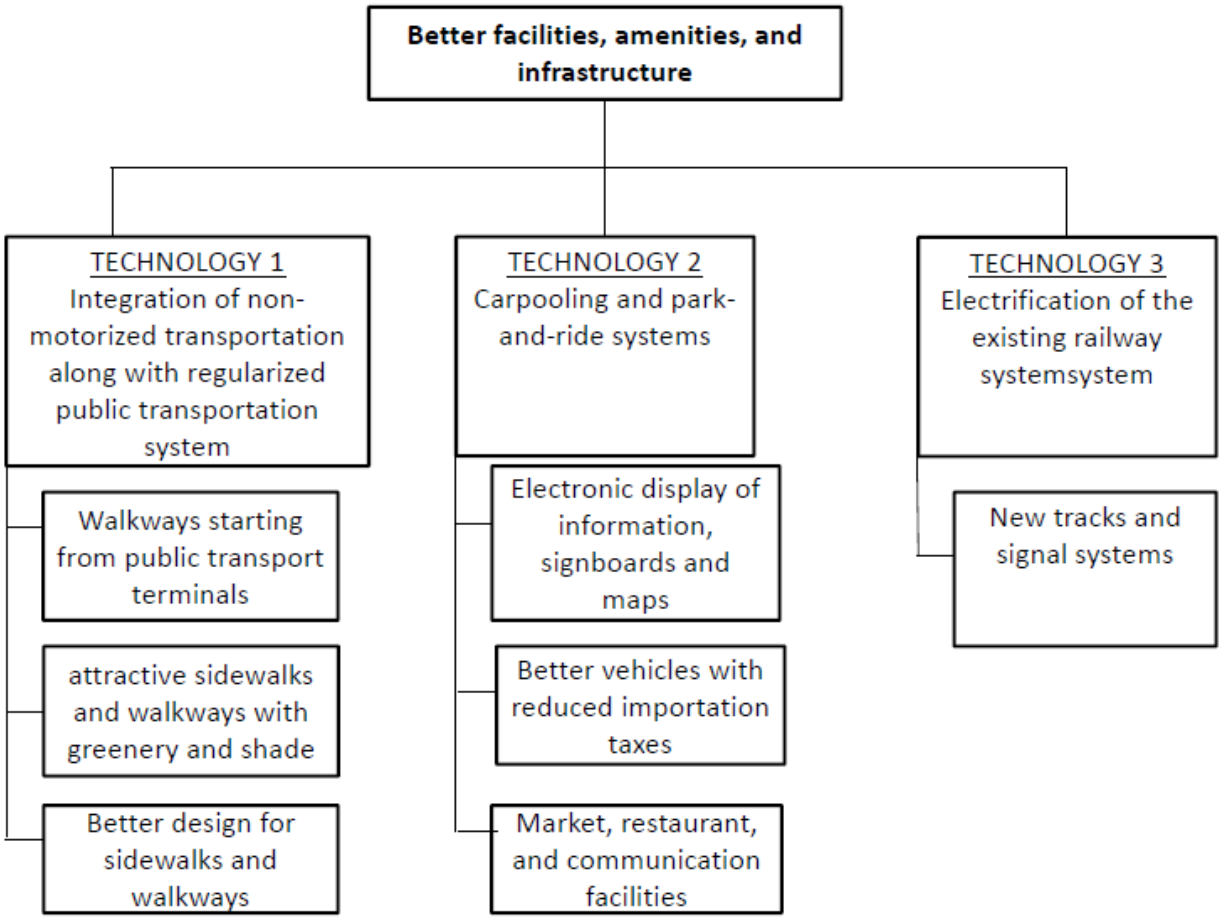

Figure 2.2: Better facilities, amenities, and infrastructure for Technologies 1 – 3.

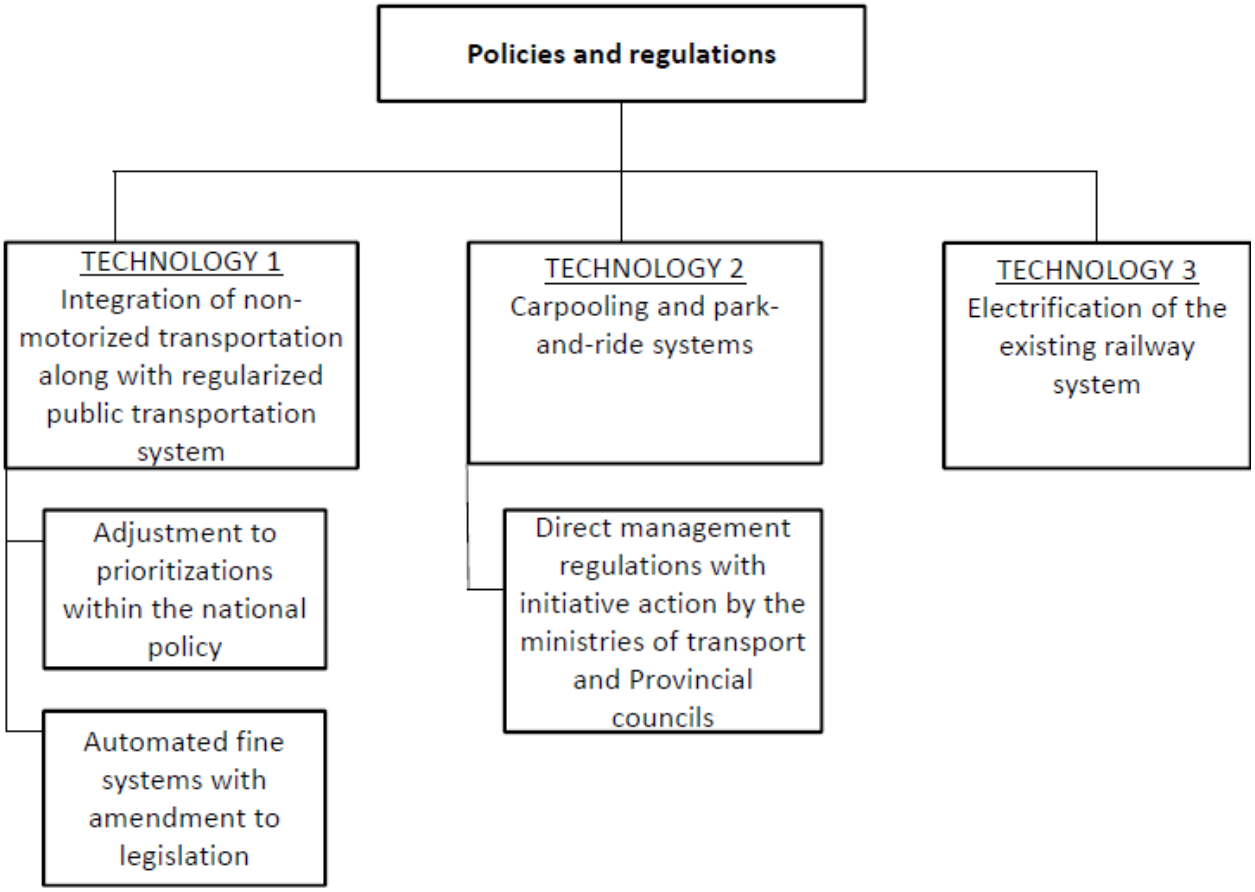

Figure 2.3: Policies and regulations for Technologies 1 – 3.

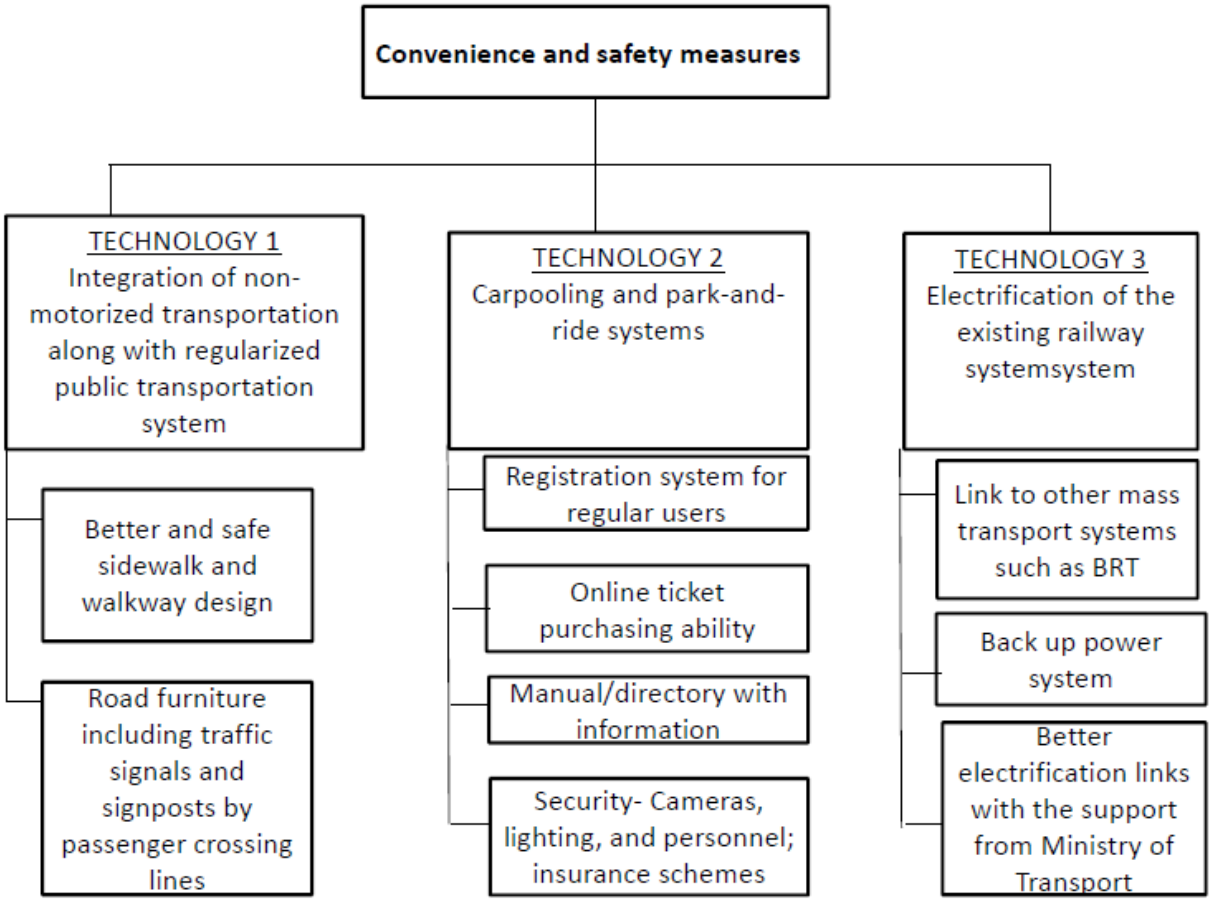

Figure 2.4: Convenience and safety measures for Technologies 1 – 3.

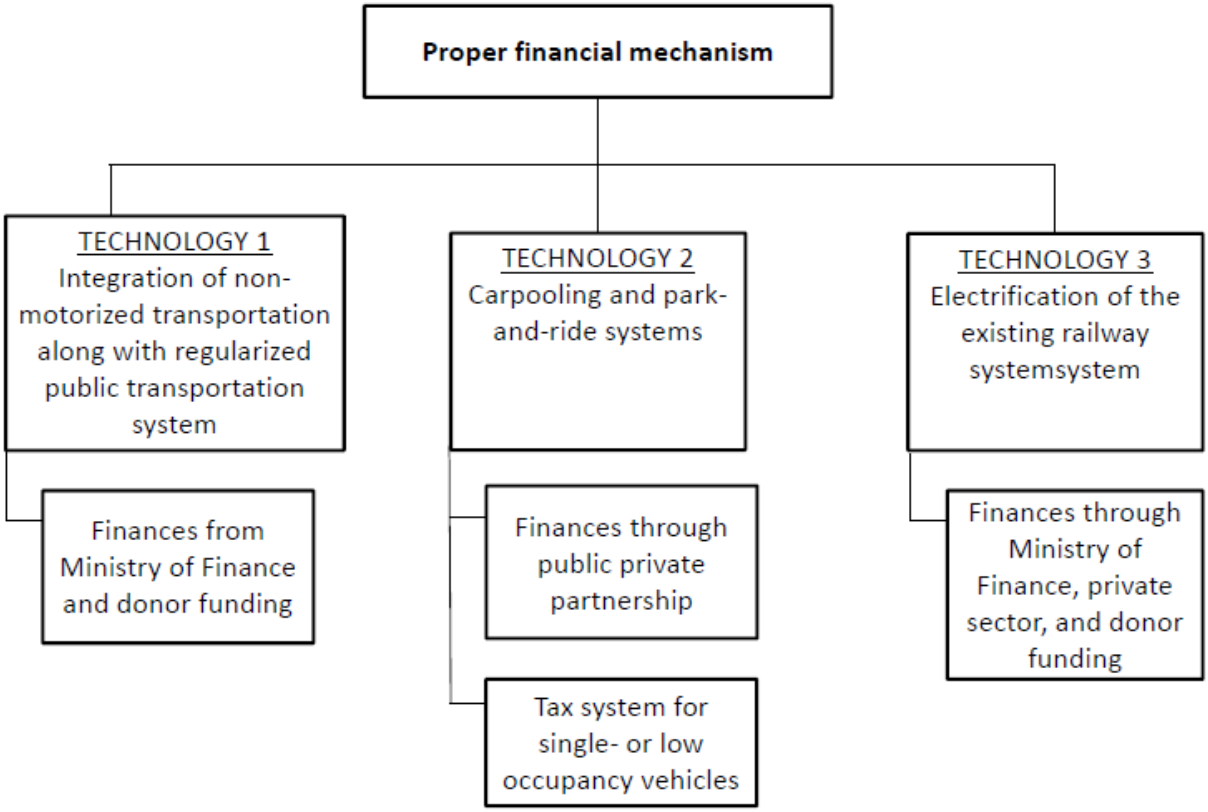

Figure 2.5: Proper financial mechanism for Technologies 1 – 3.

CHAPTER 3

INDUSTRY SECTOR

Industry sector of Sri Lanka is not a highly energy and resource consuming sector. According to the Ministry of Finance[20], the island's the industry sector share in the GDP in 2009 was 28.7% while growing at 8.4 percent from Rs. 701.1 billion in 2009 to Rs. 760.2 billion in 2010. The key industries contributing to GHG emissions are cement manufacture, lime production for construction industry, and industries using $CaCO_3$ containing material and soda ash. The energy for industrial purposes is generated from several sources such as biomass, petroleum oils and electricity. Biomass is used in tea and rubber factories, bakeries, tile and brick industries and other small scale industries. Petroleum oil is used for operating boilers, ovens and furnaces.

The GHGs emitted from the industry sector includes CO_2, CH_4, N_2O, CO, NOx, NMVOC, and SO_2. The major GHG in the industrial sector is CO_2 and it contributes about 86% of the total GHG in the sector. Of this amount, about 63% emitted from the industrial energy consumption and about 37% emitted from industrial processes. The emissions of CO_2 from these two sub-sectors are; 842.03 Gg CO_2 from industrial energy consumption and 492.4 Gg CO_2 from industrial processes.

Apart from the emissions resulted from industrial energy consumption, Cement manufacturing, Lime Production, Calcite and Dolomite use, Soda Ash use, Asphalt Production and use, Glass manufacturing, Metal & Paper industry and Food & Beverage are the main industrial processes which contribute significant amount of GHG emissions.

Process of identifying barriers

Although all possible technologies have been explored and only three of them have been prioritized during the Technology Needs Assessment stage for implementation yet there are barriers to overcome to enable meeting the objectives of technology transfer and diffusion. The identification of barrier has been carried out through stakeholder consultations (see Annex II) supplemented by literature reviews and specialist inputs. Having deliberated on all potential barriers, only most significant barriers have been identified followed by a prioritization process. Subsequently, all key barriers thus identified have been classified into hierarchy of categories and then analyzed causal relationship between barriers.

[20] MF, 2010, Annual Report, 2010, Ministry of Finance

3.1 Preliminary targets for technology transfer and diffusion

Energy efficient motors (EEM) Variable speed drives (VSD) for motors and Biomass residue based co-generation combined heat and power (CHP) are the three prioritized technologies for the sector in order of priority. All three technologies and equipments are categorized as capital goods as shown in table 3.1.

Table 3.1: Categories of the prioritized technologies – Industry Sector

No	List of Prioritized Technologies	Category of the Technology
1.	Energy Efficient Motors	Capital goods
2.	Variable Speed Drives for Motors	Capital goods
3.	Biomass Residue Based Cogeneration Combined Heat and Power (CHP)	Capital goods

Tables 3.2, 3.3 and 3.4 depicts primary targets for technology transfer and diffusion with expected economic benefits and lifetime along with climate change mitigation impacts of each technology including the other environment impacts for the given period of time.

Table 3.2: Preliminary targets of EEM

Technology	Energy Efficient Motors (EEM)
Primary target	Replace existing motors with EEM. The existing motors consume 40% of electrical energy consumed by the industries (it covers full range from small to large motors)
Expected life time	Minimum 10 years
Expected economic benefits	Electricity saving for 10 years is estimated to be about 380,679MWh and its cost saving is about Rs. 3,997,129,500 (calculated based on current industrial tariff plan; 1kWh = Rs. 10.50 (0.095 USD)
Climate Change Mitigation Impacts	Estimated CO_2 reduction potential for 10 years is about 130,192 tCO2e (calculated based on year 2010 Sri Lanka energy balance)
Other Environment Impacts	No other significant environment impacts

Table 3.3: Preliminary targets of VSD

Technology	Variable Speed Drives (VSD) for motors
Primary target	Use VSD for appropriate applications. (Assumption: VSD are applicable for about 40% of total electric motor drive application)
Expected life time	Minimum 10 years
Expected economic benefits	Estimated electricity saving for 10 years is about 1,511,088MWh and its cost saving is about Rs. 15,866,424,000 (calculated based on current industrial tariff plan; 1kWh = Rs. 10.50 (0.095 USD)
Climate Change Mitigation Impacts	CO_2 reduction potential for 10 years is about 516,792 tCO_2e (calculated based on year 2010 energy balance)
Other Environment Impacts	Improperly managed electronic waste may cause negative environment impact

Table 3.4: Preliminary targets of Biomass CHP

Technology	Biomass Combined Heat and Power (CHP)
Primary target	Promote residue biomass combined heat and power in industrial sectors such as rubber, tea.
Expected life time	Minimum 15 years
Expected economic benefits	Estimated cost of electricity delivered by the CHP plant is US$ 0.04/kWh and the estimated cost of thermal energy is US$ 0.019/kWh, both of which are lower than the corresponding cost of grid electricity at US$ 0.044/kWh and the cost of furnace oil-based thermal energy at US$ 0.021/kWh.
Climate Change Mitigation Impacts	Greenhouse gas (GHG) emissions reduction by the equivalent of about 113,000 t CO_2e
Other Environment Impacts	Although biomass energy has neutral carbon dioxide emission, it has high water footprint. Biomass should not be supplied from natural forest.

3.2 Barrier analysis and possible enabling measures for Technology 1: Energy Efficient Motors (EEM)

3.2.1 General description of the Technology

According to global energy surveys, two thirds of electrical energy in the industry is consumed by motors and hence high efficiency requirement is inevitable for overall energy efficiency. If every installation could

contribute even by a fractional improvement of efficiency, the gross saving would be enormous. Already there are such enabling agreements between motor manufactures and various enactments in the USA and Europe. Energy Policy Act 1992 (Epact 92) has directives for minimum efficiency levels for general purpose motors up to 200HP in USA. Based on such directives NEMA (National Electric Manufacturer's Association) listed different efficiency bands for motors. The motors that have higher efficiency by 2% – 8% than the standard efficiency motors are categorized as "Premium Efficiency Motors'.

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

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

3.2.2 Identification of Barriers for EEM

For the technology '***Energy Efficient Motors',*** a total number of eight (08) key barriers have been identified upon stakeholder consultations supplemented by specialist inputs and literature reviews. The key barriers thus identified have been classified into hierarchy of categories which include two (02) economic & financial, one (01) policy, legal & regulatory, one (01) institutional & organizational capacity, one (01) human skills, two (02) technical and one (01) information & awareness barriers. The identified barriers are discussed below.

3.2.2.1 Economic and Financial Barriers

a) High Capital Cost

The cost varies based on the application from a few thousand to a few million rupees. Therefore, High capital cost can be identified as a key barrier. As there is an overly competitive and aggressive business environment, where economic variables play a major role, an uncertainty in the external environment can be witnessed. These variables include GDP (PPP, official exchange rates, real growth, per capita income), labor force, unemployment rate , population below poverty line, average household income, inflation rate etc. This could be very challenging to organizations trying to adopt new technologies.

b) Lack of financial resources and incentives

Lack of financial resources and incentives is another key barrier. Commercial banks have a general reluctance to provide loans at concessionary rates to invest on new technologies. Weak government policies and lack of incentives on technology developments in industrial sector can also be

highlighted as significant issues requiring attention.

3.2.2.2 Non Financial Barriers

Policy, Legal and Regulatory

c) Insufficient legal regulatory framework and insufficient enforcement

Use of energy efficient motors is not a mandatory requirement. Absence of a regulatory framework provides less inducement for industries to utilize this technology.

Institutional and Organizational Capacity

d) Lack of professional institutions and limited capacity in existing institutions

Unavailability of professionals and professional institutions in the outstations and capacity limitations in existing institutions is another major challenge that will be encountered when implementing this technology. Most of the available professionals and professional institutions are confined to the Western Province therefore the industries located in other provinces face difficulties in securing required professional services.

Human Skills

e) Lack of skilled personnel for implementation of technology and inadequate training for maintenance

It is of critical importance to have technically qualified and skilled personnel to install and maintain the equipment. However, as at present there is a dearth of skilled personnel for the implementation of this technology and inadequate training opportunities for undertaking maintenance work. Expected benefits of a new technology cannot be achieved without having skilled personnel with adequate training, competence and equipments.

Technical

f) Poor Operations and Maintenance Facilities

Operation and Maintenance (O&M) is a critical component of the overall technology implementation process. The O & M is an integral component of the management process.

Operations include;

- Administration – To ensure effective implementation and control of operation activities.
- Conduct of Operations – To ensure efficient, safe, and reliable process operations.
- Equipment Status Control – To be cognizant of status of all equipment.
- Operator Knowledge and Performance – To ensure that operator knowledge and performance will support safe and reliable plant operation.

Maintenance include;

• Administration – To ensure effective implementation and control of maintenance activities.

• Work Control System – To control the performance of maintenance in an efficient and safe manner so as to optimize economical, safe, and reliable plant operations..

• Conduct of Maintenance – To conduct maintenance in a safe and efficient manner.

• Preventive Maintenance – To contribute to optimum performance and reliability of plant systems and equipment.

In the absence of good O & M facilities, none of the above requirements could be ensured. .

g) Inadequate standards, codes and certification

Standard is a prescribed set of rules, conditions, or requirements concerning definitions of terms; classification of components; specification of materials, performance, or operations; delineation of procedures; or measurement of quantity and quality in describing materials, products, systems, services, or practices." As at present there are inadequate standards to follow or benchmark, codes and certification with regard to the proposed technology.

Information and Awareness

h) Inadequate information, awareness, feedback and difficulties in comprehending technical communication

The stakeholders have highlighted inadequate information, awareness, feedback and difficulties in comprehending technical communication as a barrier. When there is a variety of makes and models of varied quality and system constraints, lack of information is a constraint on the buyers to enable making an informed choice.

3.2.3 Identified Measures

The enabling measures to overcome barriers have been identified using Logical Problem Analysis (LPA) methodology as described in the TNA Guidebook 'Overcoming Barriers to the Transfer and Diffusion of Climate Technologies'. Based on this analysis, potential measures to overcome all the key barriers has been identified and classified into hierarchy of categories.

A list of barriers and enabling measures identified to overcome barriers are given below

3.2.3.1.1 Economic and Financial Measures

a) Barrier*: High capital cost*

Measure*: Review the government tax policy so as to reduce capital costs of energy efficient and environment friendly technologies*

Tariff concessions to enable reducing high capital costs will be an effective measure as economic

inducements are likely to prove the most effective means of promoting novel technologies. Government will have indirect benefits through national level energy saving and industries can manufacture their products with low cost and can be more competitive in export market. Tax concessions should be considered based on efficiency level of the motor. Reduced taxes may be levied on high efficient motors while high taxes are imposed on low efficient motors.

b) Barrier*: Lack of financial resources and incentives*

Measure*: Create enabling environment for credit facilities, tax concessions and subsidies*

Market based instruments are required to encourage investing in environmentally sustainable technologies and such instruments include both non financial and financial incentives. Financial incentives such as low interest credit facilities from commercial banks, tax concessions for imports and subsidies are recommended for promoting this technology. Non financial incentives such as national awards and certification through a national rating system could be considered as to provide due recognition to most promising technology implementers.

3.2.3.2 Non Financial Measures

Policy, legal and regulatory measures:

c) Barrier*: Inadequate regulatory framework and insufficient enforcement*

Measure*: Develop appropriate regulatory mechanisms to promote mitigation technologies*

Developing appropriate regulatory mechanisms to promote mitigation technologies is a measure to address the lacunas in the existing regulatory framework and ensure efficient enforcement. Legal and regulatory framework should be designed so as to encourage continuous improvement of resource and energy efficiency and increase the energy contribution from renewable energy sources.

Measures to improve institutional and organizational capacity

d) Barrier*: Lack of professional institutions and limited capacity in existing institutions*

Measure*: Strengthen institutions and develop capacity*

Almost all the professional service providing institutions are currently confined to the Western Province. However, these services need to be made available in the outstations as appropriate to enable meeting the impending demands. Empowerment of employees at middle level for decision making will be vital for the success of technological innovations. However, such empowerment should be preceded by enhancing knowledge and skills of the personnel involved with such technologies. Rewarding the institutions for implementation of new technologies will enable motivating more industries to follow suit.

Establishing industry-university partnership for knowledge sharing and also to engage the academia in preparation of strategies and selection, assessment & verification of technologies will be a positive approach in technology diffusion.

Measures to improve human skills

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

Measure*: Focus on technical education and adequate awareness, training and competence development*

Focus on technical education on vocational and tertiary level through the national apprentice programme, technical colleges and vocational training centres to create adequate awareness and technology related training. Establish a national standardization scheme for technicians. Overseas training and exchange of training specialized for new technologies may also be considered to overcome this barrier.

Measures to address technical barriers

f) Barrier*: Poor operations and maintenance facilities*

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

Proper operations and maintenance system is a vital requirement for new technologies and equipments. Most of new technologies are integrated with sophisticated computer control systems. Regular service and maintenance is critical factor to maintain the desired efficiency level over a long period of time. In addition, after sale services and availability of spare parts are very important factors for efficient and continued use of the equipments.

g) Barrier*: Inadequate standards, codes and certification*

Measure*: Get the service from international certification, set up local institutions*

Provide capacity building for the local institutions responsible for setting up standards, codes, certifications and also provide assistance for accreditation through the expertise obtained from international organizations. It will facilitate development of appropriate standard and codes and encourage industries to seek certification.

Measures to increase information and awareness

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

Measure*: 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 programme to cover energy efficient technologies 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.

3.3 Barrier Analysis and Possible Enabling Measures for Technology 2: Variable Speed Drives (VSD) for Motors

3.3.1 General 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 requirements 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 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 for optimizing the operation.

Motor driven pumps and fans controlled by variable speed drives, as described above, can achieve high energy savings. 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 processes unless high precision of speed is required) the energy requirement can be reduced by almost 50%. This is a typical application in withering process of tea manufacturing. Most of the pumping applications can also achieve this type of savings if the speed is reduced, as reduced speed will not pose a problem because pumps generally operate only intermittently at full speed. However, since average electronic drives generally produce non-sinusoidal current wave form, it is preferable to use motors for such application for better life span.

3.3.2 Identification of Barriers and Measures for the Technology

The barriers and measures identified for '*Variable Speed Drives for Motors'* and 'Energy Efficient Motors' are same due to similarities in two technologies. Both technologies are used for improving efficiency of motors and their applications. As a result, identified barriers and proposed enabling measures are essentially identical. The process followed for identification of barriers and measures for this technology is also same as that of for the Technology 1. Since the barriers and measures described for 'Energy Efficient Motors' are equally applicable to 'Variable Speed Drives for Motors' these are not repeated for obvious reasons.

3.4 Barrier analysis and possible enabling measures for Technology 3: Biomass Residue Based Cogeneration Combined Heat and Power (CHP)

3.4.1 General 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 other products such as pulp and paper from the wood industry. Another important contribution is from post consumer residue streams such as construction and demolition wood, pallets used in transportation, and the clean fraction of municipal solid waste (MSW).

The generation of energy requirement in a rubber processing factory using saw dust can be cited as an application of CHP. Saw dust is a waste material from saw mills which has the potential of creating several environment issues if not properly managed. The average thermal requirement of the rubber processing factory is estimated as 1720 kW, and its average electrical power requirement is 1138 kW, giving a heat to power ration of about 1.5:1. The proposed CHP plant will run at a constant load of 2250 kW electricity (net) and excess electricity generated could be fed into the national grid. Process stream will be available at a constant rate of 3375 kW. Steam in excess of the demand will be either used for preheating of combustion air or boiler feed water or wasted in not utilized. The design capacity factor of the plant is 0.8, while overall efficiency is 34.5% (13.8% electric, 20.8% thermal).

Through the application of CHP in Sri Lanka, Greenhouse gas (GHG) emissions could also be reduced by the equivalent of about 11,300 t CO_2 per year. The lower cost of energy from cogeneration systems could be a key to the survival of local industrial plants in today's competitive environment. The estimated cost of electricity delivered by the CHP plant is US$ 0.04/kWh whereas the estimated cost of thermal energy is US$ 0.019/kWh, both of which are lower than the corresponding cost of grid electricity at

US$ 0.044/kWh and the cost of furnace oil-based thermal energy at US$ 0.021/kWh. Therefore, this technology can be considered as a highly cost effective alternative energy generation method.

3.4.2 Identification of barriers for Biomass CHP

A total number of seven (07) key barriers have been identified through a stakeholder consultation which involved analyzing causal relations and market map. Barrier identification has been supplemented by literature reviews and expert inputs as well. The key barriers thus identified have been classified into hierarchy of categories which include two (02) economic & financial barriers, two (02) policy, legal & regulatory, two (02) social, cultural & behavioral and one (01) information & awareness barriers. These barriers are discussed below in detail.

3.4.2.1.1 Economic and financial barriers

a) High capital cost

The initial cost of investment varies widely depending on the nature of application and considered to be very high. Therefore, the need for initial high investment can be identified as one of the major barriers. As there is an overly competitive and aggressive business environment, where economic variables play a major role, an uncertainty in the external environment can be witnessed. These variables include GDP (PPP, official exchange rates, real growth, per capita income), labor force, unemployment rate, population below poverty line, average household income, inflation rate etc. This could be very challenging to organizations trying to adopt new technologies.

b) Finance resource constraints and lack of incentives

Lack of financial resources and incentives for adoption of new technologies is another critical barrier. In the absence of high demand which has consequences on supply, which is an imperfect market conditions where a high barrier to entry and exit prevails. Thus the market for CHP is considered imperfect. Existence of poor marketing infrastructure is also identified as a related barrier.

3.3.2.1 Non financial barriers

Policy, Legal and Regulatory barriers

c) Legal issues related to felling and transport of trees and obtaining permits

The legal requirement of obtaining permits to transport timber appears to be a disincentive for promoting this technology and tends to discourage the potential users of biomass for energy generation. Since the process of obtaining permits to transport timber appears to be cumbersome and complicated, the transportation difficulties should be eliminated by simplifying the process.

d) Inadequate legal, regulatory framework and insufficient enforcement

Use of renewable energy in the industry sector is not mandatory and all related initiatives are purely voluntary. The absence of a regulatory framework provides less inducement for industries to utilize this technology.

Social, Cultural and Behavioral barriers

e) Resistance to change and lack of confidence in new technologies (High Risk Perception)

Industries are reluctant to introduce non familiar technologies which are not proven in the local context. There should be some mechanism to encourage the use of this technology by the relevant industries through development of confidence by show casing success stories. Also many industries resist change as they are comfortable with maintaining the status quo until they are fully convinced about the extra benefits of the new technology.

f) Reduction of food crop cultivation and shift to fuel crops such as Gliricidia

The high prices offered to fuel crops may divert the farmers to cultivation of non food crops such as Gliricidia. Such a scenario would contribute to reduced food supply thus impacting upon food security.

Information and Awareness barriers

g) Limited information, awareness, feedback and difficulties in comprehending Technical Communication

Awareness on proven technologies is lacking among local industrialists. There is inadequate access to such technical information particularly to the potential service providers and users of the technology. This hampers critical assessment and screening of available technological options for the purpose of identifying most suitable technology for each application.

3.4.3 Identified Measures

Identification of required measures to overcome key barriers has been done through a stakeholder consultation by using Logical Problem Analysis (LPA) methodology as described in the TNA Guidebook 'Overcoming Barriers to the Transfer and Diffusion of Climate Technologies' (please see Annex I). Thus measures thus identified were classified into hierarchy of categories and prioritized based on their significance.

These measures should be assessed based on a number of aspects. Most important among these aspects are consequences on the society (a socio-economic assessment) and a financial assessment for the benefit of the future owners and users of the technology. The financial assessment is often undertaken through Cost-Benefit Analysis and/or a Cost-Effectiveness Analysis. Since most of the policy

decisions are tend to be based on optimizing return on investment such assessments are necessary for the policy making process.

Other consequences such as impacts on resource use, the environment, fiscal balances, trade balances and employment etc. may also be included in the assessments. An indication of the relevant consequences that should be addressed may be obtained from the national development objectives while consulting policy-makers with regard to such aspects.

Measures to overcome barriers are elaborated as follows.

3.4.3.1 Economic and Financial Measures

a) Barrier*: High capita; costs*

Measure*: Government tax policy reforms for capital cost reduction*

The government may consider creating an enabling policy environment by reviewing and reforming the appropriate tariff policies with a view to reduce the capital costs by lowering the taxes on equipments. Such initiatives have often found effective at local, national and international level, as economic inducements are essential for technological innovations.

b) Barrier*: Financial resource constraints and lack of incentives*

Measure*: Set up a development bank and provide soft loan scheme to promote biomass CHP*

A mechanism in the form of a development bank should be established and a green credit line be made available for industries to enable accessing necessary financing. Since the requirement of collaterals appears to be a constraint in availing credit facilities, a loan guarantee system need to be explored.

The government may consider seeking assistance from international financial organizations such as the: World bank, ADB etc. for a low interest credit line to be channeled through the development and commercial banks to enable providing required financing on concessionary terms to the industries to invest in new technologies.

Non Financial Measures

Policy, Legal and Regulatory

c) Barrier*: Legal issues in felling and transport trees and obtaining permits*

Measure*: Set up an appropriate regulatory mechanism to streamline biomass supply chain.*

The existing procedure for obtaining permits to transport timber is complicated and acts as a disincentive for promoting biomass as fuels. Therefore, streamlining the procedure involved with issuing timber transport permits and eliminating the difficulties should be explored to promote and popularize this technology.

d) Barrier*: Inadequate legal, regulatory framework and inefficient enforcement*

Measure*: Establish appropriate regulatory mechanisms to promote mitigation technologies*

Introducing appropriate legal and regulatory mechanisms so as to promote application of proposed mitigation technologies will enable overcoming reluctance of the industrialists to adopt the relevant technologies. However it should be supported by efficient enforcement and market based instruments. Legal and regulatory framework should encourage continuous improvement of resource use and energy efficiency and increase the contribution from renewable energy sources.

Social, Cultural and Behavioral

e) Barrier*: Resistance to Change and Lack of Confidence in New technologies (High Risk Perception)*
Measure*: Build up confidence among industries in new technologies and publish local success stories and role models*

Confidence building among industries is a vital aspect in introducing new technologies. Demonstration projects and publishing success stories are seen as essential tools of convincing the potential technology users as “seeing is believing”. Renewable energy promotion agencies such as Sri Lanka Sustainable Energy Authority needs to provide necessary technical, technological, project management and supply chain management support to industries at initial stage of technology adoption as majority prefers to maintain the status quo without exploring innovations.

f) Barrier*: Reduction of food crop cultivation and shift to alternative crops such as Gliricidia*
Measure*: Promote next generation biomass resources*

When the biomass products are in high demand as a primary energy source for the industry sector, farmers would prefer cultivation of energy crops by moving away from cultivating food crops. This would create social as well as economic issues leading to insecurity of food supply especially to the low income families living in the rural areas. Therefore, biomass based technologies needs to be diversified to promote using second generation biomass products such as agriculture and industrial residues and forestry wastes.

Information and Awareness

g) Barrier*: Limited information, lack of awareness, feedback and difficulties in comprehending technical details*
Measure*: Promote technology through energy associations, industry associations and stakeholders*

Networking at different levels, cluster arrangements, involvement of professional bodies could play an important role in creating awareness and information dissemination. The Energy Service Companies (ESCOs), Trade Associations and the Sustainable Energy Authority may lead the networking process and communication between international technology developers. Such a network shall provide a enabling platform to bring all the stakeholders together which will facilitate information sharing and feed back

3.5 Linkages of the barriers identified

Barriers which are common to all three technologies are highlighted below. Barriers and measures related to energy efficient motors and variable speed drive technologies are more or less the same. However, there are a few unique barriers applicable only to biomass CHP.

3.5.1 High capital costs

Need for high capital investment is a common barrier for all three technologies. Most of the industries have a reluctance towards investing on new technologies because of unstable global economic conditions. Energy Efficient Motors (EEM) and Variable Speed Drives (VSD) technology related equipments are not locally manufactured but are imported.

3.5.2 Lack of financial resources and incentives

This barrier is closely linked with the previous barrier and it is common for all three technologies. Although this is common to all three technologies, it has more relevance to Biomass CHP technology because cost of investment of EEM and VSD can be reduced by manipulating government tariff regimes.

3.5.3 Insufficient regulatory framework and weak enforcement

Insufficient regulatory framework and weak enforcement of existing regulations is another barrier which is considered common to all three technologies. EEM and VSD are energy efficiency improvement technologies in industrial electrical energy applications whereas Biomass CHP is a renewable energy generation technology for both electrical and thermal energy applications. Insufficient regulatory framework and weak enforcement is a common barrier to promote energy efficiency and increase the renewable energy share of the industry sector.

3.5.4 Lack of and limited institutional capacities

Lack of and limited institutional capacity of the agencies responsible for technology implementation is a common barrier for all three technologies. However, it is of more relevance to EEM and VSD technologies. Availability of institutional support with required capacity appears to be adequate with regard to biomass CHP technology. .

3.5.5 Lack of skilled personnel for technology implementation and inadequate training for maintenance

This 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 the technology related equipments to maintain efficiency level of technologies is a critical barrier.

3.5.6 Poor operations and maintenance facilities

Availability of adequate operation and maintenance facilities in the respective industries for new technologies is a common barrier for all new technologies. Most of the new technologies are equipped with sophisticated electronic and computer devices. Unavailability of proper operation and maintenance facilities, service providers and spare parts for such technological advances are barriers to disseminate and popularize these technologies among industries.

3.5.7 Inadequate standards, codes and certification

Inadequate standards, codes and certification for EEM and VSD technologies are barriers to build confidence and trust of industries on the respective technologies. In the absence of proper standards or certification system to ensure the level of technological and economic efficiency achievable by using these technologies, potential users may lose confidence of the technology by using inferior quality products.

3.5.8 Inadequate information, awareness, feedback and difficulties in comprehending technical communication

Inadequate information, lack of awareness, no access to customer feedback and difficulties in comprehending technical details is a common barrier for all three technologies. These technologies are not properly diffused among industries due to lack of communication and interactions among the technology users.

3.6 Enabling framework for overcoming the barriers in industry sector

The common barriers already identified in section 3.5 above are further addressed below in order to understand potential enabling measures to overcome these barriers. Common barriers are broadly categorized as, high capital costs; lack of financial resources and incentives; insufficient regulatory framework and inadequate enforcement; lack of and limited institutional capacities; lack of skilled personnel for technology implementation and inadequate training for maintenance; poor operation and maintenance facilities; inadequate standards, codes and certification; inadequate information, lack of awareness, no access to consumer feedback and difficulties in comprehending technical details
Enabling framework for the common barriers is provided in Table 3.5.

Table 3.5: Enabling framework for the common barriers – Industry Sector

No	Broad/common barriers	Enabling framework	Technology
1.	High Capital Cost	Enabling Government Tax Policy for reduction of capital costs for high efficient and sustainable technologies	EEM, VSD, CHP
2.	Lack of Financial Resources and Incentives	1. Availability of financial instruments and credit facilities, tariff concessions and subsidies 2. Set up development Bank and provide concessionary credit facilities to promote Biomass CHP	EEM, VSD, CHP
3.	Insufficient Regulatory Framework and Insufficient Enforcement	1. Establish appropriate regulatory mechanisms to promote mitigation technologies 2. Set up appropriate regulatory mechanism to stream line biomass supply chain	EEM, VSD, CHP
4.	Lack of and limited Institutional capacity in existing ones	Strengthen Institutions and Develop Capacity	EEM, VSD, CHP
5.	Lack of Skilled Personnel for Technology Implementation and Inadequate Training for Maintenance	Focus on Technical Education and Adequate Awareness, Training and Competence Development	EEM, VSD
6.	Poor Operations and Maintenance Facilities	Set up factory level operational and maintenance management system with registered after sale services providers and spare parts suppliers	EEM, VSD
7.	Inadequate Standards, Codes and Certification	Secure service from international certification agencies and set up local institutions	EEM, VSD
8.	Inadequate Information, Awareness, Feedback and Difficulties in Comprehending Technical details	1. Energy labeling and standards, promote awareness through demonstration projects 2. Promote Technology through Energy Associations, Industry Associations and Stakeholders	EEM, VSD, CHP

Enabling framework for common barriers in detail:

1. Enabling Government Tax Policy for reduction of capital costs for high efficient and sustainable technologies

Government tax policy reforms would be helpful in reducing the high capital costs as economic inducements are considered most effective measures which can be operated at local, national and international level. Any revenue loss to the Government will be compensated by indirect savings through national level energy saving and industries ability to manufacture products with low cost having edge on competitive export market.

2. Availability of financial instruments and credit facilities, tax reduction and subsidies

Credit schemes on concessionary terms and necessary financial instruments are required to provide financial support to industries. Industries must be promoted to improve their resource efficiency.

3. Set up development Bank and provide credit on concessionary terms to promote Biomass CHP

Providing enabling financial instruments and concessionary credit schemes, tax reduction and subsidies will be an effective measure to overcome the challenge of lack of financial resources and incentives. Industries can be provided tax holidays for a limited period during the initial stage of their fuel switch to biomass as a promotional measure to encourage use of renewable energy resources.

4. Establish an appropriate regulatory mechanism to promote mitigation technologies

Having appropriate regulatory framework and effective implementation mechanisms will be an effective means of promoting adoption of mitigation technologies. Legal and regulatory framework thus developed should encourage continuous improvement of resource and energy efficiency and increase the energy contribution from renewable energy resources.

5. Set up appropriate regulatory mechanism to smooth the supply chain of biomass

It is recommended to streamline the regulatory processes to ensure uninterrupted supply of biomass in order to promote adoption of GHG mitigation technologies in industries through fuel switching.

6. Strengthen institutions through capacity development

Strengthening institutions through capacity building would address the barrier related to lack of professional institutions with required skills and capacity. Empowerment of employees at the middle level upon providing adequate knowledge at university level and skills development through in-service training would enhance institutional capacities. Improving co-ordination between institutions and industries involved with implementation of technologies woul;d also enable overcoming the challenge of weak institutional capacities. In addition, it is important to make these institutes aware of climate change related issues, impacts and possible mitigation technologies.

7. Focus on technical education and adequate awareness, training and skill development

The issues related to lack of skilled personnel for technology implementation and maintenance is proposed to be addressed through focusing on technical education and national standardization for technicians. Providing overseas training and twining arrangements with specialist organizations are some training avenues that could be explored. Adequate capital investment on training facilities locally would facilitate sustaining skill development efforts on long run.

8. Set up factory level operational and maintenance management systems with registered after sale services providers and spare parts suppliers

Proper operations and maintenance system is a vital requirement for ensuring continued efficiency of new technologies and equipments. Most of new technologies are equipped with sophisticated computer control systems. Regular servicing and maintenance is a critical factor to maintain their expected efficiency level over the life time. In addition, after sale services and adequate availability of spare parts are very important factors for the sustainability of the technology application at the desired level of efficiency.

9. Avail services of international certification agencies

Setting up of local certification institutes by involving international certification organizations would enable overcoming constraints due to inadequate standards, codes and certification.

10. *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 programs to cover energy efficient technologies 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.

11. Promote Technology through Energy Associations, Industry Associations and Stakeholders

Networking with different stakeholders including Energy Associations, Industry Associations and relevant professional bodies is recommended for promoting technologies. Trade Associations could play a lead role in networking with international technology developers. The Sustainable Energy Authority should be strengthened in order to act as a catalyst for networking and to function as an appropriate platform for stakeholder interactions.

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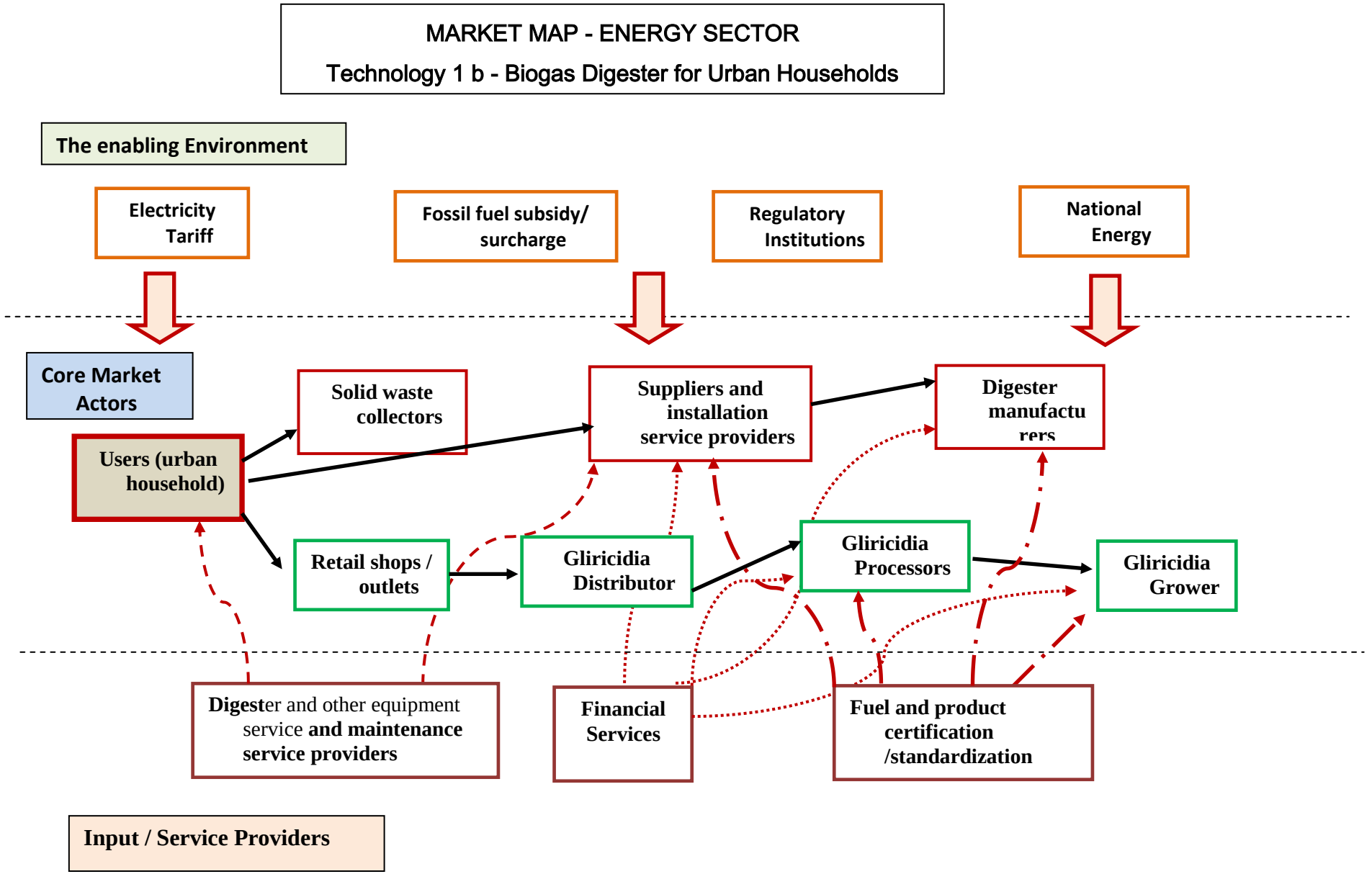
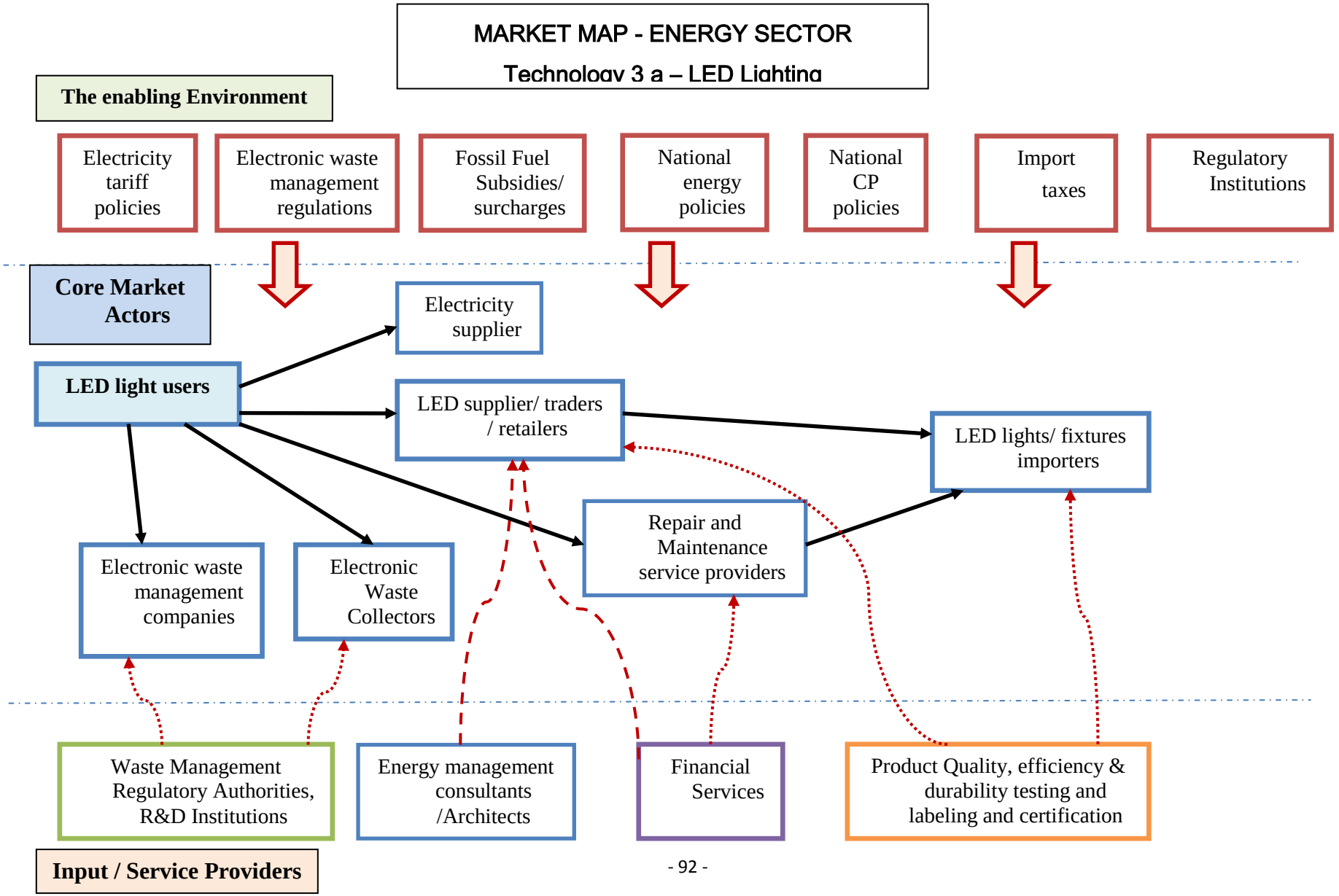
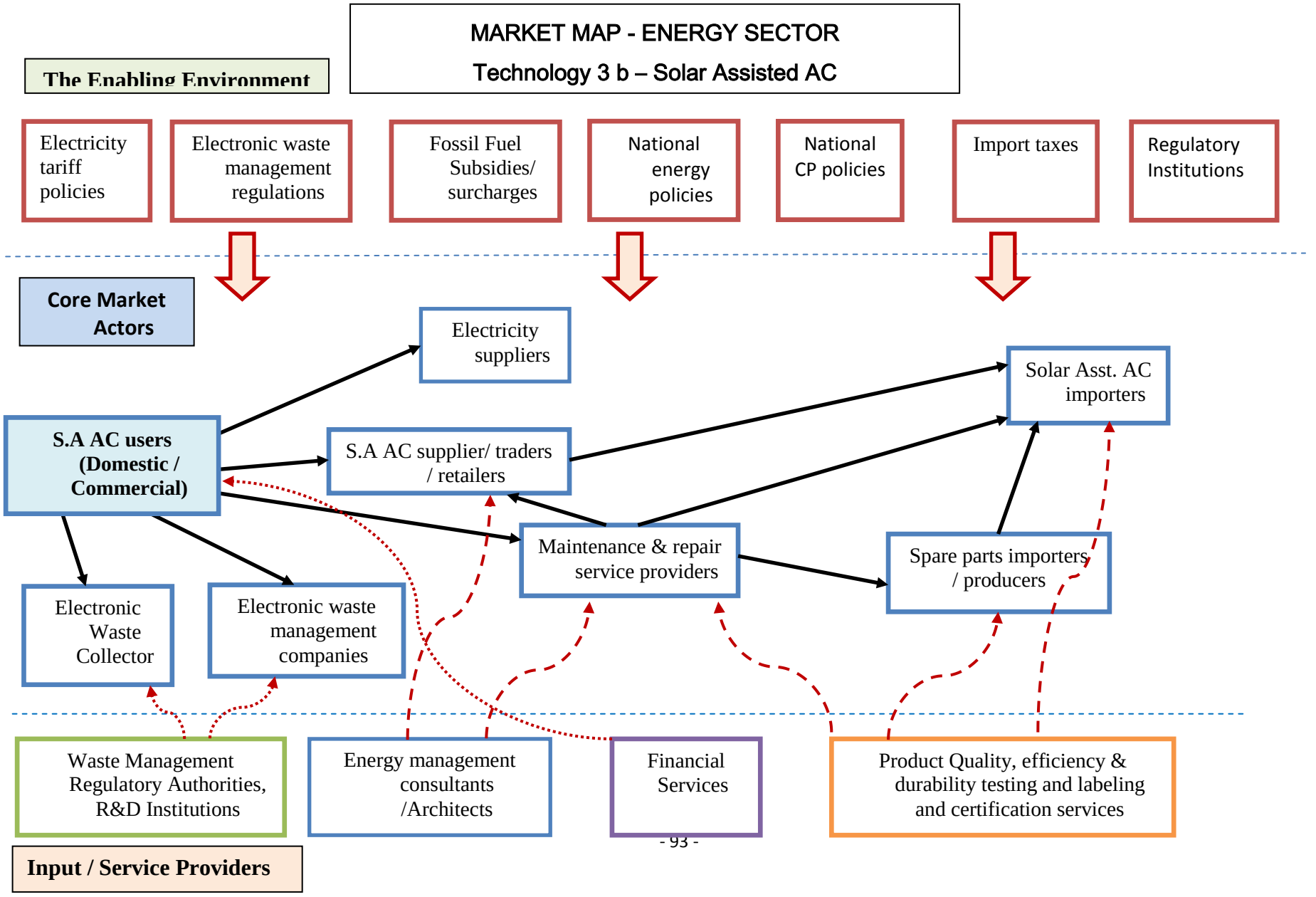
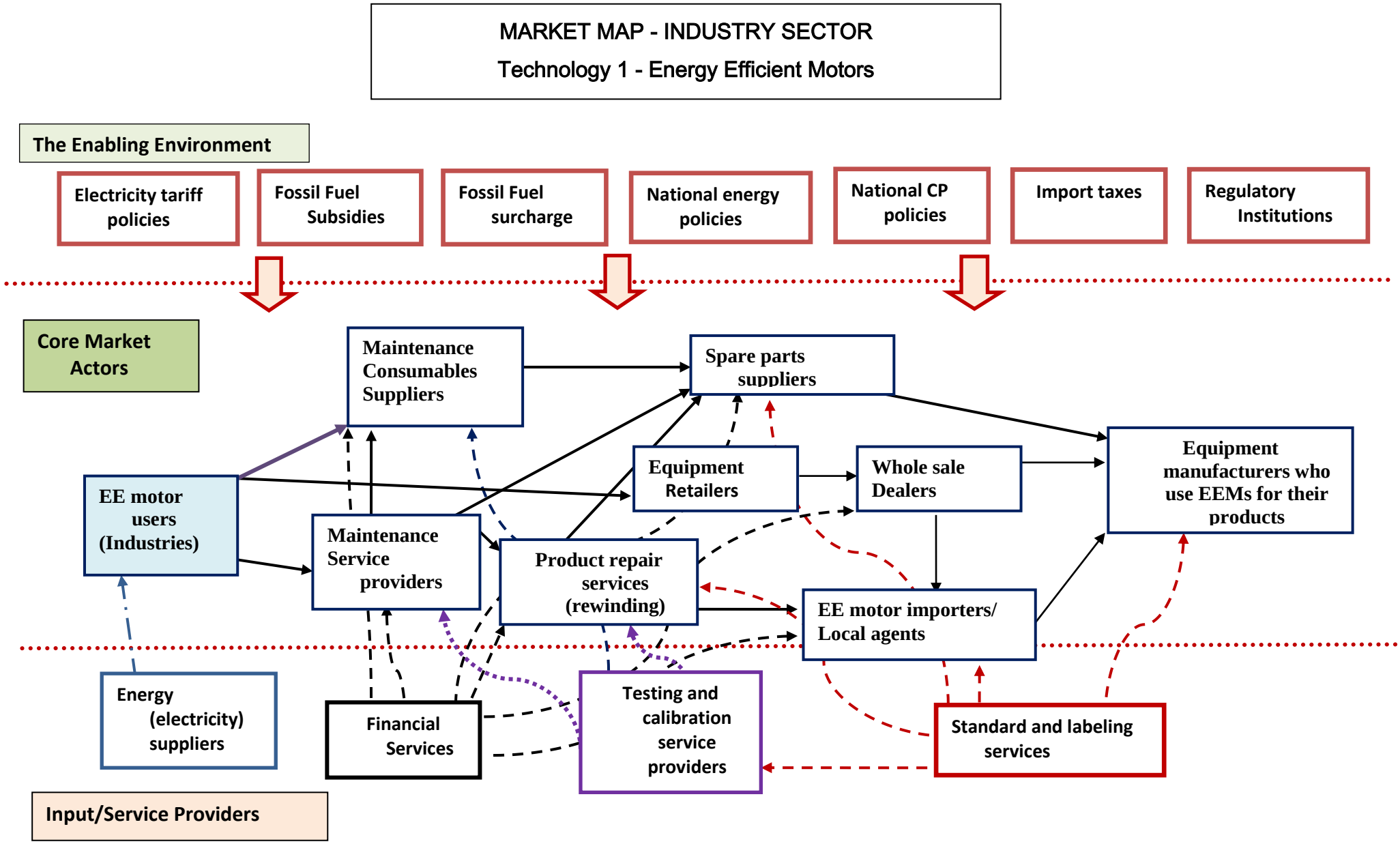
Annex I A

Market Maps


MARKET MAP - ENERGY SECTOR
Technology 1 b - Biogas Digester for Urban Households
The enabling Environment
Electricity Tariff
Fossil fuel subsidy/ surcharge
Regulatory Institutions
National Energy
Core Market Actors
Solid waste collectors
Suppliers and installation service providers
Digester manufactu rers
Users (urban household)
Retail shops / outlets
Gliricidia Distributor
Gliricidia Processors
Gliricidia Grower
Digester and other equipment service and maintenance service providers
Financial Services
Fuel and product certification /standardization
Input / Service Providers

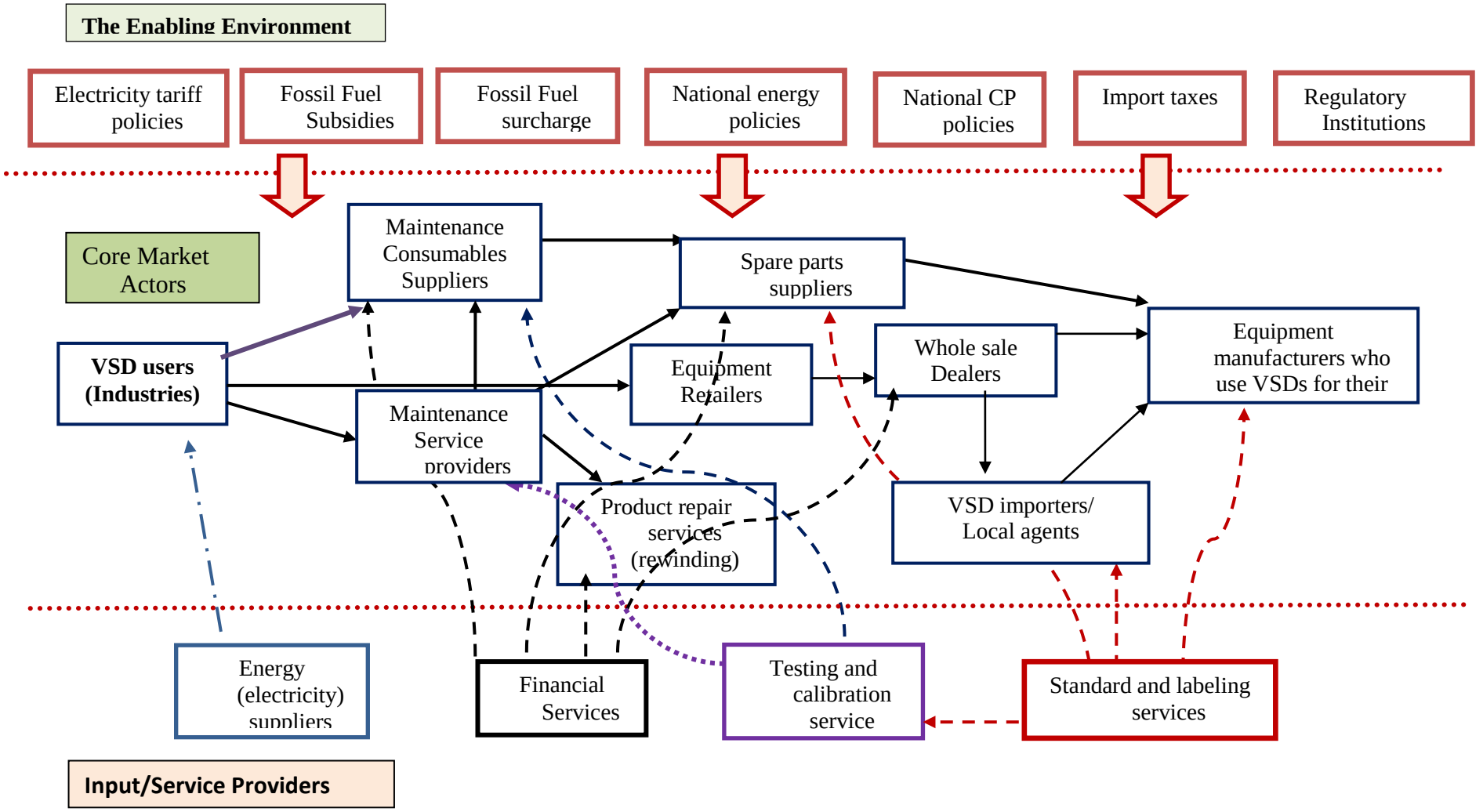

MARKET MAP - ENERGY SECTOR
Technology 3 a – LED Lighting
The enabling Environment
Electricity tariff policies
Electronic waste management regulations
Fossil Fuel Subsidies/ surcharges
National energy policies
National CP policies
Import taxes
Regulatory Institutions
Core Market Actors
Electricity supplier
LED light users
LED supplier/ traders / retailers
LED lights/ fixtures importers
Repair and Maintenance service providers
Electronic waste management companies
Electronic Waste Collectors
Waste Management Regulatory Authorities, R&D Institutions
Energy management consultants /Architects
Financial Services
Product Quality, efficiency & durability testing and labeling and certification
Input / Service Providers

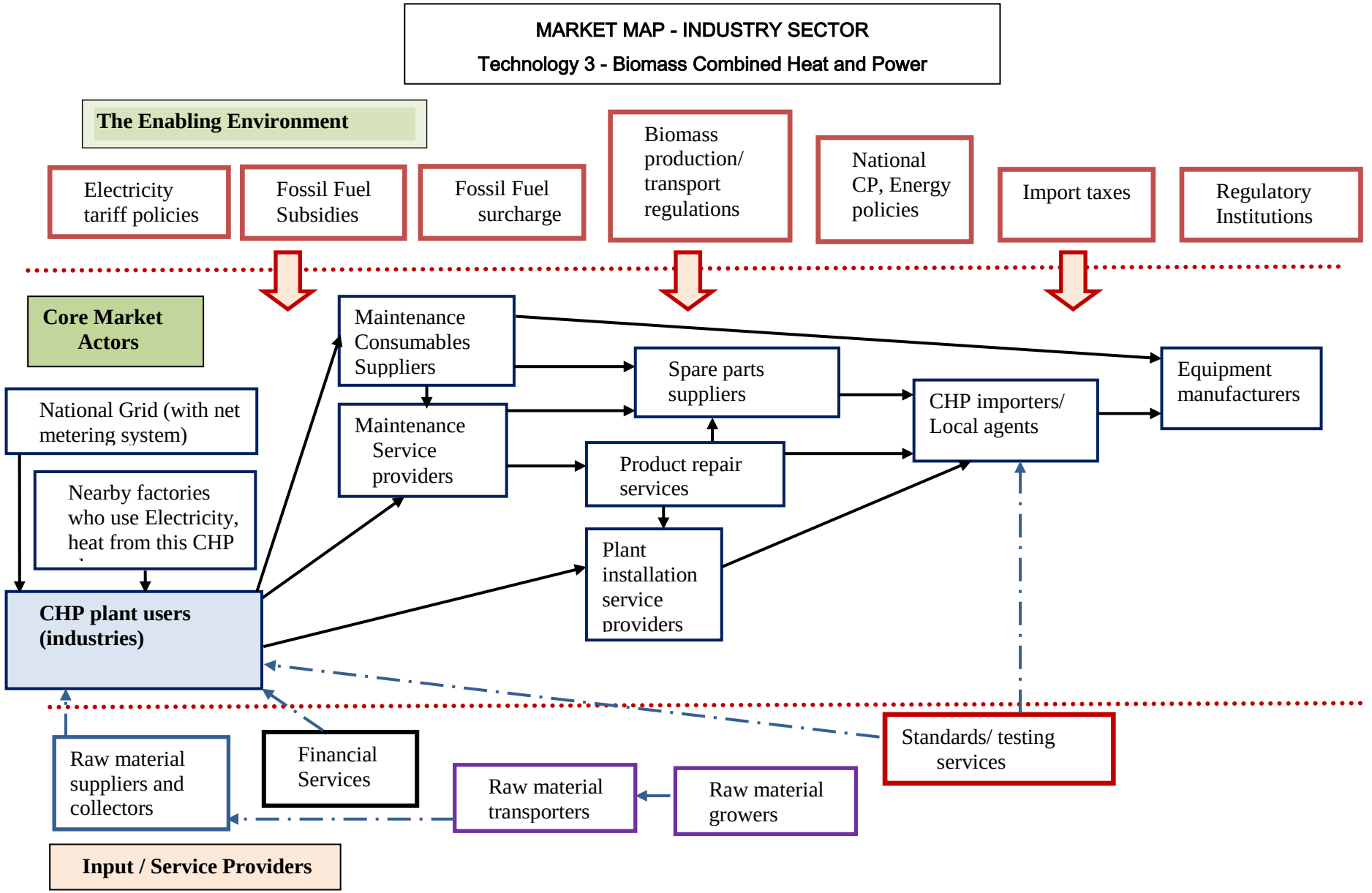

MARKET MAP - ENERGY SECTOR
Technology 3 b – Solar Assisted AC
The Enabling Environment
Electricity tariff policies
Electronic waste management regulations
Fossil Fuel Subsidies/ surcharges
National energy policies
National CP policies
Import taxes
Regulatory Institutions
Core Market Actors
Electricity suppliers
Solar Asst. AC importers
S.A AC users (Domestic / Commercial)
S.A AC supplier/ traders / retailers
Maintenance & repair service providers
Spare parts importers / producers
Electronic Waste Collector
Electronic waste management companies
Waste Management Regulatory Authorities, R&D Institutions
Energy management consultants /Architects
Financial Services
Product Quality, efficiency & durability testing and labeling and certification services
Input / Service Providers


MARKET MAP - INDUSTRY SECTOR
Technology 1 - Energy Efficient Motors
The Enabling Environment
Electricity tariff policies
Fossil Fuel Subsidies
Fossil Fuel surcharge
National energy policies
National CP policies
Import taxes
Regulatory Institutions
Core Market Actors
Maintenance Consumables Suppliers
Spare parts suppliers
Equipment Retailers
Whole sale Dealers
Equipment manufacturers who use EEMs for their products
EE motor users (Industries)
Maintenance Service providers
Product repair services (rewinding)
EE motor importers/ Local agents
Energy (electricity) suppliers
Financial Services
Testing and calibration service providers
Standard and labeling services
Input/Service Providers

MARKET MAP - INDUSTRY SECTOR

Technology 2 - Variable Speed Drives (VSD)




MARKET MAP - INDUSTRY SECTOR
Technology 3 - Biomass Combined Heat and Power
The Enabling Environment
Electricity tariff policies
Fossil Fuel Subsidies
Fossil Fuel surcharge
Biomass production/ transport regulations
National CP, Energy policies
Import taxes
Regulatory Institutions
Core Market Actors
Maintenance Consumables Suppliers
Spare parts suppliers
Equipment manufacturers
National Grid (with net metering system)
Maintenance Service providers
CHP importers/ Local agents
Product repair services
Nearby factories who use Electricity, heat from this CHP
Plant installation service providers
CHP plant users (industries)
Standards/ testing services
Raw material suppliers and collectors
Financial Services
Raw material transporters
Raw material growers
Input / Service Providers

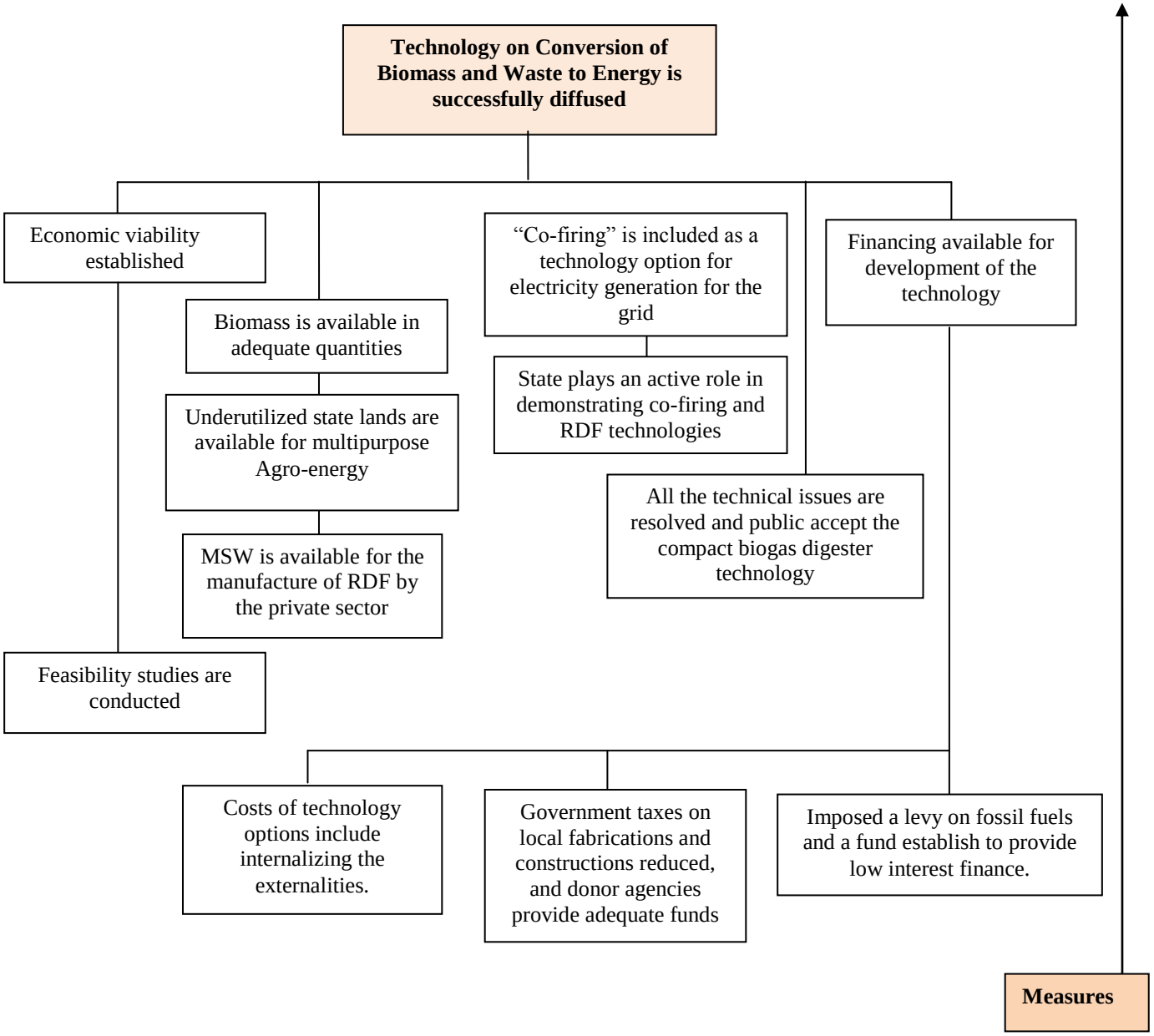
Annex I B

Logical Problem analysis (LPA)

Framework Diagrams

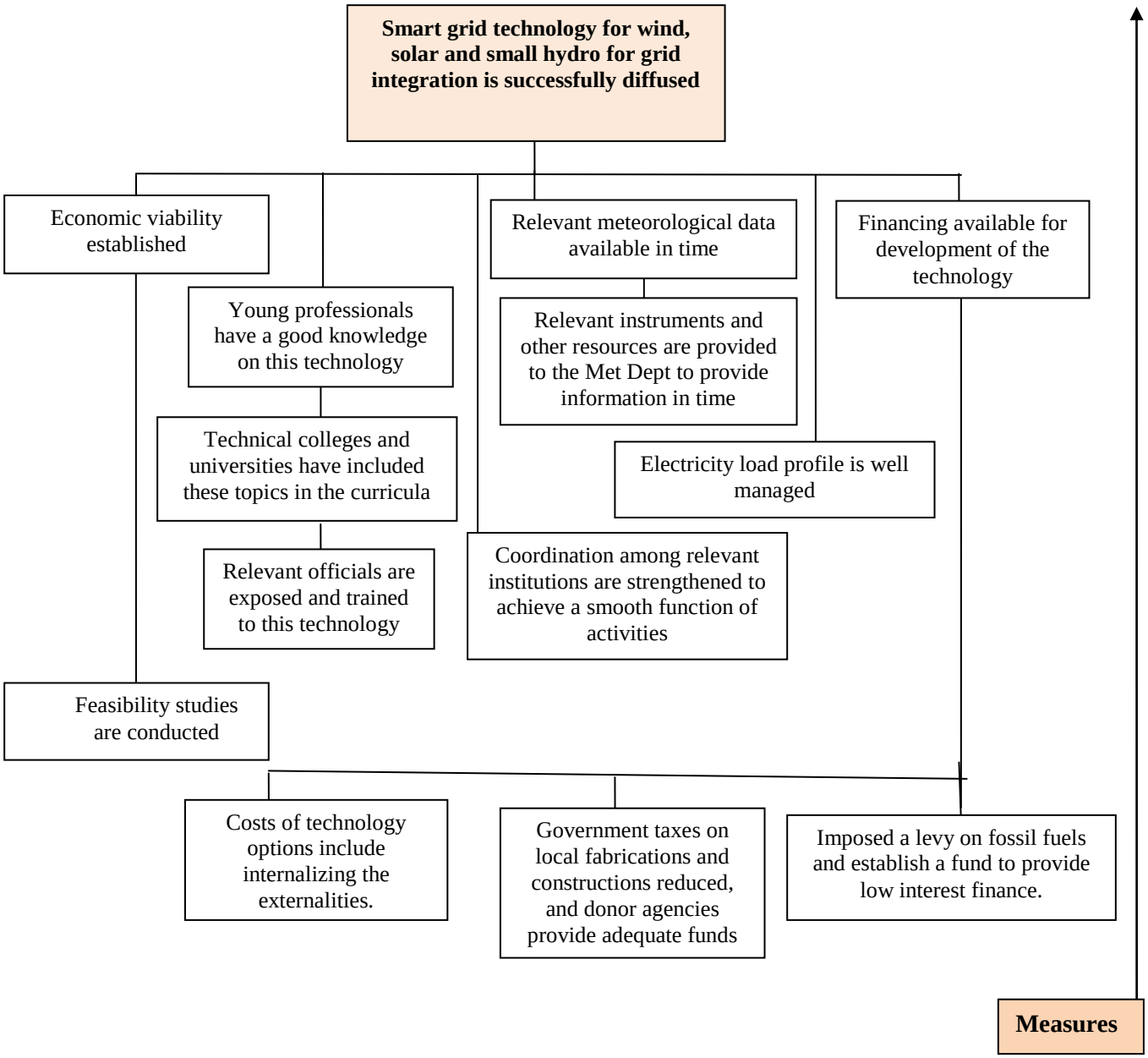
Energy Sector - Technology 1

Figure I: Objective Tree for the Conversion of Biomass and Waste to Energy



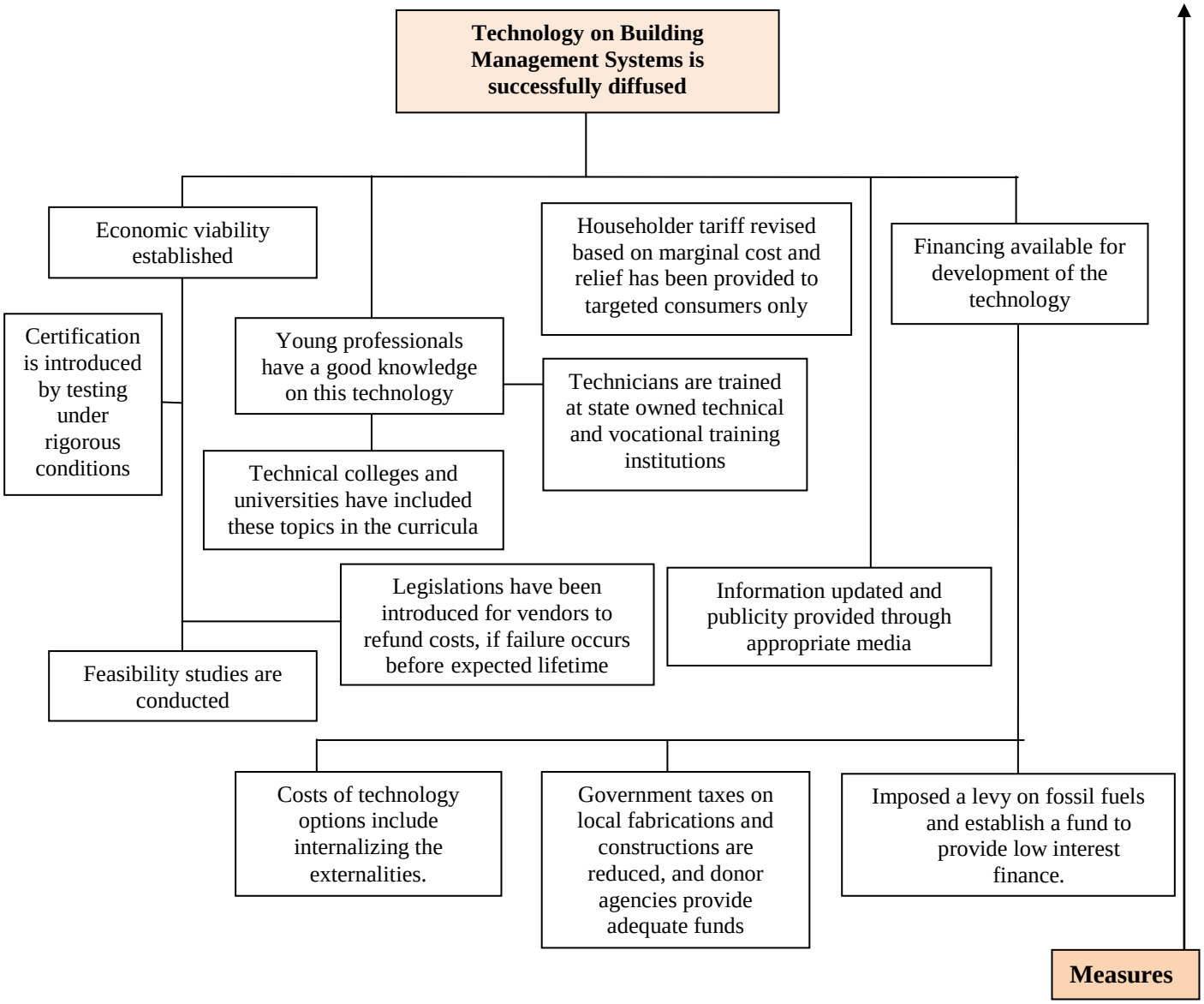
Energy Sector - Technology 2

Figure II: Smart grid technology for wind, solar and small hydro for grid integration



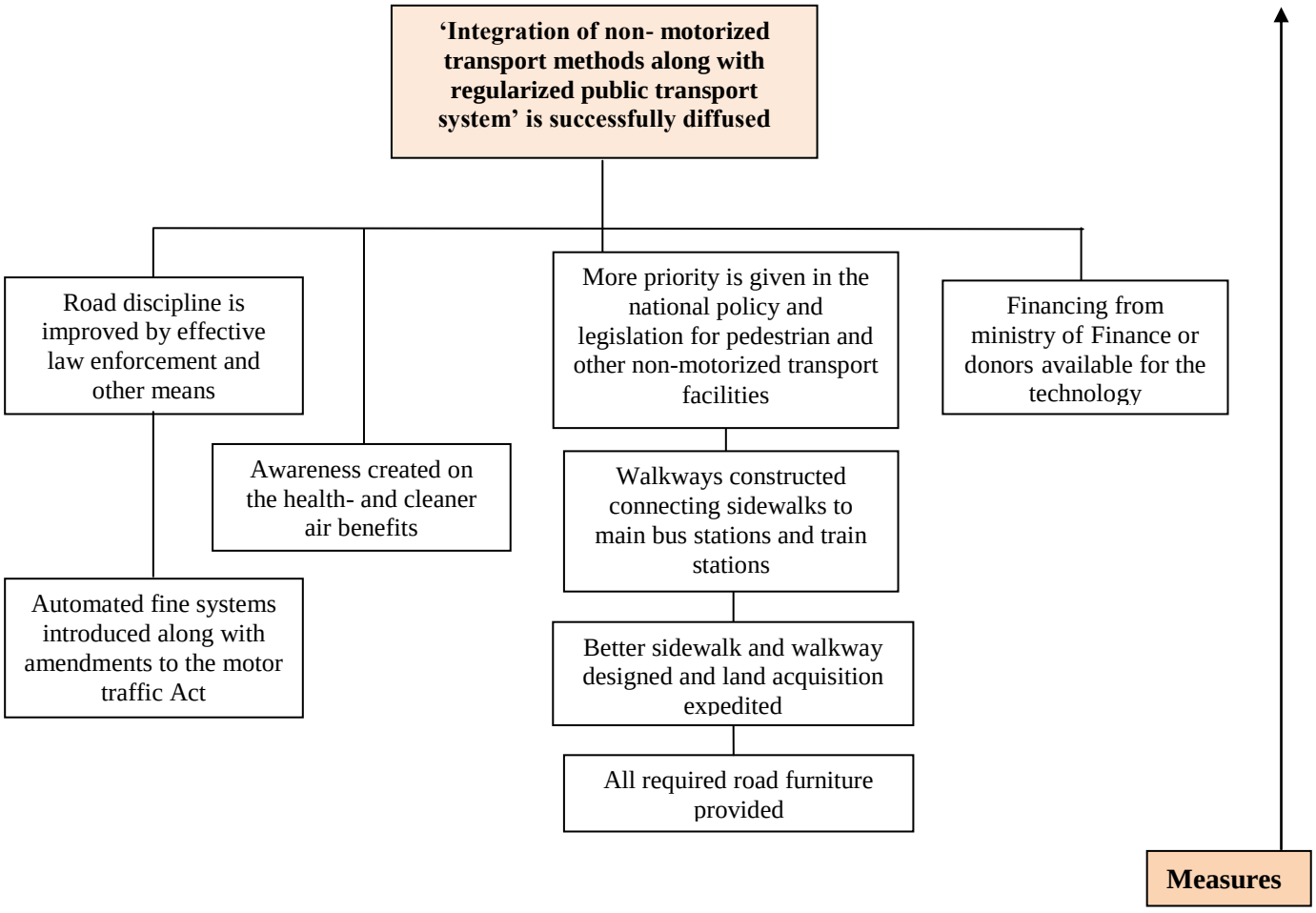
Energy Sector - Technology 3

Figure III: Objective Tree for Technology 'Building Management Systems'



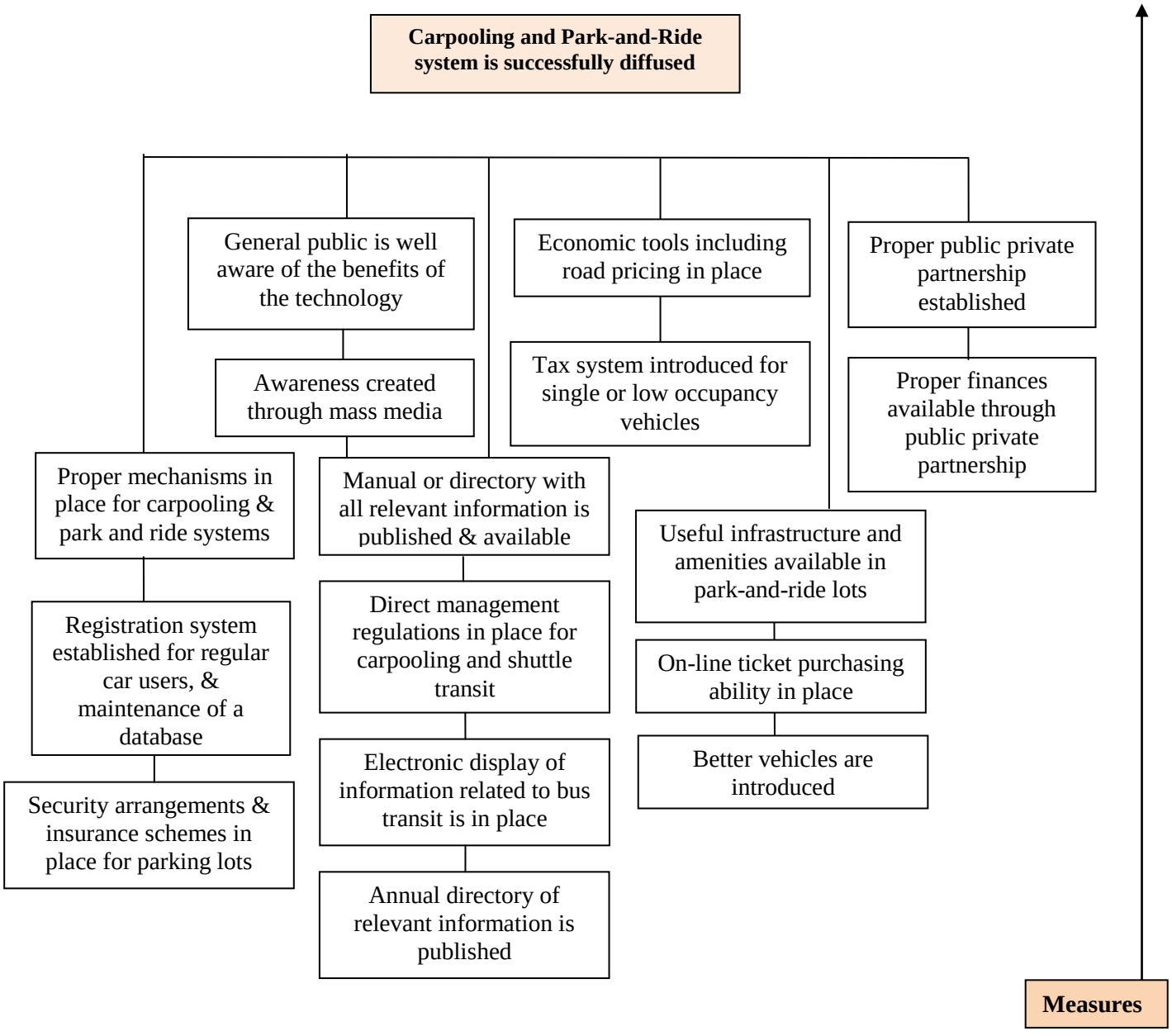
Transport Sector - Technology 1

Figure IV: Objective Tree for Technology 'Integration of non- motorized transport methods along with regularized public transport system'



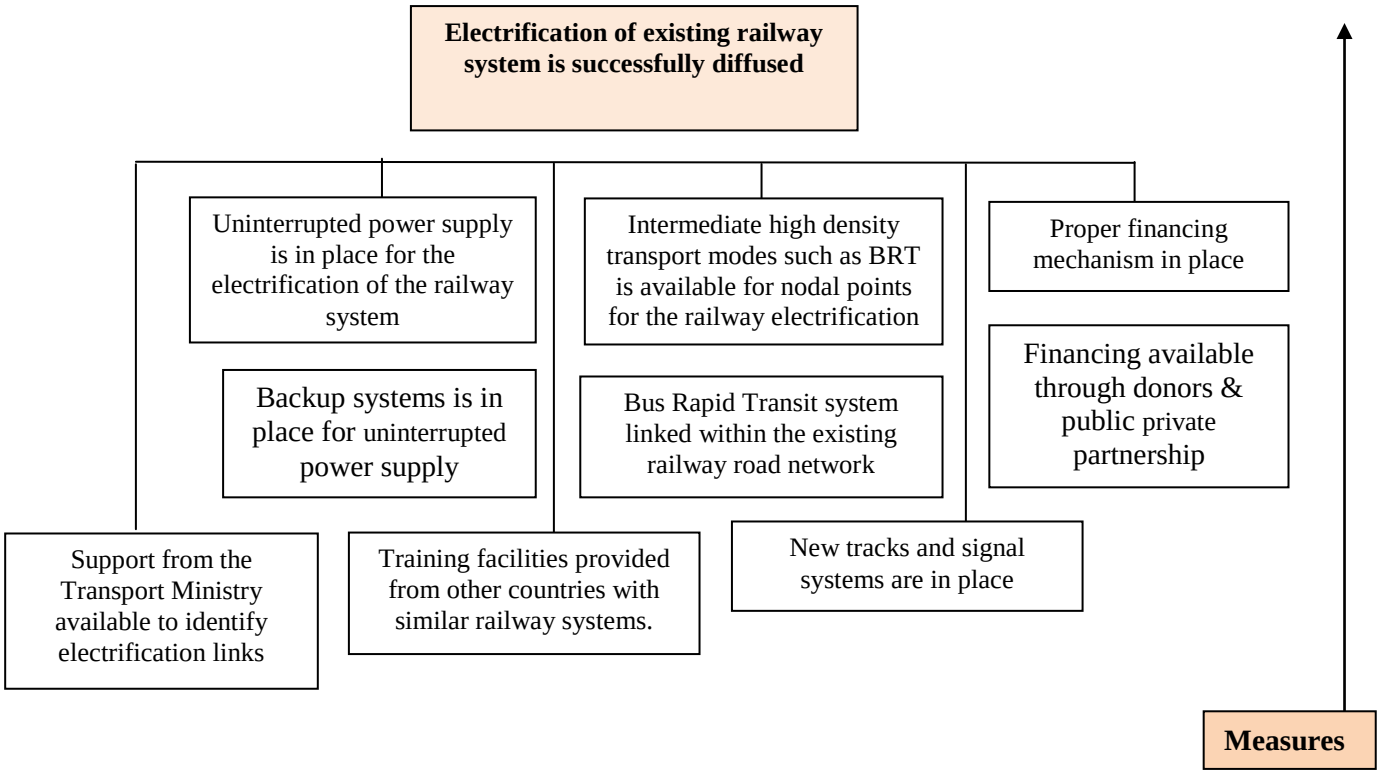
Transport Sector - Technology 2

Figure V: Objective Tree for Technology 'Carpooling and Park-and-Ride systems'



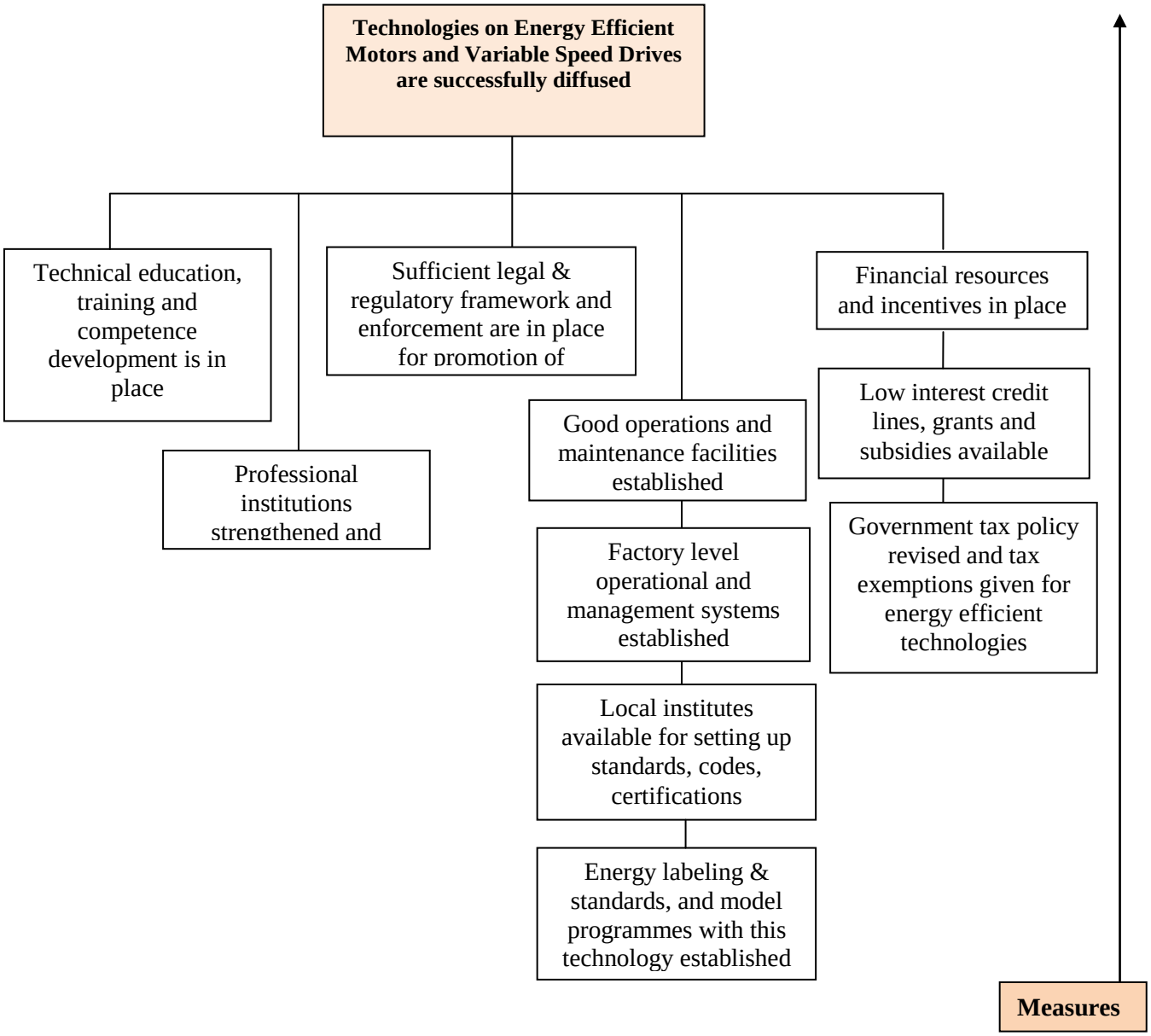
Transport Sector - Technology 3

Figure VI: Objective Tree for Technology 'Electrification of the existing railway system'



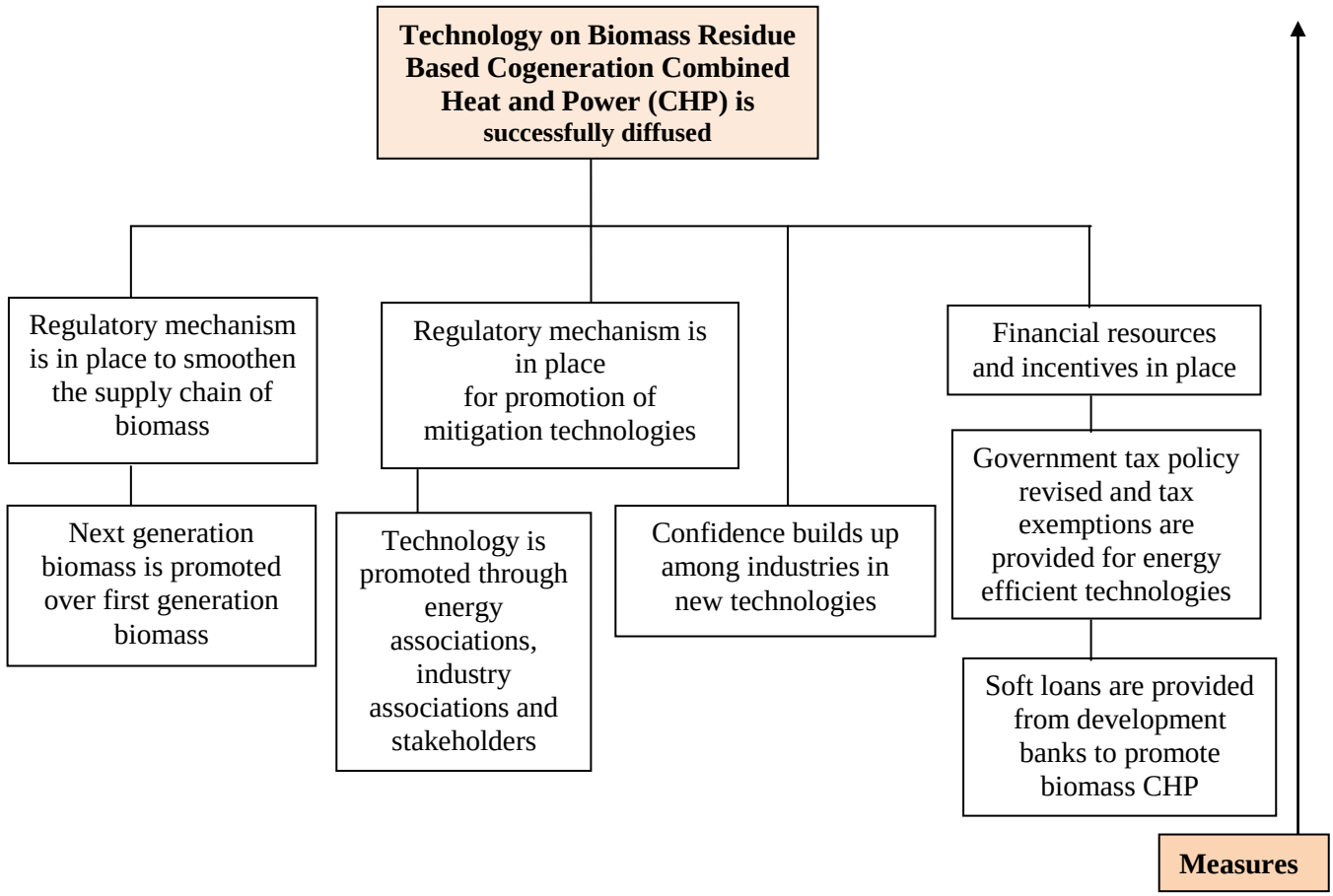
Industry Sector - Technology 1 & 2

Figure VII: Objective tree for technologies 'Energy Efficient Motors' and 'Variable Speed Drives'



Industry Sector - Technology 3

Figure VIII: Objective tree for technology 'Biomass Residue Based Cogeneration Combined Heat and Power (CHP)'



Annex II

List of Stakeholders Involved and their Contacts

ENERGY SECTOR

List of Stakeholders

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

12.	Mr. H.M.G. Herath	Deputy Director General Public Utilities Commission of Sri Lanka	6th Floor , BOC Merchant Tower, St. Michael's Road, Colombo 3
13.	Mr. Nalin Edirisinghe	Director Public Utilities Commission of Sri Lanka	6th Floor , BOC Merchant Tower, St. Michael's Road, Colombo 3

TRANSPORT SECTOR

List of Stakeholders

No	Name	Designation/Institution	Contact Address
1.	Dr. S.N.Bentotage	Senior Lecturer	University of Moratuwa
2.	Mr. K.M.V.J.Priyanjith	Assisting Director (Planning)	M/ PrivateTransport Service
3.	Mr. G.H.P.Dharmarathna	Met.Expert	M/Airport and Aviation
4.	Mr. K.A.B.Pathirathna	Engineer	Sri Lanka Railway Department
5.	Dr.D.S.Jayaweera	Driector General	Department of Development Finace
6.	Mr. Wijaya Samarasinghe	Director/Planning	Sri Lanka Railway Department
7.	Mr.S.P.Sirimana	Assisting Secretary	Ministry of Transport
8.	Mr. A.W. Dissanayake	Director/VET PMT	Department of Motor Traffic
9.	Ms. Amanthi Wickramasinghe	Research Assistant	MOFP
10.	Mr. S.M Werahera	Assistant Director/Air Resources Management Center	Ministry of Environment
11.	Mr. Ranjith Punyasoma	Supervisor/Landscaping	M/Airport and Aviation

INDUSTRY SECTOR

List of Stakeholders

No	Name	Institution	Contact Address
1.	Dr. H.V.P. Wijewardana,	Director Industrial Development Board	Industrial Development Board 615,Galle Road, Katubedda
2.	Mr. Asitha Senevirathne,	Addl. Secretary Ministry of Industry & Commerce	73/1, Galle Rd, Col. 03 Ministry of Industry & Commerce
3.	J.A.A.D. Jayasuriya	HOD NERD	IDB Industrial Estate , Ekala, Ja-ela
4.	Ms. R.D.S. Gunarathna	Asst. Director Ministry of State Resources & Enterprise Development	561/3, Elvitigala Mawatha Col 05
5.	Mr. K. Fonseka,	SRO,ITI	
6.	U. Senarathne	Board of Investment SDD	Level 26, West Tower, WTC, Col. 01
7.	Mr. Priyantha S. Dissanayake	General Manager Plantation Management Ltd Elpitiya Plantations	Plantation Management Ltd Elpitiya Plantations
8.	Mr. Chamila Jayasekara	Sustainable Energy Authority	3G-17 BMICH Bauddhaloka Mawatha, Colombo 07.
9.	Mr. K.J. Wanasinghe	President Plastic and Rubber Institute	No 341/12, Kotte Road, Rajagiriya
10.	Ms. Vishaka Hidallage	Director Practical Action Sri Lanka	05, Lionel Edirisinghe Mw, Kirulapone, Col. 05
11.	Mr. Roshan Salinda	Project Manager Green Movement	No. 9, 1st Lane, Wanatha Rd, Gangodawila, Nugegoda
12.	Mr. P.R. Dabare	Chairman Center for Environment Justice	20A, Kuruppu Road Colombo 08
13.	Ms. Induni Chathupama	Environmental Officer Center for Environment Justice	20A, Kuruppu Road Colombo 08

Annex III

Policy Fact Sheets

ENERGY SECTOR

Policy Fact Sheet 1: National Energy Policy of Sri Lanka

Name of the policy	National Energy Policy of Sri Lanka
Name of the field	Energy
Date effective	October, 2006
Date announced	
Date promulgated	
Date ended	Not applicable
Unit	EEPM, RE
Country	Sri Lanka
Policy Status	In force
Agency	Ministry of Power and Energy
Funding	No
Further information	http://www.futurepolicy.org/fileadmin/user upload/PACT/Laws/Sri Lanka Energy Policy 2006.pdf
Enforcement	
Penalty	
Related policies	Renewable Energy Policy Sri Lanka, Electricity Act
Policy Superseded by	Ministry of Power and Energy
Policy Supersedes	Not applicable
Stated Objective	Ensuring Energy Security, Promoting Energy Efficiency and Conservation, Enhancing Energy Sector Management Capacity, Enhancing the Quality of Energy Services
Evaluation	Not done
Policy Type	Energy
Policy Target	Electrification of Households, Provide targeted Subsidies, Fuel Diversity and Security, Non-conventional Renewable Energy (NCRE) Based Electricity in the Grid
URL	http://www.futurepolicy.org/fileadmin/user_upload/PACT/Laws/Sri_Lanka Energy_Policy_2006.pdf
Legal References	National Energy Policy of Sri Lanka , 2006

Description	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. Specific new initiatives are included in this policy to expand the delivery of affordable energy services to a larger share of the population, to improve energy sector planning, management and regulation, and to revitalize biomass as a significant resource of commercial energy. Institutional responsibilities to implement each policy element and associated strategies to reach the specified targets are also stated in this document. Ministry of Power and Energy has discussed the draft document with a wide group of stakeholders, obtained the views of members of the public and made the necessary amendments before publishing this National Energy Policy and Strategies of Sri Lanka. This National Energy Policy and Strategies of Sri Lanka shall be reviewed and revised after a period of three years.

ENERGY SECTOR

Policy Fact Sheet 2: National Policy on Clean Development Mechanism

Name of the policy	National Policy on Clean Development Mechanism
Name of the field	Clean development
Date effective	drafted in 2009
Date announced	
Date promulgated	
Date ended	
Unit	Climate Change
Country	Sri Lanka
Policy Status	Drafted, not gazette
Agency	Ministry of Environment and Natural Resources, Ministry of Power and Energy,
Funding	Not applicable
Further information	
Enforcement	Ministry of Environment
Penalty	
Related policies	The National Sustainable Development Policy, The National Environment Policy
Policy Superseded by	
Policy Supersedes	Not applicable
Stated Objective	To contribute to sustainable development through developing and establishing the institutional, financial, human resources and legislative framework necessary to participate in Clean Development Mechanism (CDM) activities under the Kyoto Protocol while developing a mechanism for trading “Certified Emissions Reductions” (CER) and “Removal Units” (RMU) earned through CDM activities.
Evaluation	Not done
Policy Type	Energy and Industry
Policy Target	Limiting or reducing emissions,CO2 emission reductions or removals, Save the countries severely effected by the Global warming and Make a compensation for the countries emit CO2 below the levels.
URL	http://www.google.lk/url?sa=t&rct=j&q=cdm%20policy%20sri%20lanka&source=web&cd=1&ved=0CFEQFjAA&url=http%3A%2F%2Fwww.nri.org%2Fprojects%2Fbiomass%2Fconference_papers%2Fcdm-srilanka_kasturiarachchi.ppt&ei=n5bRT9iFLKi6iQeTioCkAw&usg=AFQjCNFTKJ5VlezaonlhlGyLTkm6lHuuFg

Legal References	National Policy on Clean Development Mechanism, drafted in 2009
Description	The Clean Development Mechanism(CDM) is a mechanism defined under Article 12 of the Kyoto Protocol. It is expected that CDM will assist parties Not included in Annex 1; in achieving sustainable development.
	Included in Annex 1; in achieving compliance with their quantified emission limitations & reduction commitments under the Kyoto Protocol.
	CDM Projects should be certified based on emission reductions from activities that are; -Voluntary participation approved by parties involved. -Long term benefits related to mitigation. -Adverse occurrence in absence of the project. -Real & measurable CDM potential in Sri Lanka ;Sri Lanka acceded the Kyoto Protocol on 3rd September 2002 & hence is eligible for CDM In line with the Kyoto Protocol, the National Framework Policy for CDM has been developed. -In 2009 February the drafted policy was published in the papers but still not gazette. According to recent estimates, Sri Lanka has the potential to claim about 6.2million CERs.

INDUSTRY SECTOR

Policy Fact Sheet 1: National Policy on Cleaner Production

Name of the policy	The National Policy on Cleaner Production
Name of the field	Cleaner production
Date effective	2005
Date announced	2005
Date promulgated	2005
Date ended	Not applicable
Unit	CC, RE and EEMP
Country	Sri Lanka
Policy Status	In force
Agency	Ministry of Natural Resources and Environment in collaboration with relevant stakeholders including the National Cleaner Production Centre
Funding	Not applicable
Further information	http://www.ncpcsrilanka.org/home.htm
Enforcement	Ministry of Natural Resources and Environment in collaboration with relevant stakeholders including the National Cleaner Production Centre
Penalty	None
Related policies	National Environmental Act, CDM policy
Policy Superseded by	
Policy Supersedes	
Stated Objective	Reduce consumption pressure, Improve environmental performance and Improve efficiency of water and energy consumption
Evaluation	Not done
Policy Type	Industry
Policy Target	Improve efficiency of water and energy consumption by minimizing wastage and excessive exploitation and use through improving the
	production process of better products and provision of services
URL	http://www.ncpcsrilanka.org/home.htm
Legal References	The National Policy on Cleaner Production

Description	Unlimited and unsustainable production and consumptions pave the way for increasing poverty, disparity in economic development opportunities and affecting the balance of the environmental system is a crucial issue. As a result of unsustainable consumption patterns there is an increasing demand on natural resources. It is necessary to address this problem immediately aligning with sustainable utilization of natural resources while preventing and or minimizing the pollution of the environmental. Accordingly negative impacts caused by unsustainable consumption of natural resources on human health and environment could be minimized. It has been acknowledged globally that application of Cleaner Production practices is conducive for the improvements of productivity hence reducing the production cost. Consequently this will facilitate industrial and services sectors to be competitive in the international market. The Ministry of Environment and Natural Resources combined with all relevant stakeholders including the National Cleaner Production Centre has formulated the National Policy and the Strategy on Cleaner Production for Sri Lanka. The policy states that Cleaner Production principles should be applied to improve the efficiency of natural resource use while maintaining and improving environmental quality.