Kingdom of Cambodia

Ministry of Environment

TECHNOLOGY NEEDS ASSESSMENT AND TECHNOLOGY ACTION PLANS FOR CLIMATE CHANGE MITIGATION

March 2013

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ABBREVIATIONS

AIT	Asian Institute of Technology
CCD	Cambodian Climate Change Department
CDM	Clean Development Mechanism
CRCD	Cambodian Research Centre for Development
CMDGs	Cambodia's Millennium Development Goals
DNA	Designated National Authority
EEZ	Exclusive Economic Zone
INC	Initial National Communication
MAFF	Ministry of Agriculture, Forestry and Fisheries
MCA	Multiple Criteria Analysis
MCDA	Multiple Criteria Decision Analysis
MDG	Millennium Development Goal
MEF	Ministry of Economy and Finance
MIME	Ministry of Industry, Mines and Energy
MOE	Ministry of Environment
MOP	Ministry of Planning
MOWRAM	Ministry of Water Resources and Meteorology
MPWT	Ministry of Public Works and Transport
MRC	Mekong River Commission
NCCC	National Climate Change Committee
NCDM	National Committee for Disaster Management
NIS	National Institute of Statistics
NPRS	National Poverty Reduction Strategy
NSDP	National Strategic Development Plan
RGC	Royal Government of Cambodia
RS	Rectangular Strategy
RUA	Royal University of Agriculture
SEDP	Socio-Economic Development Plan
SNC	Second National Communication
TAP	Technology Action Plan
TNA	Technology Needs Assessment
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
URC	UNEP Risoe Centre

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FOREWORD

Cambodia is highly vulnerable to climate change impacts due to a combination of factors: limited financial and human resources, weak infrastructure, an agriculture-based economy, and limited access to and diffusion of climate-friendly technologies. The Royal Government of Cambodia clearly recognises the threats paused by climate change to the country's social and economic development and is therefore fully supportive of efforts to address climate change at both national and global levels.

Cambodia sees technology development, transfer and diffusion as a necessary prerequisite for a meaningful response to climate change since this will help build resilience as well as promote low carbon social and economic development in the country. In this regard, we support the technology needs assessment, particularly the urgent need for transfer and diffusion of technologies for both adaptation and mitigation to developing countries, in particular, to least developed countries.

Despite the fact that Cambodia's emissions are regionally and globally insignificant, it is important for the country to assess technology needs and to develop technology action plans for climate change mitigation. This is a win-win approach to help Cambodia avoid traditional economic growth models by increasing energy efficiency, promoting renewable energy, and reducing environmental pollution and GHG emissions while sustaining social and economic development of the country.

The present Technology Needs Assessments (TNAs) and Technology Action Plans (TAPs) for climate change mitigation technologies have been undertaken in support of Cambodia’s national sustainable development objectives as stated in its National Strategic Development Plan Update 2009-2013, and complement the Cambodian national policies and plans in mitigating climate change. Specifically, we expect the TNAs and TAPs for climate change mitigation produced under the TNA Project will be used for the following purposes: (1) as roadmaps for policy making for specific priority sectors in mitigation consistent with the country's sustainable development objectives; (2) as support to Cambodia’s position in climate change negotiations in the area of technology transfer; and (3) as a medium to access international sources of funding for the implementation of mitigation activities.As the initial stage, the current TNA aims at assessing technology needs and developing technology action plans for priorities in transport and in energy efficiency. This is a modest but important contribution to the efforts to build low carbon society in Cambodia.

Implementation of the Cambodian TAPs will significantly contribute to the achievement of the Cambodia Millennium Development Goals and national sustainable development objectives as articulated by the RGC. Therefore, our next task is to mobilise resources for their implementation.

I would like to take this opportunity to express our sincere gratitude to all the national stakeholders, particularly the national Climate Change Committee serving as the Steering Committee of this project and the inter-ministerial Mitigation TNA Team, for their support and cooperation in developing this important document. Specifically, I thank the Global Environment Facility (GEF), the United Nations Environment Programme (UNEP), and the Risoe Centre for their

support in preparing the Cambodian TNAs and TAPs. The RGC looks forward to cooperating with all stakeholders to ensure successful implementation of this plan.

Senior Minister, Minister of Environment
Chair of the National Climate Change Committee

Dr. Mok Mareth

Part I: Technology Needs Assessments Report

EXECUTIVE SUMMARY

As a least developed agrarian and rural country, Cambodia is highly vulnerable to the impacts of climate change, yet its emissions are regionally and globally insignificant. While Cambodia has little industry, its main sources of greenhouse gases are agriculture (rice and livestock) and energy processes (supply and transport). However, as a whole these emissions are evenly balanced by carbon sinks. The forest cover is estimated to be at 61% of the total land area, which includes 3.2 million ha of protected areas.

The present Technology Needs Assessment (TNA) for climate change mitigation technologies is undertaken in support of Cambodia's national sustainable development objectives, and complements Cambodian national policies and plans in mitigating and adapting to climate change. Because of time and budgetary constraints, it is not possible for the TNA project to cover all of Cambodia's sources and sinks of greenhouse gases. While agriculture is the highest source of greenhouse gas emissions in Cambodia, these constraints do not allow to cover an analysis of mitigation priorities in agriculture alone, in addition to transport, energy efficiency and adaptation priorities. Thus, the TNA project aims to assess technology needs and develop technology action plans for priorities in transport and in energy efficiency. Technological options are prioritised by the national stakeholders according to their respective costs and benefits, using a Multiple Criteria Analysis (MCA) framework. Benefits are further divided into four categories: reduction of vulnerability to climate change, economic, social and environmental benefits.

Out of fourteen technologies in transport and twelve technologies in energy efficiency, the following sets have been selected for the development of Technology Action Plans (TAPs).

Table 1: Prioritized Sector and Technologies

Sector	No.	Technologies
Transport	1	Energy Efficient Urban Mass Transport
	2	Vehicle Emission Standards
Energy Efficiency	1	Energy Efficient Lighting
	2	Energy Efficient Household Appliances

CHAPTER 1: INTRODUCTION

1.1 Objectives of the TNA Project

The present Technology Needs Assessment Project follows the footsteps of TNA activities supported by the Global Environment Facility (GEF) in Cambodia (additional financing for capacity building in priority areas, 2002-2003) and other countries. However, the TNA reports to be submitted under the current TNA project differ from the previous exercises in the following aspects. The proposed TNAs will not only include a listing of climate change technologies but also focus on Technology Action Plans (TAPs) which set targets to be achieved in technology transfer, diffusion and adoption, analyses barriers to technology transfer, and articulates a framework and action plan for overcoming these barriers. While earlier TNAs in Cambodia only considered greenhouse gas (GHG) mitigation technologies, the present exercise also addresses the country's vulnerabilities to climate change with the identification of adaptation technologies. The UNDP TNA handbooks, as well as sectoral handbooks developed by URC, provide guidance on the conduction of TNA and preparation TNA report. Guidance for the preparation of TAPs is provided by URC.

1.2 National Sustainable Development Strategies

The National Poverty Reduction Strategy (NPRS) was adopted in 2002 and the Cambodia's Millennium Development Goals (CMDGs) in 2003. The goals and strategies of these documents have been included in the National Strategic Development Plan (NSDP) 2006-2010, a framework which harmonizes development efforts and aid-effectiveness in Cambodia. In 2010, the NSDP was subsequently updated for covering the period of 2009-2013. It is the first policy document that states climate change as the major priority of the Royal Government of Cambodia (RGC). The NSDP update focuses on a number of key climate change actions such as climate change capacity strengthening and mainstreaming into relevant sectors, preparation of a national climate change strategy and action plan, promoting implementation of adaptation (including the National Adaptation Programme of Action on Climate Change or NAPA) and mitigation (including the Clean Development Mechanism or CDM) measures, and climate change education and awareness raising.

The overarching priority of the RGC is to reduce poverty towards the achievement of Cambodia's Millennium Development Goals, which include the eight goals of the United Nations MDG, and a ninth goal to move towards zero impact from landmines and unexploded ordnance by 2012. The Rectangular Strategy (RS) for growth, employment, equity and efficiency guides the government's action in achieving sustainable development and reducing poverty. The Rectangular Strategy has, at its core, good governance and public sector reform, and focuses on agriculture, infrastructure, human resources, and employment through the private sector.

Figure 1: The Rectangular Strategy of the Royal Government of Cambodia

Source: Royal Government of Cambodia (2010)

1.3 Climate

Cambodia's tropical monsoon climate is characterized by two distinct seasons: a wet or rainy season and a dry season. The rainy season, from May to October, is marked by heavy rains which accounts for 90% of annual precipitation. The dry season, from November to April, is associated with the northeast monsoon, which brings drier and cooler air from November to March, and then hotter air in April and early May. The maximum mean temperature is about 28°C and the minimum mean temperature about 22°C. Maximum temperatures above 32°C are common before the start of the rainy season. The average annual rainfall from 1994 to 2004 has fluctuated between 1,400 mm and 1,970 mm. Inland provinces may experience less than 600 mm of rainfall annually, while precipitation may reach 3,800 mm in coastal areas.

1.4 National Inventories of Greenhouse Gases

National inventories of greenhouse gases have been conducted for year 1994 (Initial National Communication) and year 2000 (Second National Communication), following the IPCC 1996 Revised Guidelines and IPCC Good Practice Guidance. Cambodia provides estimates of anthropogenic emissions for three gases by sources and removals by sinks: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The inventories cover energy, agriculture, land use change and forestry, and waste. The 1996 inventory includes emissions from a cement factory as part of industrial

processes, but the 2000 inventory reports that the factory has ceased operations. Cambodia's industrial emissions are considered insignificant.

Agriculture was the largest contributor to national emissions both in 1994 and 2000. Livestock populations have been constant over the period but rice cultivation has increased with area harvested. Between 1994 and 2000, emissions from energy increased by 48%. At the same time, removals from land use change and forestry (LUCF) only increased by 7%. While Cambodia was a net sink in 1994, it had become a net source by 2000. Paragraph 7 of the Climate Convention states that for the Second National Communication, non-Annex I Parties shall estimate GHG inventories for the year 2000. However, Least Developed Countries (LDC) can choose any year at their discretion. According to Paragraph 8, Non-Annex I Parties should use the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories. Following these COP agreed decisions, Cambodia followed the Revised 1996 IPCC Guidelines to conduct its national inventory for the year 2000.

Table 2: National Greenhouse Gas Inventories in 1994 and 2000

GHG Source and Sink Categories	Emissions 1994 (Gg CO_2eq)	Emissions 2000 (Gg CO_2eq)
Energy	1,279	2,050
Industrial processes	50	0
Agriculture	13,735	21,186
Land use change and forestry	-17,907	-18,545
Waste	142	210
Total	-2,701	4,901

Source: Ministry of Environment (2010)

For the year 2000, transport accounted for the highest proportion of CO_2 emissions in the energy sector (38%), followed by energy industries (27%). In agriculture, rice cultivation was the highest contributor of methane emissions (68%), followed by enteric fermentation from domestic livestock (16%). Significant removals of CO_2 by forests balanced losses to conversion and logging. Total net emissions in Cambodia for the year 2000 were estimated at 4,901 Gg CO_2eq.In its Initial National Communication, Cambodia reported emissions from cement manufacturing for the year 1994. However, the company has since ceased its activities, and was not in operation in the year 2000. Cambodia does not currently process or produce minerals, chemicals or metals. Thus for the purpose of reporting, Cambodia's emissions were nil in industrial processes in the year 2000.

Table 3: Total Emissions and Removals by Sector for the Year 2000 (Gg)

GHG Source and Sink Categories	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	Total CO_2eq
Energy	2,050	0	0	0	2,050
Agriculture			876	9	21,186
Land use change and forestry	0	-19,217	32	0	-18,545
Waste			10	0	210
Total	2,050	-19,217	918	9	4,901

Source: Ministry of Environment (2010)

Following the Revised 1996 IPCC Reference Approach, emissions were estimated from the carbon content of fuels imports to Cambodia. In the year 2000, 630 kilotons of petroleum products worth US $162 million were imported. Total national emissions from fuel combustion amounted to 2050 Gg CO_2 in the year 2000. In the IPCC Source Categories Approach, emissions are estimated from the carbon content of fuels supplied to the main fuel combustion activities. Despite some data gaps, it appears that in the year 2000, transport sector was the largest net contributor to national GHG emissions with 38% of the total emission from fuel combustion followed by energy industries with 27% of the total emission.

Table 4: Emissions by Source Categories for the Energy Sector for the Year 2000 (Gg)

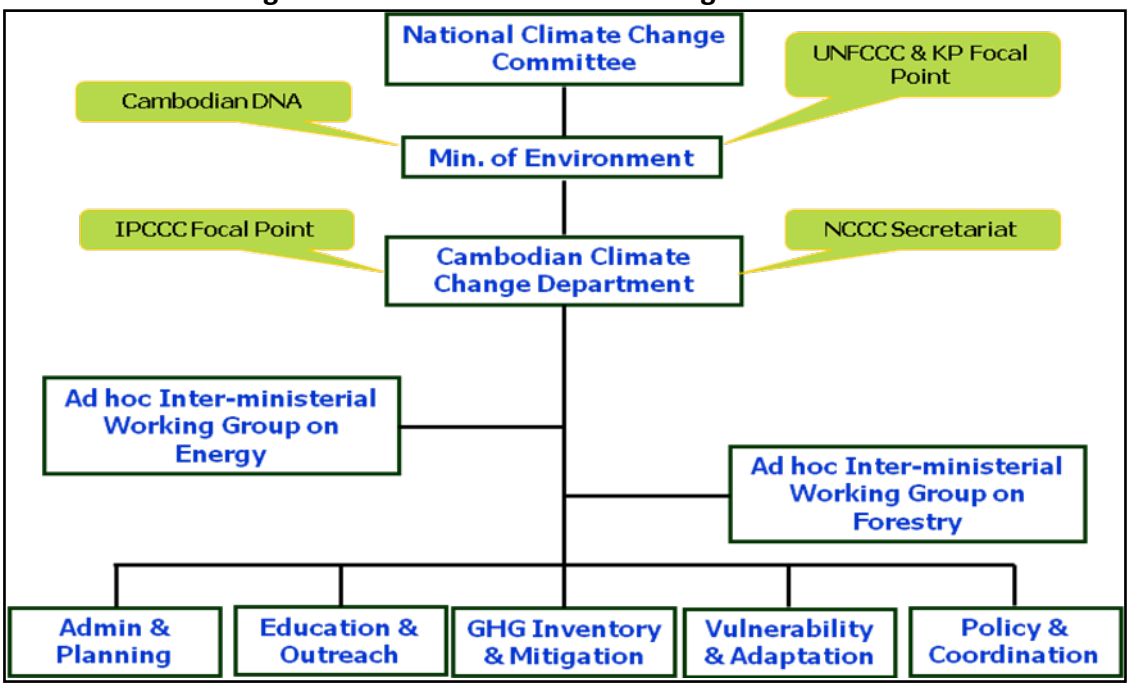
Energy Fuel Combustion GHG Source Categories	CO_2 Emissions (Gg)	CO_2 Emissions (%)
Energy industries	546	27
Manufacturing industries and construction	78	4
Transport	774	38
Road Transportation		
Railways	*9*	
Commercial/Institutional	62	3
Residential	189	9
Agriculture/Forestry/Fishery	212	10
Other	188	9
Total	2,050	100

Source: Ministry of Environment (2010)

1.5 National Climate Change Mitigation Policies and Activities

Cambodia's climate change institutions have grown in complexity--the issue gained higher prominence on the national agenda with the increased awareness of policy makers. A graph describing the national institutional framework for responding to climate change is provided below. The Cambodia's National Climate Change Committee (NCCC) is an inter-ministerial mechanism with the mandate to prepare, coordinate and monitor the implementation of policies, strategies, legal instruments, plans and programs of the Royal Government to address climate change issues. The Committee is cross-sectoral and multidisciplinary and is composed of high-level representatives (Secretaries and Under-Secretaries of State) of 20 Ministries and other concerned Government agencies. The NCCC is a policy-making mechanism chaired by the Minister of Environment. The Prime Minister accepted the role of the Honorary Chair of the NCCC in late 2009. The Cambodian Climate Change Department (CCD) serves as the NCCC Secretariat and provides administrative and technical support to the NCCC in fulfilling its mandate including all tasks related to the implementation of the UN Convention on Climate Change (UNFCCC). CCD coordinates inter-ministerial working groups specialized in sectors (energy and forestry), and along climate change themes (GHG inventory, mitigation, vulnerability and adaptation, and UNFCCC implementation). The Ministry of Environment (MoE) through CCD is the national focal point for the UNFCCC and its Kyoto Protocol, the secretariat of the Cambodian Designated National Authority for the Clean Development Mechanism (CDM), and the coordinating agency for the TNA Project.

Figure 2: Cambodia's Climate Change Institutions



Source: Ministry of Environment (2010)

Options for GHG mitigation in Cambodia include low-emission development paths, based on energy efficiency and renewable energy, and conserving and enhancing carbon sinks through forests and land-use management.

Cambodia's renewable energy sources consist of biomass, hydropower, wind and solar. Although these renewable resources are abundant when compared to the country's development needs, their technical potential remains untapped (CRCD 2005). Biomass is Cambodia's main source of energy, with wood accounting for 80% of national energy consumption. According to national population censuses (1997 and 2007), firewood is the main source of cooking for 90% of the households. The technical potential for electricity generation from biomass has been estimated at 18,852 GWh per year, including forest products, agricultural crops and residues, municipal waste and sewerage (CRCD 2005). Cambodia's technical potential for hydropower has been estimated at 10,000 MW of installed capacity (Mekong Secretariat 1971, 1973). Electricity production from the 194 MW Kamchay hydropower project, currently in its final stage of construction, alone will be able to supply the entire capital city. Production of electricity is scheduled for the end of 2011 when water levels have risen sufficiently to fill up the 717 million cubic meter reservoir. Despite Cambodia's relatively high level of insolation, high investment costs and low awareness level have restricted the use of photovoltaic and solar thermal energies. Photovoltaic installed capacity is concentrated on communication towers for mobile networks and selected rural health centers only. Cambodia's wind power resources has an estimated technical potential of 1,380 MW, but is similarly hindered by high upfront costs and low level of awareness (World Bank 2001). With the exception of hydropower, renewable energy applications in Cambodia have been limited to small-scale and demonstration activities only.

Cambodia currently imports its entire consumption of petroleum products. However, oil and gas exploration, halted by the years of conflict, resumed in the 1990s. Cambodia's first significant

petroleum discovery was announced in January 2005. Oil and gas reserves lie offshore within the country's Economic Exclusivity Zone (EEZ). Reserves have been estimated to date at 700 million barrels of oil and up to 5 trillion m^3 of gas (World Bank 2007). These reserves are based on preliminary test drills and are likely to be much larger. Cambodia is the only Southeast Asian country endowed with commercially exploitable reserves of both oil and gas. It is expected that the availability of nationally produced petroleum products will dramatically alter Cambodia's energy balance, national GHG emissions and prospects for low carbon development.

The Clean Development Mechanism (CDM) of the Kyoto Protocol as well as voluntary carbon markets have provided funding opportunities for GHG mitigation. Cambodia was one of the first Least Developed Countries to approve CDM activities. There are currently nine registered activities: biomass (rice husk powered cogeneration), biogas (methane capture from agricultural and animal waste), waste heat/gas utilisation (cement production), and hydropower. The main obstacle to the development of CDM projects in Cambodia comes from the small size of potential projects, which are more household and community- based in nature. These projects tend to have higher transaction costs than large-scale industrial activities. Local organisations have also successfully opted for voluntary carbon standards as viable alternatives to the CDM. There two largest Voluntary Emission Reductions (VERs) projects namely, Cambodia's National Biodigester Programme (NBP) and Cambodia Fuelwood Saving Project (CFSP). NBP covers 10,000 family-sized biodigesters for expected annual emission reductions of 59,000 t CO_2eq. CFSP commercializes improved cookstoves that consumes about 20% less charcoal than traditional stoves, and is expected to reduce emissions by 160,000 t CO_2e over the period 2003-2012.

Figure 3: A Methane-Fired Power Generation CDM Project

Source: Ministry of Environment (2012)

1.6 TNA Relevance to National Development Priorities

It is envisaged that the TNAs and TAPs produced under the TNA Project will be used for the following purposes: (1) as roadmaps for policy making for specific priority sectors in mitigation and adaptation consistent with the country's sustainable development objectives; (2) as support to Cambodia's position in climate change negotiations in the area of technology transfer; and (3) as a medium to access international sources of funding for the implementation of mitigation and adaptation activities. As such, the TNAs and TAPs should not be viewed as stand-alone documents. They are developed in support of Cambodia's national sustainable development objectives, and may complement Cambodian national policies and plans in mitigating GHG emissions and in adapting to climate change.

CHAPTER 2: INSTITUTIONALARRANGEMENT FOR THE TNA AND THE STAKEHOLDERS' INVOLVEMENT

2.1 TNA Team, National Project Coordinator, Consultants, etc.

The TNA project is coordinated in Cambodia by the Climate Change Department (CCD) of the Ministry of Environment, with the technical support of the Cambodian Research Centre for Development (CRCD), a non-profit non-government organization, and the Royal University of Phnom Penh (RUPP). The TNA report reflects a six-month discussion and consultation process, which involves small group meetings as well as face to face meetings. While the TNA Team members are the joint contributors to the TNA report, the choice of sectors and technology priorities is validated by a broad range of stakeholders. The Mitigation TNA report is in line with the national sustainable development objectives of the Royal Government of Cambodia and the Cambodian Millennium Development Goals. The Mitigation TNA report also draws from the strategic choices of Cambodia's Initial and Second National Communications, and aims to assess in greater detail specific climate change adaptation technologies.

Figure 4: Technical Meeting of the TNA Mitigation Team

Source: Ministry of Environment (2011)

2.2 Stakeholder Engagement Process Followed in TNA– Overall Assessment

To ensure synergies, country drivenness and sustainability, Cambodia decided to use the existing climate change institutional structure to support the implementation of the TNA project. Thus, the NCCC serves and the National TNA Project Steering Committee, CCD as the Project Coordinator and selected members of the two Inter-ministerial Working Groups and the National Climate Change

Technical Team are invited to join the National TNA Teams (both mitigation and adaptation). The National TNA Teams are technically supported by national consultants/experts.

The Inception Workshop for the TNA Project took place in Phnom Penh in September 2010, and presided over by Secretary of State of the Ministry of Environment. More than fifty participants representing Government agencies, non-governmental organizations, academia and the private sector have attended the workshop. The information of the TNA project was comprehensively introduced, followed by small group discussion designed for leading participants to discuss about priority sectors for both adaptation and mitigation. The outputs derived from group discussions have been used as a primary reference for deeper study and analysis in the following steps of TNA preparation process.

Figure 5: TNA Inception Workshop in Phnom Penh, Cambodia

Source: Ministry of Environment (2010)

CHAPTER 3: SECTORPRIORITIZATION

3.1 An Overview of Sectors, and Projected Climate Change and the GHG Emission Status and Trends of the Different Sectors

Cambodia's Initial National Communication (INC 2002) and Second National Communication (SNC 2010) to the UNFCCC discuss the country's GHG mitigation options based on national inventories conducted for 1994 and 2000, and forecasted GHG emission trends. As a least developed country party to the UNFCCC, Cambodia does not have any obligations to reduce its emissions. Consequently, there has not been any specific focus of Government on emission reductions. However, many activities carried out by Cambodia in order to achieve its national sustainable development objectives, specifically in the energy, agriculture and forestry sectors, also contribute to global efforts in reducing anthropogenic GHG emissions including improving forest sinks.

Cambodia's National Communications also discuss available mitigation options and opportunities in the sectors corresponding to the national GHG inventory, as articulated in the IPCC Guidelines. The main sources and sinks of GHG emissions in Cambodia are energy, land use change and forestry, and agriculture. Industrial processes and waste have been insignificant sources of emissions since the first national inventory was conducted. Considering the present low level of industrialization of the country, industry will not become a main source of emissions in the foreseeable future. However, waste sector may be a significant emission source for the near future as it correlates with increasing production activities, change of lifestyle and overall economic development of the country.

Emissions from energy sector have increased steadily with economic development, with transport (essentially road transportation) accounting for the largest share in the sector's emissions at 44% for the year 1996 and 40% for the year 2000. Agriculture was the largest contributor to national emissions both in 1994 and 2000. While livestock populations have remained relatively constant, the expansion of rice cultivation has resulted in higher emissions of methane. Rice cultivation accounted for 68% of agricultural emissions in 2000. The Land Use Change and Forestry sector has been a net sink since Cambodia's first national inventory was conducted for 1994. Removals and changes in forest and other woody biomass stocks and in abandonment of managed lands have remained more significant than emissions from forest and grassland conversion. Some 25% of Cambodia's forests lie within a system of 23 protected areas. The 3.2 million ha of national parks, wildlife sanctuaries, protected landscapes, and multiple use areas was established to conserve the country's biodiversity. Cambodia's forest cover has been estimated at 11.1 million ha or 61% of the country's land area (MRC/GTZ 2002). Although Cambodia was a net sink in 1994, it had become a net emitter by 2000. This underlines the need for exploring potential for curbing GHGs from energy and agriculture, because existing forest sinks are unable to absorb growing emissions. These figures should however be interpreted with some amount of caution, as more than a decade has passed since the base year of 2000. The time lag between national communications combined with the absence of an on-going and continuous greenhouse gas inventory process, is inadequate for timely policy making. National planning for greenhouse gas mitigation should take into account more recent macro-economic data and trends. Cambodia's economy achieved a growth rate of nearly 10% per annum over the 1998-2007 decade (World Bank 2009). Growth has relied on four sectors: agriculture, construction, industry and tourism. Industry, the fastest growing sector, has been

mainly driven by export-oriented garments and footwear. Although still significant in terms of employment, agriculture (29%) has fallen behind industry (30%) and services (41%) in terms of contribution to GDP and value added since 2007. In the light of these economic trends, it appears likely that future efforts to mitigate GHG emissions in Cambodia will increasingly need to focus on energy consumption (demand side management such as energy efficiency and saving), renewable energy development, and production activities.

The findings from national GHG inventories conducted in Cambodia under the national communications to the UNFCCC indicate that energy, land use change and forestry, and agriculture are the sectors that contribute the most to GHG emissions. These sectors are considered by the Royal Government of Cambodia, in its official development plans and policies, as priority development sectors. However, because of time and budgetary constraints, it is not possible for the TNA project to cover all of Cambodia's sources of emissions and all feasible technologies. Therefore, TNA project aims to assess technology needs in two to three sectors, and develop technology action plans for two to three technologies in each sector. More significant resources would have been needed to fully assess needs and develop technology action plans for each of the broad ranging sectors of energy, land use change and forestry, and agriculture. The consensus among Cambodian stakeholders, with the support of the project coordinating agency, is to focus on the two sub-sectors of transport and energy efficiency. Although efficiency in energy production and use, and transport are priority development objectives for the Royal Government of Cambodia, these have received relatively little donor attention when compared to renewable energy development, and forest conservation and enhancement. The TNA Project has an opportunity to fill this gap and better assess GHG mitigation options for energy efficiency and transport, which would complement Government efforts in agriculture, forestry and sustainable energy supply.

3.2 Process and Criteria of Prioritization

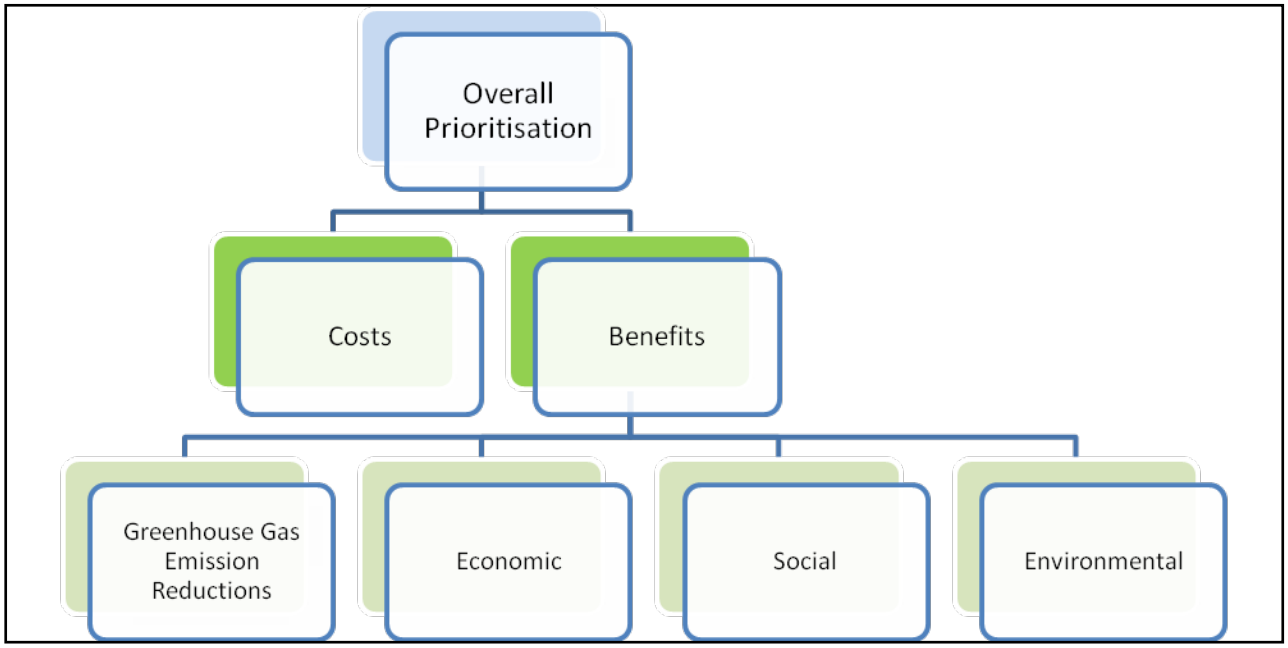
As articulated in its National Communications under the UNFCCC, Cambodia favors mitigation options that are in line with its national sustainable development objectives, that is, yield the highest possible development benefits for its people. These mitigation options are already justified because they provide real and tangible social and economic benefits for local communities if implemented. Although as a non-Annex I party Cambodia does not have any obligation to reduce GHG emission, the implementation of GHG emission reduction measures in support of its national development would also make a contribution to global efforts to fight climate change. The prioritization process of technologies for climate change mitigation by the TNA Team uses criteria based on the Royal Government of Cambodia's development priorities as articulated in the Rectangular Strategy for Growth, Employment, Equity and Efficiency; the Cambodian Millennium Development Goals (CMDG); the National Strategic Development Plan Update 2009-2013 and other relevant policies and plans.

The available technologies for mitigating emissions from transport and energy efficiency are prioritized according to their respective costs and benefits, using a Multiple Criteria Analysis (MCA) framework. Benefits are divided into four categories: reduction of vulnerability to climate change, economic, social and environmental benefits.

Table 5: Criteria for Assessing the Benefits of Mitigation Technologies in the Transport Sector

Greenhouse Gas Emission Reductions	
▪ reductions	Potential for climate change mitigation and emission
Economic Benefits	
▪	Support for sustainable development
▪	Provision and maintenance of infrastructure
▪	Increase in productivity
Social Benefits	
▪ opportunities	Creation of employment and income generation
▪	Improvement of public health
▪	Improvement of education and public awareness
▪	Improvement of local living conditions
Environmental Benefits	
▪	Improvement of air and water quality
▪	Avoidance of soil pollution
▪	Conservation and sustainable use of resources
▪ technologies	Use of appropriate and environmentally friendly

Figure 6: Hierarchical Representation of Costs and Benefits of Mitigation Technologies



3.3 Current Status of Technologies in Transport

The main modes of transportation in Cambodia are land, water and air transport. Land transport consists of a national network of road and rail. Water transport is significant as it links Cambodia's inland waterways to its immediate neighbors through the Mekong River, and to the global economy through maritime shipping. Air transport has experienced steady growth with the country's expansion of its international and regional airports.

Cambodia's road development began in the late 19th century and came to an end in the early 1970s with the beginning of civil war that lasted over the next three decades. The road network was severely damaged and is in a state of disrepair due to lack of funds for reconstruction and basic maintenance. Rehabilitation of this network is a priority for the government, as less than 16% is paved (SEDP II). The network consists of approximately 40,000 km of national roads (11%), provincial roads (17%), and rural roads (71%). National roads are asphalt based with low embankment and a width of up to six meters that can accommodate light traffic. About 1,700 km of two-lane national roads are covered with asphalt, and connect Phnom Penh to the provincial capitals and border crossings. The provincial network is near impassable during the rainy season when floods isolate parts of the country. Years of severe floods such as 1991, 1996, 2000, 2001 and 2002 caused significant structural damage. Despite major rehabilitation work since the 1990s, about half of the road network is considered to be in poor condition and another 10% in bad condition. Between 1994 and 2004, the number of registered motor vehicles (cars, minibuses, pick-ups, buses, trucks, motorcycles) increased by 79%, which corresponds to an annual growth rate of almost 7%. Cambodia has more than a million of registered vehicles, of which 70% represent motorcycles and 26% cars. Unregistered vehicles may account for another 20 to 30% of the fleet.

Cambodia's rail network was built between 1929 and 1942 (385 km Northern Line), and in the 1960s (266 km Southern Line). The northern line runs from Phnom Penh to the Thai border, and the southern line from Phnom Penh to the port city of Sihanoukville. The Cambodian railroads reached their heydays in the 1960s, when they were operated at a profit and a symbol of economic and social prosperity. Phnom Penh and Bangkok were then connected by rail. Speed averaged 60 km/hour for a fleet of about 75 locomotives and close to a thousand cars. Much of the network has been in a dilapidated state since the war and is not usable along large sections. Freight and passenger transport by rail has decreased over the past decade. Most of the track is 50-60 years old, and average speed has fallen to 30 km/hour. Rehabilitation of the southern line is scheduled for completion in mid 2011, followed by the northern line in 2013. The Phnom Penh to Vietnam link could be achieved by 2015, which would mark the completion of the 1960s initiated Trans-Asian Railway.

Sihanoukville, Cambodia's only deep sea port, has seen its quantities of cargoes, containers and vessels steadily increased since 1996. About 4 million tons of cargo is handled through the port up from 1.6 million tons in 1999. While Sihanoukville is Cambodia's main seaport, Phnom Penh is accessible by inland waterways from the Mekong Delta. At the confluence of the Bassac, Mekong, and Tonle Sap Rivers, the port of Phnom Penh occupies a central position in river transportation. The throughput of the port peaked in 1997, as lack of dredging prevents the use of large vessels in the navigable waterways. Vessels of up to 7,000 dwt can in theory reach Phnom Penh, but decreasing flows in the dry season allow only smaller boats further north.

Cambodia has ten airports, including international airports in Phnom Penh, Sihanoukville and Siem Reap, the gateway to the temples of Angkor, a main tourist destination. Cambodia's open sky policy has resulted in a substantial increase in air travel over the last decade. Both international airports have undergone major extension and modernization works, including widening and lengthening of runways and construction of buildings. Passenger arrivals and departures at Phnom Penh International Airport exceeded 3.3 million people in 2010 up from 2.2 million in 2005. Cambodia has direct flights to most other Asian capital cities. While international air traffic has increased over the past five years, domestic traffic has remained stable because the national road network has been progressively rehabilitated.

3.4 Current Status of Technologies in Energy Efficiency

To date, there has not been any thorough assessment of Cambodia's potential for energy efficiency improvements, as detailed energy balance and sectoral data such as equipment and systems in use, as well as conditions of operation are not available. A study by the Cambodian Research Centre for Development (CRCD) has identified and assessed potential energy savings per sector based on industry benchmarks and existing energy studies (CRCD 2004). These estimates are necessarily coarse due to gaps in data but show significant potential in energy efficiency. The technical potential for energy efficiency in the residential sector alone would be in the order of 6,500 GWh/year. Energy efficiency savings would come from lighting, air conditioning and cooking. There are similar energy saving opportunities in power generation and distribution, as well as in the commercial sector in lighting, air conditioning and water heating (see Figure 11). Cooking in households may be an obvious focus of any nationwide residential energy efficiency program in Cambodia because over 95% of total household energy use is in the form of fuelwood or charcoal for cooking in a traditional cookstove (NIS 2008). The introduction of locally manufactured improved cookstoves over the past several years has targeted both rural and urban households.

Table 6: Examples of Energy Efficiency Projects and Potential Savings in the Power, Commercial and Residential Sectors

Project Type	Project Description	Potential Energy Saving
Power Sector		
Generation	Upgrade equipment to more efficient modern designs, optimize engine sizing and control strategies, install monitoring sensors and improve maintenance programs and energy management.	15%
Distribution	Optimize network design to balance loads, upgrade conductor sizes and quality to reduce losses, install power factor correction.	10%
Cogeneration	Harness waste heat for on-site heating or cooling load (or sell to neighboring factory, building etc.).	30%
Commercial Sector		
Lighting	Optimize design to minimize energy use by using daylights, windows, task lighting and zoning; upgrade technology with high efficiency fittings, reflectors, lamps, ballasts and voltage controllers; improve automatic and manual control using occupancy sensors, brightness sensors, dimmers and timers.	15%
Air Conditioning	Optimize building design to maximize insulation, minimize direct solar gain (e.g.: plant trees and shading), zoning to avoid cooling unused areas and ceiling fans where possible; upgrade technology using improved refrigerants + lubricants, heat pumps, exhaust air heat capture; and improve system control by using comfort and occupancy sensors, timers, and possibly night-purge function.	40%
Water Heating	Optimize system design using centralized or small individual units, reduce distance from source to use, minimize water temperature for application, and harness waste heat where available (from nearby industry or air conditioning); upgrade technology to solar where possible, avoid electric storage systems, insulate ducting; reduce water use by fixing leaks and using efficient nozzles, taps and showers.	95%
Cogeneration	Harness waste heat from generator and use for on-site heating or cooling load, such as water heating or air conditioning and refrigeration (or sell to neighboring factory, building etc).	30%
Residential Sector		
Improved Cook Stoves	Disseminate improved cookstove design, with improved insulation and air flow, to provide greater combustion and thermal efficiency.	30%
Energy Saving Fluorescent Lamps	Replace incandescent lamps with energy saving lamps, which use less power to provide the same amount of light, and also have a longer life (e.g.: replace 25W incandescent with 7W fluorescent).	72%

Source: Cambodian Research Centre for Development (2004)

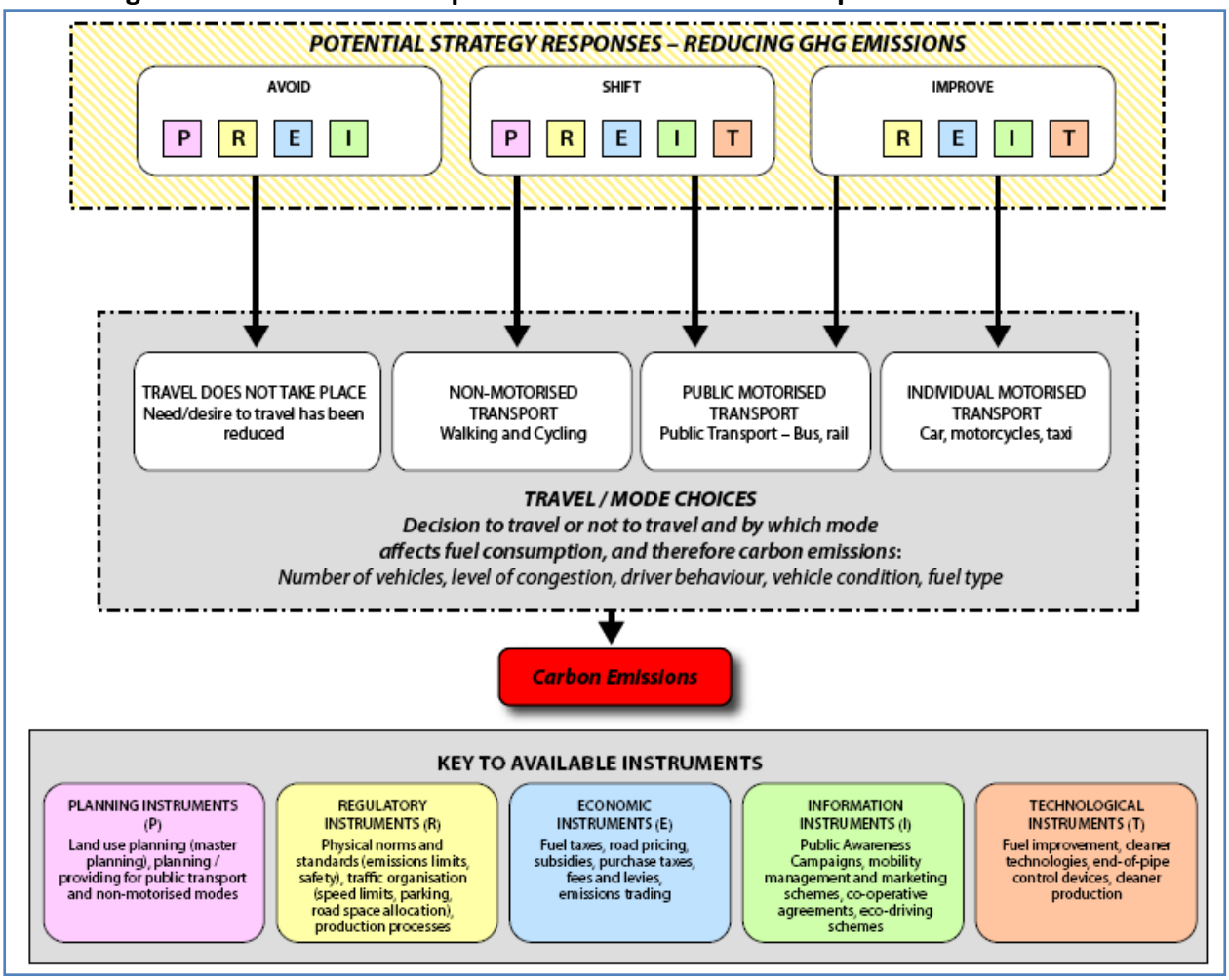
CHAPTER 4: TECHNOLOGYPRIORITIZATION FOR TRANSPORT

4.1 An Overview of Possible Mitigation Technology Options in Transport and their Mitigation Benefits

Cambodia's Initial National Communication identifies specific technology options for GHG mitigation in transport such as energy efficient mass transit, Phnom Penh city shuttles, establishment of a national fuel testing laboratory, driver and pedestrian training and education. Based on national sustainable development objectives, Cambodia's National Communications, the TNA Guidebook on Technologies for the Transport Sector (URC 2011), and a broader review of the literature, the TNA Mitigation Team, in consultation with national stakeholders has established a list of fourteen available technologies for transport. These cover a range of hard technologies, as well as institutional and organizational knowhow.

To reduce GHG emissions from transport, there are three main strategic responses: avoid or reduce travel, shift to more environmentally clean modes of travel, and improve energy efficiency and transport technology (GTZ 2007). Instruments to promote sustainable transport may be broadly divided into five categories: planning, regulatory, economic, information, and technological instruments. Under the TNA project, technology is not limited to hard instruments or equipment, but also includes practices and policy tools, and therefore covers the whole range of instruments required for sustainable transport.

Figure 7: Sustainable Transport Instruments and their Impact on Carbon Emissions



Source: GTZ (2007)

4.2 Criteria and Process of Technology Prioritization

Each of the fourteen mitigation technologies for the transport sector has been scored on a scale of 1 to 100 according to the prioritization criteria (costs and benefits), with 100 forthe highest priority technology. The overall score for a specific technology is obtained by averaging its scores for individual criteria. The final ranking represents a consensual position among the members of the TNA Mitigation Team and has been obtained through a series of discussions and consultations facilitated over the course of six months period.

Table 7: Prioritisation of Mitigation Technologies for the Cambodian Transport Sector on a Scale of 1 to 100

No.	Criteria / Technology Options	Costs	Benefits				Total Score
			Mitigation	Economic	Social	Environmental	
1	Energy Efficient Urban Mass Transport	50	90	90	90	90	82
2	Vehicle Emission Standards	80	90	60	80	90	80
3	Electric Motorbikes and Bicycles	80	90	50	70	90	76
4	Biofuels	80	90	60	60	70	72
5	Rail	50	90	70	70	80	72
6	Eco-Driving	90	70	60	70	70	72
7	Traffic Management	80	70	70	70	70	72
8	Transport Demand Management	80	80	60	60	70	70
9	Modal Shift (Walking, Cycling)	50	70	60	80	90	70
10	Road Improvement	70	70	80	70	60	70
11	Urban Transport Master Plan	80	70	70	70	50	68
12	Education Campaign on Transport and Climate Change	90	60	60	70	60	68
13	Electric and Hybrid Vehicles	50	90	50	60	90	68
14	Inland Water Transport	50	70	70	50	60	60

4.3 Results of Technology Prioritization

The top three technologies are: (1) Energy efficient urban mass transport, (2) Vehicle emission standards, and (3) Electric motorbikes and bicycles. The following four technologies having an equal ranking are Rail, Biofuels, Eco-driving, and Traffic management.

Cambodia's urban transport infrastructure was severely damaged during the years of war. All urban transport is now road-based which has led to widespread traffic congestion in the larger cities, especially in the capital city of Phnom Penh. Trains, buses and boats only operate between cities. There is no urban mass transport at this stage in Cambodia. Most people rely on cars and motorcycles to travel within cities. The rapid growth of vehicle ownership is mainly associated with the absence of mass transport. Thus, an energy efficient urban mass transport system would not only reduce GHG emissions, but also alleviate traffic congestion and improve local environment quality. Cambodia does not currently have vehicle emission standards, which results in highly

polluting vehicles being operated on the roads. This has negative impacts not only on GHG emissions, but also on air quality standards in the cities.

There is only a 10% score difference between the fourth and the thirteenth technology, which implies that these technologies are significant for Cambodia in terms of development and mitigation benefits. Beyond mere ranking and numbers, it is important to note that the higher rated technologies broadly correspond to Cambodia's development priorities. However, because of budgetary and time constraint, it is not possible to develop, at this stage, Technology Action Plans for all technologies. Thus, energy efficient mass transport and vehicle emission standards are selected for the purpose of developing TAPs.

CHAPTER 5: TECHNOLOGYPRIORITIZATION FOR ENERGY EFFICIENCY

5.1 An Overview of Possible Mitigation Technology Options in Energy Efficiency and their Mitigation Benefits

Cambodia's Initial National Communication identifies technology options for GHG mitigation in energy efficiency as Compact Fluorescent Lamps (CFLs), energy efficient building codes, efficiency improvements for existing and new building shells, passive solar building design, establishment of a national fuel and appliance testing laboratory, and training on energy audit. The Second National Communication also outlines a number of actions to facilitate energy efficiency, including setting up a national energy efficiency program, awareness raising through media campaigns supported by promotion materials, appliance labeling, fiscal measures, and energy building standards.

Substantial emission reductions can be achieved from energy use in buildings by using existing mature technologies in energy efficiency (IPCC 2007). The IPCC Fourth Assessment Report lists twenty-one technological opportunities according to their appropriateness and applicability in developed and developing countries, as well as warm and cold climates. These technologies are further assessed according to their economical feasibility and market maturity. Based on national sustainable development objectives, Cambodia's National Communications, and a broader review of the literature, the TNA Mitigation Team, in consultation with national stakeholders has established a list of twelve available technologies for energy efficiency. These cover a range of hard technologies, as well as institutional and organizational knowhow.

5.2 Criteria and Process of Technology Prioritization

Each of the twelve mitigation technologies for energy efficiency has been scored on a scale of 1 to 100 according to the prioritization criteria (costs and benefits), with 100 for the highest priority technology. The overall score for a specific technology is obtained by averaging its scores for individual criteria. The final ranking represents a consensual position among the members of the TNA Mitigation Team and has been obtained through a series of discussions and consultations facilitated over the course of six months period.

Table 8: Prioritisation of Mitigation Technologies for Energy Efficiency in Cambodia on a Scale of 1 to 100

No.	Criteria Technology Options	Costs	Benefits				Total Score
			Mitigation	Economic	Social	Environmental	
1	Energy Efficient Cookstoves	90	80	60	90	80	80
2	Energy Efficient Lighting	100	90	60	70	70	78
3	Energy Efficient Appliances	90	80	60	80	60	74
4	Energy Efficient Brick Kilns	70	80	80	60	70	72
5	Energy Efficiency Standards	90	70	70	70	60	72
6	Awareness Raising and Education on Energy Efficiency	80	80	60	80	60	72
7	Energy Efficiency Building Codes	90	70	60	70	60	70
8	Passive Solar Building Design	80	70	60	70	70	70
9	Energy Efficient Water Heating	80	70	60	70	60	68
10	Building Energy Management Systems	70	70	70	70	60	68
11	Energy Efficient Air Conditioning	80	70	60	60	60	66
12	District Cooling	50	70	60	60	60	60

5.3 Results of Technology Prioritization

Energy efficient cookstoves and efficient lighting are the energy efficiency technologies with the highest scores. In addition to mitigation benefits, both have the potential for the largest social impacts and involvement of general population. In addition, efficient cookstoves also have positive impact on forest resources of the country. The Cambodian Fuelwood Saving Project (CFSP) commercializes an improved cookstove model that consumes about 20% less charcoal than traditional stoves. The project trains manufacturers of cookstoves and provides credit facilities. As Cambodia households overwhelmingly use biomass (wood and charcoal) for cooking, the commercialization of improved cookstoves contributes to preserving forest resources. While cookstoves have been at the centre of Government and international organizations efforts in Cambodia since the late 1990s, the general population and policy makers are far less familiar with efficient lighting options. Compact Fluorescent Lamps (CFL) are considered premium products, and Light Emitting Diodes (LED), although start to become available locally, are not affordable to most households. In addition, consumers may not be fully aware of the benefits of efficient lighting. Efficient energy appliances are ranked third among mitigation technologies. Cambodia imports all of the appliances it uses. These often come with labeling and instructions in foreign languages on

their energy consumption. Thus, there is a need for a national labeling of electric appliances according to their energy efficiency.

Energy efficient brick kilns, energy efficiency standards, and awareness raising and education on energy efficiency obtain similar scores and priority. These technologies are closely followed in total scores by energy efficiency building codes and passive solar building design. There is little score difference between the fourth and the tenth technology, which suggests that these technologies are significant for Cambodia in terms of development and mitigation benefits. Beyond mere ranking and numbers, it is important to note that the higher rated technologies broadly correspond to Cambodia's development priorities. However, because of budgetary and time constraint, it is not possible to develop, at this stage, Technology Action Plans for all technologies. The TNA Mitigation Team and national stakeholders agree that although energy efficient cookstoves are in the highest priority in Cambodia, they are already the focus of Government and donor activities. Thus, energy efficient lighting and energy efficient appliances are selected for the purpose of developing TAPs.

CHAPTER 6: CONCLUSION AND RECOMMENDATION

According to Cambodia's national GHG inventories, the country's major sources and sinks are energy, land use change and forestry, and agriculture. Industrial processes and waste have not been significant sources of emissions since the first national inventory was conducted for 1994. Emissions from energy have increased steadily with economic development, with transport (essentially road transportation) accounting for the largest share in the sector's emissions. Land use change and forestry sector has been a net sink in Cambodia because removals and changes in forest and other woody biomass stocks and in abandonment of managed lands have remained more significant than emissions from forest and grassland conversion. These sectors are considered by the Royal Government of Cambodia, in its official plans and policies, as the priority development sectors. However, because of resource constraint, it is recommended that only two sectors,namely transport and energy efficiency, should be considered under this project. These sectors need practical measures for technology transfer and diffusions, and additional donor support.

For each sector, a list of available technologies and practices are examined. The available technologies for transport and for energy efficiency are prioritised according to their respective costs and benefits as guided in MCA framework. Benefits are divided into four categories: potential for climate change mitigation and emission reduction, economic, social and environmental benefits.

Table 9: Mitigation Technologies Prioritized and Selected for the Technologies Action Plans in Cambodia

Sector	No.	Technologies
Transport	1	Energy Efficient Urban Mass Transport
	2	Vehicle Emission Standards
Energy Efficiency	1	Energy Efficient Lighting
	2	Energy Efficient Appliances

Part II: Technology Action Plans

EXECUTIVE SUMMARY

Technology Action Plans (TAPs) for Cambodia have been developed for energy efficiency and transport, as substantiated by the TNAs. In the energy efficiency sub-sector, energy efficient lighting and energy efficient household appliances have been prioritized, while in the transport sub-sector energy efficient urban mass transport and vehicle emission standards are the proposed priority technologies. These technologies have been selected through stakeholder consultations, because they present the greatest potential for improving the welfare of Cambodians, through multiple benefits: more efficient commuting, cleaner air and improved public health, or electricity savings that can be used for other household expenditures.

Barriers to the diffusion of CFLs and household energy efficient appliances consist of similar barriers in terms of higher price of product, absence of regulations to mandate or encourage public use, and limited public awareness. Although these technologies are generally available in Cambodia, they have had limited success with end consumers who cannot yet discern their economic, social and environmental benefits. Public awareness raising is thus critical in the diffusion of CFLs and energy efficient appliances as end consumers are the ones to ultimately make the purchasing decision.

The transfer and diffusion of technologies in the transport sector face significant barriers in terms of capital and investment requirements, and well-established public preference for private modes of transport including cars and motorcycles. Phnom Penh remains the only major Asian city without any form of mass public transport. Limitations of existing physical infrastructures will need substantial private investments and donor support as government does not have sufficient financial resources.

A total of 7 project ideas are presented, all of them requiring international contributions in terms of financial and technical resources. They address Cambodia's most urgent needs in energy efficiency and in transport, and would yield considerable economic, social and environmental benefits, as well as GHG emission reduction, if implemented.

CHAPTER 1: ENERGY EFFICIENCY

1.1 Preliminary Targets for Technology Transfer and Diffusion Based on TNA Report

Technology options for GHG mitigation in energy efficiency including Compact Fluorescent Lamps (CFL) and energy efficient appliances are ranked as a priority for Cambodia.

CFLs are called compact fluorescent lights, energy-saving lights, or compact fluorescent tubes, and are lamps designed to replace incandescent lamps. Of the many technologies invented in the last century, CFLs offer developing nations the best opportunity to reduce energy consumption in the residential sector, thereby providing a range of major benefits to consumers, utilities, governments, and the environment (World Bank 2009).

Table 10: Benefits of Energy Efficient Lighting

Customer	Energy savings, reduced bills, mitigation of impact of higher tariffs
Utility	Peak load reduction, reduced capital needs, reduced cost of supplying electricity
Government	Reduced fiscal deficits, reduced public expenditures, improved energy security
Environment	Reduction in local pollution and in GHG emissions

Source: World Bank, 2009

Within the context of Cambodia, CFLs is a technology that is recognized by the Government because of its much longer average product lifetime, less energy consumption for same light effect and affordable costs. By acknowledging these benefits, MOE in cooperation with other Government agencies and development partners such as MIME, RUPP, CRCD and the UNEP Risoe Centre (URC) has been implementing a pilot project called “Energy Savings Siem Reap – Promoting and Demonstrating Energy Conservation in Siem Reap, Cambodia”. Public awareness raising on energy efficiency and energy conservation in the context of climate change and sustainable development, and demonstrating the practical feasibility of simple energy conservation measures by installing solar water heaters in selected sites and distributing compact fluorescent lamps (CFLs) to the general public are the two main purposes of the pilot project. According to the a study conducted by CRCD (2004), the energy efficiency savings from lighting, air conditioning and cooking in the residential sector alone would reduce consumption by about 6,500 GWh/year.

1.2 Barrier Analysis

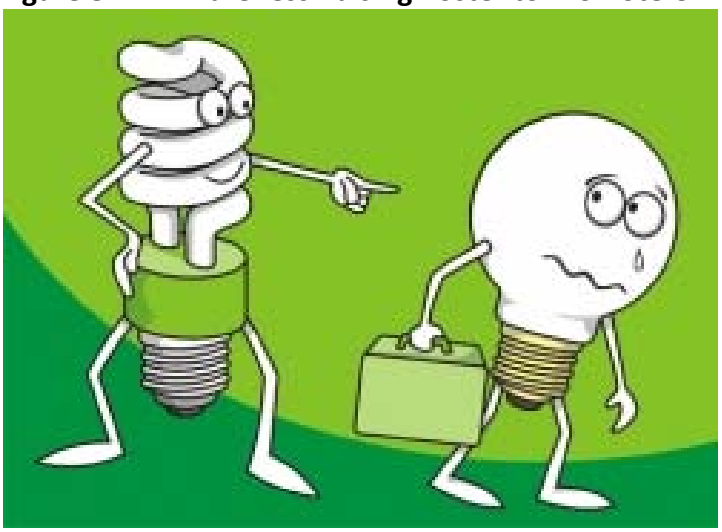
Barrier identification and analysis of the two prioritized technologies (CFL and energy efficient appliances) consist of four main steps, namely: (1) identify all possible barriers, (2) identify key barriers, (3) establish hierarchy of barriers, and (4) analyze causal relations as guided bythe TNA Guidebook (UNEP 2010). Through the stakeholder consultation workshop, all possible barriers are categorized into eight groups, including economic and finance, market failure/imperfection, regulatory/policy/legal and IPR, institutional and organization capacity, human and technical skills, information and awareness, and network failures.

As agreed during the stakeholder consultation, three top barriers were selected for conducting the logical problem analysis and market mapping in order to define comprehensive options for the barriers identified. A full market mapping and barrier analysis are attached in annex II.

1.2.1 Barrier Identification and Analysis to the Transfer and Diffusion of CFLs

CFL is regarded as the energy saving light and compact fluorescent tube designed to replace an incandescent lamp. Using CFLs could provide a number of benefits including: (1) lower energy consumption of up to 75%, (2) lasting up to 10 times longer than the incandescent lamp, (3) up to 75% less heat produced, and (4) reduced GHG emissions from electricity generation. These advantages are favorable drivers to a successful implementation of CFLs in Cambodia to reduce GHG emissions. The main barriers foreseen and highlighted during stakeholder consultations are reported below.

Figure 8: An Awareness Raising Poster to Promote CFL



Source: Ministry of Environment (2012)

The major benefit of energy-efficient CFLs lies in the improved energy efficiency, which has socio-economic benefits in terms of increased energy security and environmental quality, i.e. lower GHG emissions, and lower environmental impact of electricity generation. In addition, CFLs lead to cost-savings for the consumer over the life-cycle of the lamp, and improve local air quality. The cost of a CFL varies with the design features, materials used, and application. In the United States, a CFL has a higher purchase price than an incandescent lamp, but can save over US$40 in electricity costs over the lamp's lifetime (Climatetechwiki 2012). This pattern of purchase prices is similar to Cambodia's market prices, in which CFLs are always more expensive than the normal lamps. For instance, a 75 W incandescent lamp is sold for around 2,000 Riels or US$ 0.5, whereas an equivalent 11 W CFL usually costs more than US$ 2 for end consumers.

CFLs also help preserve environmental quality as they can help reduce mercury emissions, which is a substance with health risk and waste treatment concerns. Although a CFL contains a small quantity of mercury in its bulb (3–5 mg per bulb),a regular incandescent light bulb actually releases much more mercury into the environment than a CFL. CFLs reduce energy demand at the power plant and thus prevent mercury from entering the air, where it most affects human health. The

highest source of mercury in the air comes from burning fossil fuels such as coal, the most common fuel used to produce electricity. A CFL uses up to 75% less energy than an incandescent light bulb and lasts up to 10 times longer. It is confirmed that a power plant will emit 10 milligrams of mercury to produce the electricity to run an incandescent bulb compared to only 2.4 milligrams of mercury to run a CFL for the same time (US EPA 2003).Three key barriers were identified by the participants of the consultation workshop: high price, no regulation to enhance public to use CFL, and limited public awareness raising.

1.2.1.1 Economic and Financial Barriers

High price of product is one of the top three barriers identified which could directly affect efforts to promote technology transfer and diffusion across the country.
In free market economies, demand is a function of price, meaning that a higher price of CFLs could lower demand of local customers. The root cause of high price is commonly associated with three key barriers, namely lack of local investment and promotion taxation on imported product, and limitation in public awareness raising.

CFL is an imported production. It is not locally produced and no investment for local manufacturing. Promotion programme to improve acceptance from the public is also very limited as so far it was little involvement and intervention from skill institutions.

A study report on improving solar lantern in Cambodia revealed that consumers are in general not able to save money and are not willing to borrow money due to high interest rates. A high initial price of a durable product (like a solar lantern) is a significant investment for people, although it could be cost effective on the long run. Overall, poor households in Cambodia tend not think far ahead due to their many urgent and immediate needs, so keeping the initial price low is important. Possibly a micro credit or “Fee for services” programme could be a solution (van Diessen 2008). CFL is different from solar lantern physically and technically, but the attitudes of consumers toward these two products are quite similar.

Taxation on CFL is still as same as other imported products, except solar panel, for which the Government reduced importation tax significantly. It could be a contribution to high selling cost of product. Current taxation is a factor that could prevent retailers from offering CFLs at a more affordable price, and that consequently leading to limited quantities sold.

Poverty and low access to electricity are limiting factors for local demand and market size. Cambodia has a population of approximately 14 million people, of which 80% live in rural areas and 75% without grid electricity (NIS 2008, Picosol Cambodia 2011). About 55% of Cambodia’s households use car batteries as electricity storage to power a television and lighting, which is not a sustainable option for the long run (Kamworks 2005). According to the Cambodian Human Development Report 2011, a third of the population still lives under the national poverty line and the average rural poverty rate is 35% (UNDP 2011). Thus, limited purchasing capacity leads to a small market, which consequently acts as a barrier to commercial distribution of CFLs at lower costs.

1.2.1.2 Non-Financial Barriers

- *Absence of Regulation to Mandate or Encourage Public Use*

Government's specific policy on such kind of energy efficient products is still a gap. In general, the initiative of low carbon development, or green growth initiative is still in the initial step of development in Cambodia. Even though the Government has recently adopted some important policy and institutional measures related to green growth development, concrete strategies and action plans for implementation or low-carbon related activities are needed. Cambodia has a good potential to integrate green growth, more specifically climate change mitigation, into its national, sub-national or sectoral plans based on its current situation of economic development.

Policy or regulation to discourage or ban the low quality lighting bulbs may be necessary. Simultaneously, there is a need for a policy/regulation to promote energy efficient lighting technologies that will bring multiple benefits. To support their development, some baseline studies on the energy efficiency lighting technologies together with their social, environmental and economic benefits are required to better understand these technologies, needs for national guidelines and standards, etc.

- *Limited Public Awareness*

As mentioned earlier, public understanding on energy efficient technologies and their benefits, as well as climate change, is a key factor for their diffusion. Public understanding and awareness about energy efficient lighting in Cambodia is generally low, and is a major challenge that needs to be taken into account. For example, a MoE study conducted in 2011 has found that the level of understanding of climate change among most Cambodians is generally low despite the fact that climate change is increasingly affecting them. Likewise, low level of awareness has also been highlighted as a barrier for solar home systems in Cambodia (Picosol 2011). Presently, both incandescent lamps and CFLs are commercially available in Cambodian market. However, there is no available detailed information on advantages and disadvantages of the respective technologies for users. A wide range of means can be considered for awareness raising campaigns. These include development and dissemination of awareness raising materials in local language (Khmer), such as leaflets, brochures, newspaper articles, radio and TV spots, etc. Formal workshops, face-to-face meetings for target beneficiaries, demonstration projects can also be implemented to promote public awareness. In sum, public awareness raising and capacity building at all levels, from grassroot to national, is important for promoting these technologies.

In addition, energy labeling for energy efficient products, including CFLs, is very important to inform consumers about their benefits. Consumer purchase decisions should be made based on essential information about key specifications of the products (such as energy efficiency and lamp lifetime), rather than on superficial factors such as shapes, colors or prices. Preferably, energy labeling of lights and other electric appliances shall be made in local language (Khmer) to ensure better understanding for the general public.

1.2.1.3 Market Mapping of CFLs

There are few import companies in Cambodia that provide wholesale service in Phnom Penh. The companies import many types of final electronic products including CFLs to Cambodian market. A couple of local establishments, such as KAMWORK and the Local Capacity Builder, work on assembling lighting systems such as solar home systems (SHSs). Some of them are consumer-oriented and offers a range of solar products such as SHSs and solar pumps. SHSs are sold to users who want to power their homes and can afford them. In the local markets and electric shops in the capital Phnom Penh, all kinds of lighting products are sold. In rural area, KAMWOK has discovered that battery/TV retailers also sell lighting products apart from batteries. The commonly sold products are black and white television sets, TL lights, tape recorders, fans and small electronic products. The retailers of batteries have a very good coverage of the rural areas. It is about 1 retailer shop for 3,000-5,000 households. This is an existing market to be considered for future improvement in lighting sector. From this market map, it is clear that to boost the CFLs, other activities such as lighting standards, labeling in national language, and tax policy for energy efficient lighting application, financial incentives, implementation strategy, and networking improvement shall be taken into account.

1.2.2 Barrier Identification and Analysis for the Transfer and Diffusion of Household Energy Efficient Appliances

Household energy efficient appliance describes here is mainly referring to water heater technology. Other technology like efficient refrigerator is also taken into account, but obviously not comprehensively incorporated in this report. According to the result of the national consultation workshop, it is founded that the barriers associate with household energy efficient appliance(s) is quite similar to those of CFLs. However, some other different issues are also identified such as scale/capacity of a system to be installed, and trust of potential customers. . Those key barriers are described as below.

1.2.2.1 Financial Barriers

- *High Market Prices of Products*

For most electric appliances such as air conditioners, electric boilers, refrigerators and cookers, higher efficient products are relatively more costly. The root causes of the high product prices are: (1) absence of local manufacturing or local assembling, (2) small market size, (3) import taxes. Those appliances are not manufactured or assembled in Cambodia, but merely imported as the final products. By law, all imported products are subject to 7% tariff for primary products, 15% for capital goods and 10% VAT, except medical and educational materials. These taxes would increase the price of imported products to make them unaffordable for many households especially for those who live in the provinces. As previously discussed, about 80% of the total population resides in rural areas and 75% of households are without grid electricity. The combination of high poverty rates and low access to electricity could limit the size of local markets for energy efficient household appliances.

1.2.2.2 Non-financial barriers

- *Absence of Regulation to Enhance Public Use*

The Royal Government of Cambodia fully supports renewable and energy efficiency development as clearly stated in the NSDP update 2009-2013. However, there are gaps in technology information dissemination, lack of national guidelines and standards, as well as limited promotion activities. The main root causes identified are lack of energy labeling in local language, lack of market based instrument to promote energy efficiency appliances, and lack of institutional capacity in its promotion.

Most of imported electric products in Cambodian market are labeled in foreign languages, such as English, Thai and Chinese. Most local consumers could not understand well about the products of their interest, and consequently, this may lead to wrong or improper application. Therefore, a national labeling system is necessary. Market based instrument is not properly functioned to promote the market of the energy efficiency appliances since the policy to provide tax allowance for those products is not in practice.

- *Limit Public Awareness*

Public awareness raising is an important pillar for achieving the ultimate goal of technology transfer and diffusion. Improving public awareness on energy efficiency and conservation is key to promote the market and use of energy efficient appliances, and reduction of energy consumption. With increasing understanding on energy efficiency and conservation, the public can gradually incorporate energy saving practices into their daily habits and become more prudent with their energy consumption expenditures. The 2011 Cambodian Human Development Report (CHDR) indicates that limitation of adaptive capacity is arguably the main factor in Cambodia's vulnerability to climate change, which is related to the limited capacity at all levels. The limited public awareness has its roots in the low level of education of the general public and is a deep-rooted and longstanding challenge to development. CRCD (2010) highlighted that national energy labeling of lights and other electric appliances in local language would provide useful information for consumers. Furthermore, lack of awareness raising materials in local language, low public interest, shortage of comprehensive communication and awareness raising campaigns can be translated as the root causes of limited public awareness.

It is equally important to establish an aftersale service system for repairing and maintenance of purchased appliances. Experience from a small scale solar home system program in Cambodia shows that many users do not have good understanding about proper use of appliances and often rely on unqualified, untrained servicemen to fix their appliances, a practice that can lead to an undesirable outcome. Therefore, a well-designed aftersale service system is needed.

1.2.3 Linkages of the Barriers Identified

The diffusion and transfer of both CFLs and household energy efficient appliances are mainly under the responsibility of MIME and MOE together with the contribution from key stakeholders including private sector and development partners. Low public awareness of the rural population is a main

challenge to overcome because it leads to a low acceptability of the technologies despite its social, economic and environmental benefits. In addition, the absence of regulation to require and encourage public use contributes to a lower acceptability of these technologies. Though technologies are commercially available in the local markets, the higher price of quality product is still a barrier for due to high proportion of the poor in the countryside.

1.3 Enabling Framework for Overcoming the Barriers

1.3.1 Possible Solutions to Address the Barriers for the Transfer and Diffusion for CFLs

Enabling frameworks for these two technologies are illustrated in figures 9 and 10.

Figure 9: Market Mapping for CFLs

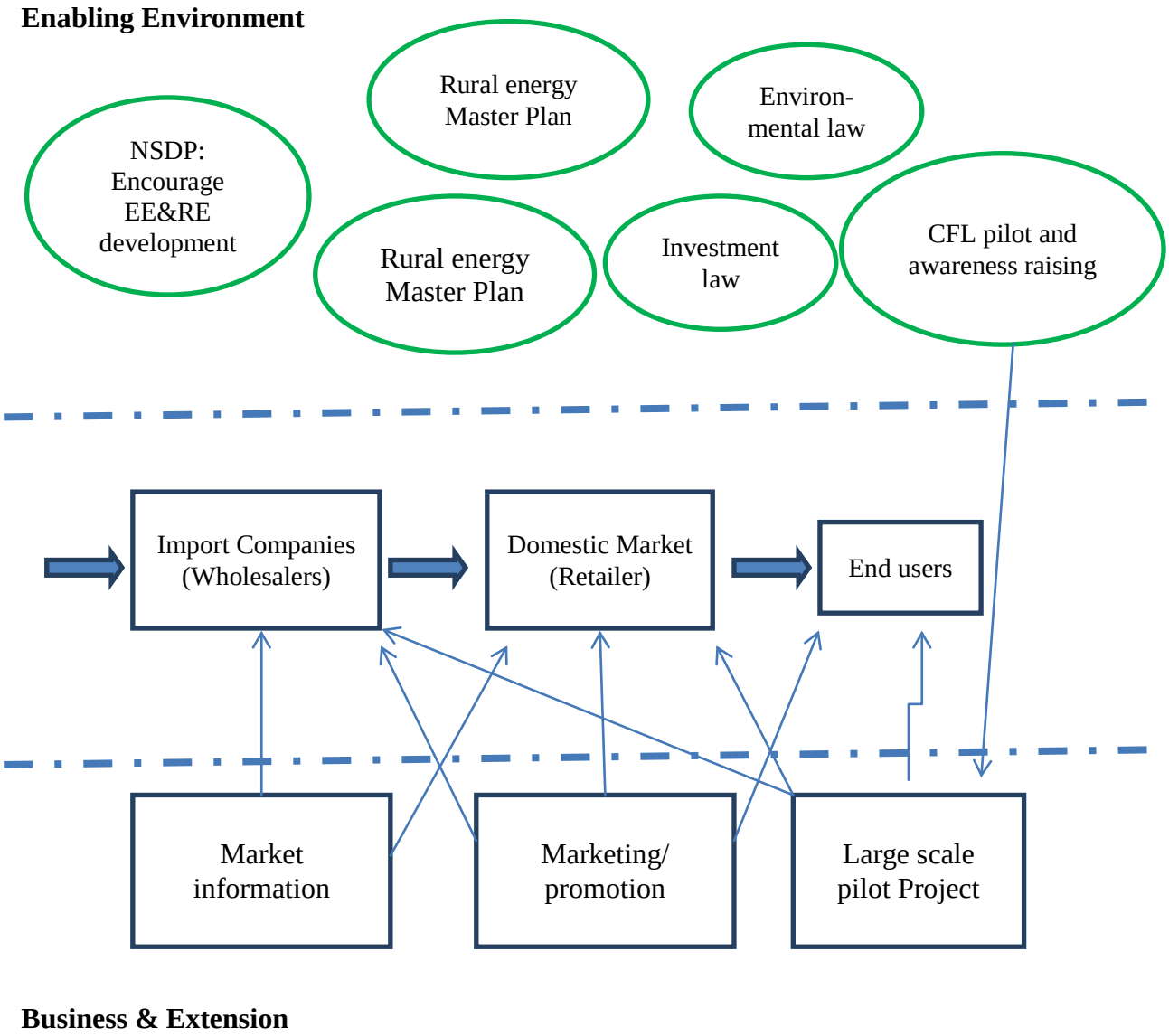
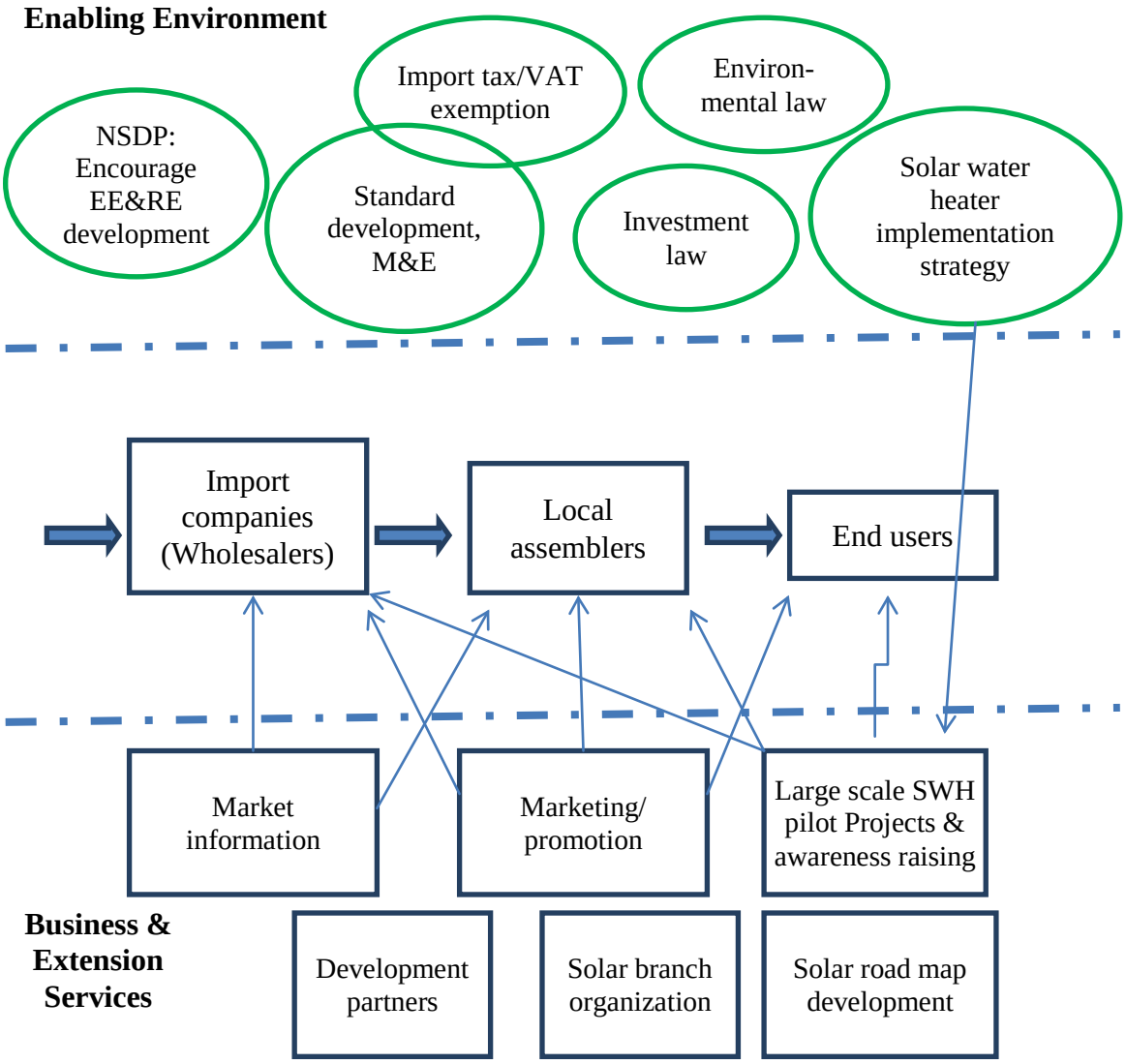


Figure 10: Market Mapping for Energy Efficient Household Appliances



Local investment promotion– CFL is among of the most promising technologies which are applicable for the context of Cambodia. Local investment in its manufacturing can be a solution to lower the cost of CFLs in the local markets. Moreover, Cambodia has a high potential for solar energy together with large proportions of people living in rural areas without grid electricity connection. Therefore, CFL powered by solar electricity could be an ideal solution. Private sector involvement is a key to materializing this option.

Improvement of the existing energy efficiency regulation – To encourage efficient use of energy and to minimize detrimental environmental effects resulting from fossil fuel based energy supply and use, is one of the priorities of the Royal Government of Cambodia. To achieve this objective, energy efficiency guidelines should be developed or updated. National standard establishment, monitoring and evaluation procedure development and implementation should be included into sector development plan. Mainstreaming energy efficient lighting into the national and sectoral development would encourage public use in particular of CFLs. This can provide economic benefits

(resulting from the reduction of the electricity bill) for families and protect the environment through GHG emission reduction. In addition, institutional capacity building and strengthening at national and sub-national levels of the government institutions, such as MIME and MOE, in view of existing gaps in capacities is required.

Promoting public awareness – several studies have identified that low public awareness is a key barrier in implementing the project, thus, promoting public awareness is considered as a prerequisite. To enhance the level of understanding of the public, the development of awareness raising materials (preferably in Khmer) is an initial step. The materials should be disseminated to the public through appropriate media such as radio, TV, newspapers, posters, leaflets, brochures and public events such as World Environment Day. National and local governments can provide examples through the use of CFLs in public buildings and street lighting. The cooperation between public and private sectors is key to promote public awareness. Private firms might aim to promote their products, thus, participate in increasing the basic understanding of the local consumers. Awareness raising is an opportunity for marketing and can drive market expansion of the private sector. For the long term perspective, the integration of the concepts of energy efficiency as well as environmental protection into the educational curriculum should be considered.

1.3.2 Possible Solutions to Address the Barriers for the Transfer and Diffusion for Household Energy Efficient Appliances

Local investment encouragement – To implement Government energy strategies and policies, the local market must be expanded. All appliances are imported from foreign countries and subject to import tariffs and VAT. To respond to this, a lower tariff and tax policy for energy efficient appliances should be taken considered. Reducing the import tariff will make appliances more affordable and possibly increase the size of the local market.

Regulating energy labeling – It is essential to label all appliances in Khmer, or at the very least translate existing energy labels from foreign languages. Energy labeling can be a tool to encourage consumers to consider the advantages and disadvantages of each appliance before purchasing any items. Under the project of Energy Savings Siem Reap, the development of energy labeling for fans, refrigerators and air conditioners sold in Cambodia has been initiated. However, this is a one-time activity tied to a donor funded development project that will need to be further developed into a coherent national system. An example from Thailand indicates that energy labeling of refrigerators and air-conditioners could lead to significant energy saving as well as reduce GHG emission.

Table 11: Energy Saving from the Energy Labeling in Thailand

Product	Peak MW Saving October 1997		GWH/year Saving October 1997		CO_2 Reduction May 1999
	Target	Achieved	Target	Achieved	Achieved
Refrigerator	27	39 (144 percent)	186	297 (154 percent)	177,000
Air-Conditioner	22	13 (59 percent)	117	297 (254 percent)	102,000

Source: Kristina Egan (n.d.) retrieved from http://www.unescap.org

Public awareness promotion – is a key factor of success. Public awareness raising can be done through different pathways. Broadcasting in media such as TV, radio, newspapers can be an

effective tool to deliver the message to the public at large. Temporary direct subsidy for a particular product or class of products can be considered as a catalyst to promote public awareness.

1.3.3 Possible Solutions to Address the Barriers for the Transfer and Diffusion for Energy Efficiency

Both CFLs and household energy efficient appliances are proven and working technologies with benefits in reduction of GHG emissions and electricity savings. The specific recommendations for each technology are listed below.

CFL: The higher price of quality CFLs combined with low public awareness need to be overcome. Demonstration projects with international support can lower the price of CFLs through subsidies and increase public awareness of the benefits of CFLs for the environment and electricity savings.

Household energy efficiency appliance–Labelling of electric appliances in Cambodia should be initiated and implemented. Government incentives for research and development on energy efficiency could encourage local investment in this particular sector.

1.4 Technology Action Plans, Project Ideas, and Other Issues in Energy Efficiency

1.4.1 Technology Action Plan for the Transfer and Diffusion of CFLs

Enhancing the local market – High poverty prevalence in rural Cambodia together with limited access to electricity has limited the market size and has subsequently led to higher prices of CFLs. A favorable environment for local investment on this technology should be developed to attract potential investors (either local or international) to produce CFLs available for the local market with a competitive price and affordable for local people. Ministry of Commerce and Ministry of Industry, Mines and Energy should have a key role to play in this. Beyond this, CDM consideration should be promoted for the investor since it is aligned with the Government commitment in reducing GHG emission and could lower the price of a unit of CFL produced via additional incomes generated from selling certified emission reductions. To promote the inclusion of CDM in the investment project, Ministry of Environment should take a lead while Ministry of Industry, Mines and Energy, and Ministry of Economy and Finance should take part in promoting the energy efficient lighting systems; for example, via provision of tax exemption for the energy efficient products. Local investment does not only providing a lower product price, but also creates job opportunities for the people. Time frame for implementing this activity shall be between 2013-2018, while CDM component shall be considered before 2020, i.e. the end of the Second Commitment Period of the Kyoto Protocol.

Encouraging public acceptability through improving the existing regulation – Although the Government encourages energy efficiency and saving to reduce expenditures on fuels and to minimize detrimental environmental effects, the lack of relevant guidelines or regulation has prevented key stakeholders from successful implementation of this decision. Initially, the development and/or updating the existing energy efficiency guidelines shall be developed which could serve as a fundamental instrument to promote the public use of energy efficient lighting. In addition, green tax and green business policy should be taken into consideration to be consistent

with the green growth initiative and development. Due to the limited knowledge on this technology at both national and sub-national levels, mainstreaming of energy efficient lighting into the development plan for both levels shall be included in the agenda and this should aligned with the overall 5-year planning cycle of the Government (2013-2018). Ministry of Industry, Mines and Energy should be a key player with a contribution from Ministry of Environment. Since implementation of these tasks requires considerable resources, and due to the current Government budget constraint, financial support from potential development partners, both bilateral and multilateral, should be looked into.

Public awareness improvement – Currently, there is a lack of information accessibility to new developed technologies that could provide co-benefits for both reducing the electricity bill and contributing to GHG emission reduction, which are in line with the Government priority to promote energy security. To improve the accessibility to information and with a purpose to enhance public awareness, the first important step is to develop awareness raising materials in local language to enable the better understanding of the general public. Awareness raising materials should be developed and make ready for dissemination by 2015 under the cooperation between Ministry of Environment; Ministry of Industry, Mines and Energy; Ministry of Information; and academic institutions. For a long term education, the integration of energy efficiency and climate change into the education curriculum, especially at either primary or secondary levels, should be carried out by 2017 in which the Ministry of Education, Youth and Sports should take a lead with contribution from key agencies such as Ministry of Environment, Ministry of Industry, Mines and Energy.

1.4.2 Technology Action Plan for the Transfer and Diffusion of Household Energy Efficient Appliances

Promoting local market investment – All imported products including the energy efficient products are subject to import tax charge and thus making the prices of products higher. It is important to look into the existing import duty tax policy to explore possibility for tax incentives for energy efficient products including household appliances. This task shall be under the responsibility of Ministry of Economy and Finance and Ministry of Industry, Mines and Energy. By 2017, the import tax for the energy efficient appliances should be refined to provide a favorable condition for the local market expansion. Another important step is to promote the private sector involvement in technology development and local production of appliances to lower their prices and to provide jobs for local people. This initiative should be led by the Ministry of Commerce and Ministry of Industry, Mines and Energy.

Refinement of regulation to enhance public use – All household appliances are imported and lack clear information on their energy efficient specifications. Thus, it is important to develop new or update the existing guidelines and standards for these technologies and to implement them at both national and sub-national levels. The guidelines/standards should be prepared by 2017 with Ministry of Industry, Mines and Energy being the lead agency in cooperation with Ministry of Environment. The second important action that could be considered is the development of energy efficient labeling since all imported products have labels in foreign languages which are difficult to understand for local users. Ministry of Industry, Mines and Energy, and Ministry of Environment should prioritize what products to be selected and included in the labeling. By 2020, the energy efficient labeling system, including comprehensive capacity to test products, shall be established

and fully functional in Cambodia. Beyond this, institutional capacity development is also an important part to be considered in the process of formulating the energy labeling system in Cambodia. Establishing a country own labeling system requires significant financial resource and expertise, thus the Government will need to work closely with bilateral and multilateral development partners.

Improving information accessibility for the public – Research and dissemination activities associated with energy efficient appliances and other related issues are absent in Cambodia. Promoting research and dissemination activities should be considered in the technology action plan. To make this initiative implementable, key agencies to be actively involved are Ministry of Industry, Mines and Energy; Ministry of Environment, Ministry of Information, research/academic institutions as well as relevant NGOs. To promote awareness for the general public, awareness raising materials should be developed in local language and disseminated using a wide range of media such as TV, radio, brochures and other possible means. By 2015, the level of the public awareness on the energy efficient appliances should be improved significantly. Collective effort of key stakeholders is required together with financial support from potential development partners. Another possible action is initiating a demonstration project on the energy efficient appliances in which public awareness is included. This could provide a success story or positive lesson learnt that can be used to improve public awareness and support the replication and scaling up of these technologies. For the demonstration project, Ministry of Environment should co-lead with the Ministry of Industry, Mines and Energy in partnership with relevant universities, private sector and NGOs. At least two demonstration projects shall be implemented by 2015.

1.4.3 Brief Summary of Project Ideas for International Support

1. Promoting energy efficient lighting through demonstration and outreach
2. Mainstreaming energy efficient lighting into sub-national and national development plans
3. Energy efficient labeling in Cambodia
4. Promoting research and development in low cost energy efficient household appliances

Detailed descriptions of the project ideas are attached in Annex III.

1.4. 4 Other External Barriers

The existing technical capacity of and financial resources available to responsible Government agencies are limited. Therefore, the development and implementation of these proposed projects can be realised only if external technical and funding supports become available. Furthermore, a holistic approach in designing full project proposal is needed to ensure that all key elements are put in place related to technical and institutional capacity building, legal and policy framework establishment, awareness raising and information sharing, public-private partnership, strategy to ensure sustainability, etc. Furthermore, The absorbing capacity of key stakeholders need to be improved to facilitate a more effective access to available international funds such as the Global Environment Facility, Least Developed Country Fund, Green Climate Fund, etc.

1.5 Summary

Both CFLs and household energy efficient appliances are mitigation technologies prioritized by stakeholder consultations. The implementation of these technologies typically relies on MIME, MOE as well as other key players including MOC and MEF. The high price of energy efficient products, the absence of regulations to require or encourage public use, and limited public awareness are the main barriers for transfer and diffusion. A number of possible solutions to overcome these challenges are suggested and include: public awareness campaign through demonstration activities, development of energy efficiency labeling, and encouragement of research and development which can be a catalyst to promote the local investment. It is crucial that international support in terms of funding and technical knowledge be available to make the proposed projects possible.

CHAPTER 2: TRANSPORT

2.1 Preliminary Targets for Technology Transfer and Diffusion

Cambodia's transport system can be classified into road network, railway, civil aviation, and inland water way. The major trend and development in the transport sector is the significant increase in traffic which is mainly due to an expanding economy and improving roads. Consequently the number of registered vehicles has been increasing leading to increasing vehicle emissions and traffic accidents which have significant impacts on the environment and health. In urban areas the rapid increase of privately owned vehicles, causes frequent and serious congestion and worsening pollution, particularly due to the use of many old second hand vehicles, poor maintenance and lack of vehicle emission standards. In addition, there is no mass transit public transport system operating within any urban areas. The most predominant transport means within urban areas is provided by motorcycle taxis (Phollak 2012).

Transport technology can be classified as a public good. The dramatically increasing number of registered vehicles on road combined with inadequate road infrastructure development has led to traffic congestions in the major urban areas, in particular, Phnom Penh, and increases air pollution (table 12). Consequently, the emission of GHGs in transport sector is expected to steadily increase for coming years.

Table 12: Emissions in Gg CO_2eq for Vehicles

Type of Vehicles	GHG Emissions in Transport Sector (Gg CO_2eq)										
	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Motorbike	117	203	356	433	527	642	781	950	1155	1406	1710
Car	146	267	424	516	627	763	929	1130	1374	1672	2035
Pickup	173	303	455	554	674	819	997	1213	1476	1796	2185
Minibus	55	105	168	204	248	302	368	447	544	662	806
Bus	27	47	77	93	114	138	168	205	249	303	369
Truck 2 axle	183	314	506	648	829	1062	1359	1739	2226	2849	3646
Truck 4axle and trail	8	11	18	22	27	33	40	48	59	72	87
Truck 5 axle	11	12	16	19	23	28	34	42	51	62	75

Source: Adapted from MPWT (2012)

To reduce GHG emissions from transport, three main strategic responses are suggested: 1) avoid or reduce travel, 2) shift to environmentally clean modes of travel, and 3) improve energy efficiency and transport technology (GTZ 2007). The consultation workshops identified the energy efficiency in Urban Mass Transportation and Vehicle Emission Standards as the major mitigation measures in Cambodian transport sector. Urban Mass Transport or Urban Public Transport promotion is an appropriate measure to reduce individual travel mode that normally causes energy inefficiency and traffic congestion, and a decline in urban air quality.

2.2 Barrier Analysis

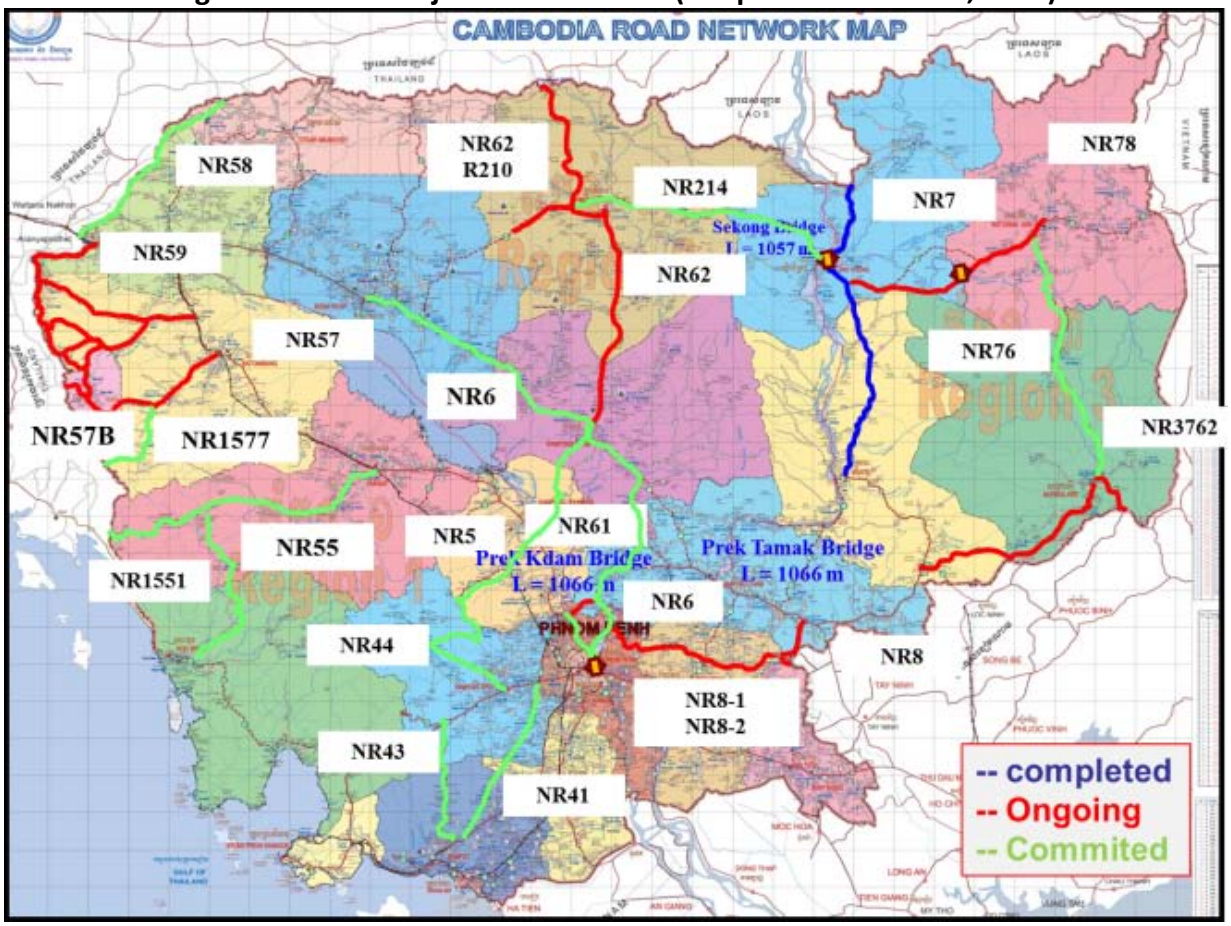
Information on various urban transport systems is readily available such as Intelligent Transport Systems (ITS), a conventional bus system or urban mass transport, etc. However, the current barrier analysis focused mainly on two prioritized technologies, namely vehicle emission standards and urban mass transportation, and followed four main analytical steps: (1) identify all possible barriers, (2) screen for the key barriers, (3) establish hierarchy of barriers and (4) analyze causal relations (UNEP 2010). Through the stakeholder consultation workshop, eight types of considerable barriers have been identified including economic and finance, market failure/imperfection, regulatory/policy/legal and IPR, institutional and organizational capacity, human and technical skills, information and awareness, social, cultural and behavioral, and network failures.

2.2.1 Barrier Identification and Analysis for the Transfer and Diffusion of Urban Public Transport

Limited capacity of road network and rapid urbanization present tremendous challenge to current on-land transportation systems, particularly in urban areas. Both the capital and other urban areas are experiencing transport problems caused by inadequate transport means, physical road facilities, and traffic management systems inadequate for the rapid growth of the population and socio-economic development activities. The existing physical infrastructures were designed over the past 60 years including the recent 3 decades of neglect during the civil wars. Therefore, they may not fit with current traffic flow requirements and urban environmental quality concern. Public transportation can reduce GHG emissions and conserves energy compared with individual use of vehicles. However, its promotion faces some challenges as well. Preference for individual driving in public road, limited road design, and near or on side walk business activities may be important factors that limit road network capacity. Consequently, this has limited bus service in urban areas of Phnom Penh, and other major cities like Battambang, Sihanoukville and Siem Reap. Major causes of the poor physical transport infrastructure is the inadequate urban planning, limited management and maintenance capacity, and limited financial resources. A study conducted by JICA (2006) suggested that US$2.5 billion should be spent for upgrading road in entire country until 2020. As of 2010, MPWT reported that several road and bridge projects have been completed with external financial supports (MPWT2010). However, this result is not coming out only from specific urban areas, but actually for the entire country.

In addition to the above mentioned issues, it is founded that lack of an urban transport master plan is another major challenge. It is common practice that urban transport master plan is an integral part of urban planning. This issue may be closely associated with inadequate coordination of key players involving in urban land use planning. Therefore, integration of all transportation measures/means into urban planning in order to improve transportation sector shall be promoted. Furthermore, it is important to have a well elaboration in urban management master plan. Urban master plan shall not consider just on road and road network improvement, but also focuses on diversification of urban transportation means, basic traffic law, policy and regulation improvement and engagement of private investment and public involvement.

Figure 11: Road Projects in Cambodia (Adapted from MPWT, 2012)



Source: Ministry of Public Work and Transport (2012)

Lack of clear regulation for the promotion of public transportation–The number of motorcycles and passenger cars used for private and individual transport have been increasing steadily. Therefore, improved policy and regulation need to be put in place to reduce the private traveling mode which could contribute to the reduction of traffic congestion, better air quality and reduction of GHG emissions. Public private partnership should be considered in promoting urban mass transport development. Under a JICA project in 2001, a bus service was put in trial for about two months as a pilot activity, but was not successful due to some associated factors such as inadequate existing road infrastructure including side walk condition, traveler's behavior, limited geographical coverage, limited mobility and frequency, public attitude, etc. The lack of clear policy or regulation to curb the growth of individual vehicles resulted in traffic congestion which increased bus travel time. Many factors such as poor traffic management, uncontrollable parking along the main roads, and road management especially walking side in the inner cities are also hindrance to public transportation, thus, the enforcement of existing traffic regulation need to be reinforced.

Behavior change of service users– Acceptability of public transport by users is key toward successful project/programme implementation. Public transportation use is one of the most effective actions, which individuals can benefit from since it offers an immediate alternative for comfortable travel, and reducing travel cost, traffic accidents, energy consumption and carbon footprint. The possible root causes are: (1) lack of clear regulation to promote public transportation, (2) lack of cost-benefit study, and (3) lack of public awareness raising and

promotion. The lack of clear regulation to promote public transportation over private transportation is a contributing factor to the negative attitude of users. The cost-benefit analysis of public transportation against individual travelling has not been comprehensively conducted in Cambodia. Consequently it is difficult for policy makers to make appropriate decision on public transport without clear information on its potential benefits to individual users and society as a whole.

Figure 12: Traffic Congestion in Phnom Penh

Source: Ministry of Environment (2012)

2.2.2 Barrier Identification and Analysis for the Transfer and Diffusion of Vehicle Emission Standards

Limited technical capacity of Government officials – Government agencies do not have sufficient capacity to implement vehicle inspection and check vehicle emissions. The General Department of Transport of Ministry of Public Works and Transport is responsible for inspecting vehicle emissions at roadside but does not have the resources to do so. While the Sub-Decree on Air Pollution and Noise Disturbance stipulates levels of concentrations for air pollutants, it is yet to be implemented in practice (RGC 2000). The Environmental Strategic Plan for Cambodia 2004-2008 requires air pollution emitted by movable sources to be controlled and monitored. However, currently no activities related to vehicle emission inspection are implemented roadside in the major Cambodian cities because of a lack of equipment, fund, staff capacity and monitoring plan.

Lack of vehicle inspection and maintenance – Most vehicles imported to the country are second hand. The engine combustion efficiency is much lower than standard. Therefore, vehicle inspection and maintenance are necessary in order to protect local air quality and promote energy efficiency use. Inspection and maintenance of vehicles should cover safety checks as well as compliance with emission standards. Unsafe vehicles can operate freely on Cambodian roads. Combined with other factors such as insufficient traffic policy and regulation, weak law enforcement, lack of cost-benefit analysis of using new and old vehicles, this is a contributing factor that leads to increasing number of traffic accidents and increase of pollution. By law, vehicle inspection is the responsibility of the

General Directorate of Transport of MPWT. Vehicles are classified under three categories: (a) light vehicles, (b) heavy vehicles, and (c) motorcycles. A four-year certificate is given to a new car. After that, inspection is required every two years interval. Lack of public facilities and equipment for responsible institution/agency is one of the causes. The modern inspection and maintenance service is available in Phnom Penh in recent years, while it is founded very limited in various provinces and lower level. The installation of such equipment/facility is very costly, requires highly qualified technical staff for operation, while emission control policy and effective enforcement requires adequate resources to develop and strengthen.

Lack of coordination among key agencies – In the vehicle inspection, cooperation among key agencies is important. Insufficient cooperation among relevant agencies could cause poor vehicle performance and low result in inspection and maintenance service. The Traffic Section of the Ministry of Interior, Department of Transport of the Ministry of Public Works and Transport, and Department of Pollution Control of the Ministry of Environment, Kamcontrol of the Ministry of Commerce (in charge of fuel quality control) are among the key relevant agencies in enforcing implementation of emission standards in Cambodia. Generally, a proper coordination mechanism, which is a determining factor in ensuring a successful enforcement of vehicle inspection, is not found between the key line agencies due to the differences of their mandates, roles and responsibilities even though the nature of the work could not be isolated at some circumstances.

2.2.3 Linkages of the Barriers Identified

The diffusion and transfer of urban mass transportation technology relies mainly on the mandate of MPWT and other key agencies such as the Phnom Penh Municipality, MOE and international donors. There is a total absence of public transportation in Cambodia's cities. The road infrastructure is generally in poor condition and inadequate to meet the population's needs for access and mobility within a sustainable, safe and healthy environment. There is no clear guideline for the development of public transport and no government support either. Restrictions on the use of individual vehicles will need to be introduced as traffic congestion has reached critical levels. At the same time, users have no reliable and convenient alternative to the use of private vehicles. The introduction of public transport will need to be accompanied by public awareness of its benefits along with restrictions on the use of private vehicles. Regulations can encourage users to accept public service, which in turn will increase the efficiency of public transport.

Vehicle emission standards are considered an option for mitigation of greenhouse gases. The vehicle inspection and maintenance of MPWT is under the control of the General Department of Transport. However, in practice, little has been done, because of the inadequate technical capacity, facilities and equipment. Significantly, a vehicle inspection has not been a priority because of limited government budget. Lack of cooperation and coordination, and sometime overlapping mandates between key agencies is also a barrier to implementation of the technology.

2.3 Enabling Framework for Overcoming the Barriers

2.3.1 Possible Solutions to Address the Barriers for the Transfer and Diffusion of Urban Mass Transportation

Physical infrastructure improvement – Additional financial and technical resources can speed up and improve the expansion of the physical infrastructure in place. Expanding the cooperation with the key donors, for example, ADB and World Bank, would allow proper infrastructures development or rehabilitation. However, future developments must be in line with the master plan and urban land-use planning. Under the mandate of MPWT, the repair and rehabilitation of the existing road infrastructure and its effective operation and maintenance are on the agenda of the National Strategic Plan for GHG Mitigation and Climate Change Adaptation in Transport.

Support from urban planners and policy makers – Urban mass transportation must have clear directions and perspectives from policy makers. Mainstreaming GHG mitigation and urban mass transportation can be a driver for change in policy making and planning. The existing legal tools should be amended based on the current requirements. Priority lanes set up for urban mass transportation should be considered to reduce traffic congestion and favor public transport.

Public transportation investments – Capital investment is a key. Investment can be either from government or private and possibly companies, or public-private partnerships. The National Transport Policy encourages private sector involvement in the development of infrastructures and transport services (MPWT 2010).

Promoting public awareness and participation – The RGC recognizes the significance of public awareness and participation and is committed to the dissemination of information about transportation (MPWT 2010). To promote public participation, clear policies or regulations need to be on board and more stringent enforcement implemented in order to reduce the use of private vehicles. A case of success is the compulsory helmet wearing for motorcycle driving implemented over the past three years by the RGC.

2.3.2 Possible Solutions to Address the Barriers for the Transfer and Diffusion of Vehicle Emission Standards

Institutional capacity building – Technical capacity building for the key responsible agencies, such as MWPT and MOE, at both national and sub-national levels is important to provide them with the knowledge to enforce their respective mandates in vehicle emission control and inspection.

Coordination and cooperation – The Department of Transport of MPWT is responsible for emission testing upon the registration of vehicles. The Department of Pollution Control of MoE is responsible for road emission inspection based on emission standards of the Sub-Decree on Air Quality and Noise Disturbance. Coordination and cooperation between these agencies and police authorities will ensure that emission standards are coherent and vehicles are inspected regularly.

Investment on inspection and maintenance – The development of an effective inspection and maintenance system requires proper modern equipment and facilities, which in turn requires

considerable investment. Because of the limited national budget, it is unlikely that this measure can be realised in the near future, in particular, when the abatement of greenhouse gases through vehicle emission control is not a high priority. This gap could partially be filled by private sector investments.

Law enforcement – Mandatory inspection and maintenance would increase the number of inspected vehicles and lead to the achievements of emission standards for GHG emission reduction and other benefits such as reducing traffic accidents and improving local air quality. As stipulated in the Sub-decree on Air Quality and Noise Disturbance, individuals whose vehicles emit above emission standards are subject to fines or imprisonment. The increase of taxes and import duties of old and second hand vehicles could be an effective way to reduce the number of used vehicles in Cambodia.

2.3.3 Possible Solutions for Energy Efficiency in the Transport Sector

Urban mass transportation – The first step is to review existing legal tools and their implementation in the transport sector. Restrictions on individual driving could be enforced providing there are alternative means of transport for the public. Setting up a transport authority with actual decision and management powers should be considered to coordinate urban development and public transport. It is also important to carry out demonstration projects in major urban areas where large volumes of vehicles and traffic congestion are common place.

Vehicle emission standards – To put into action vehicle standards, capacity development and institutional strengthening are key. Both emission control and inspection & maintenance training programs for concerning agencies are necessary to achieve the goal of regulating emission standards. Service should be expanded to other provinces where there is currently a total lack of regulation. Private sector involvement in inspection and maintenance is an option because of limited national budget.

2.4 Technology Action Plans, Project Ideas, and Other Issues in the Transport Sector

2.4.1 Technology Action Plan for the Transfer and Diffusion of Urban Mass Transportation

Upgrading the physical infrastructure – Rehabilitation and construction of road infrastructure are included in the subsector priorities of the Royal Government of Cambodia as stated in NSDP Update 2009-2013.However, as of to date limited national budget together with the lack of sustainable urban planning to promote public transport have put the public bus transportation in doubt. It is important that this kind of project be implemented by 2020 in order to keep pace with the current economic development and to ensure the low carbon development society. By nature, the infrastructure development must be led by the Ministry of Public Works and Transport, while Ministry of Economy and Finance also has a key role to play. Due to the lack of sufficient national budget, therefore, promoting public-private partnerships is one of viable options that must be looked into besides seeking for the donor support from both bilateral and multilateral sources in the form of either grant or loan. Road maintenance could also expand the lifespan of the infrastructure, hence, the maintenance program must be developed and implemented regularly and timely rather than focusing on repairing work after damages happened.

Refinement of policies and guidelines for the promotion of public transportation – Due to the failure of the first attempt in operating the public transportation in Phnom Penh, it is important to develop a more thorough plan based on the previous lessons to ensure a successful implementation. Development or refinement of existing policies and guidelines must be considered to serve as a basic tool to promote the public transport. One of those should be considered is the restriction of unregistered motor-taxi, taxi, or remorque (tuk-tuk) service providers because they could block the public transportation. These tasks shall be led by Ministry of Public Works and Transport with contribution from Ministry of Environment and other key stakeholders, the timeframe for these tasks should be done by 2015.A clear roadmap for promoting urban mass transportation needs to be developed and mainstreamed into the development plans. To smoothen the coordination between the urban development and public transport, an establishment of a transport authority should be considered, in which Ministry of Public Works and Transport should be a leader and cooperate with other key agencies such as Ministry of Land Management, Urban Planning and Construction; Ministry of Environment. Since budget remains a problem for the Government, international support from and cooperation with bilateral and multilateral development partners need to be looked into.

Enhancement of users' behavior toward public transportation – Statistics indicate that the number of private vehicles keeps increasing annually due to the lack of effective and reliable public transportation service and increase of people well-being. Cost-benefit research/study on the mass transportation shall be carried out and its results should be disseminated to the general public to improve their understanding about its benefits and to build up trust in using public transport in anticipation of its implementation in the future. This task should be jointly conducted by Ministry of Public Works and Transport, and universities or research institutes with the final support from either the Government or potential donors. When the fundamental tools are in place, a demonstration project with subsidy scheme shall be implemented to promote public participation. The demonstration project shall be carried out by 2017 and Ministry of Public Works and Transport shall be the lead agency with close cooperation with key agencies such as MOE and MOI.

2.4.2 Technology Action Plan for the Transfer and Diffusion of Vehicle Emission Standards

Capacity development of government officials –Cambodia appears to be facing a growing air pollution problem due to the emissions from vehicles. The Environmental Strategic Plan for Cambodia (2004-2008) stated that emissions from movable sources need to be controlled and monitored. However, lack of skilled technical staff remains an issue, and thus capacity building of responsible staff is crucial in order for them to perform this particular task. For vehicle emission control and monitoring, both Ministry of Public Works and Transport, and Ministry of Environment are the key players. Ministry of Public Works and Transport shall mainly focus on vehicle inspection while Ministry of Environment will take part in the emission control and monitoring. The capacity development should be in the form of trainings, on-the-job training, pilot projects, exchange visits or participating in research activities. The key concerned agencies should have a clear capacity development plan according to their respective mandates. By 2017, at least 100 technical staff must have enough capacity to conduct emission control and monitoring. To be able to carry out capacity development activities, financial support is vital, thus, both local support (from the Government) and international support (bilateral and multilateral) need to be explored.

Enhancement of vehicle inspection and maintenance – Currently the Government does not put a high priority on vehicle emission control due to budget constraint despite the fact that vehicle emission control is one of key measures to reduce air pollution and emission of GHG from vehicles. Refinement of the existing inspection/monitoring and emission control rules and regulation shall be carried out every 5 years because the vehicle technologies keep changing. Importantly, the enforcement of rules and regulations associated with the emission control must be strictly and continuously implemented. A technical working group on the emission control and monitoring could be established to enhance the quality of emission control as well as to strengthen the cooperation and coordination between key agencies such as Ministry of Public Works and Transport, Ministry of Environment. The establishment of a technical group should be done by 2015 in which both Ministry of Public Works and Transport and Ministry of Environment should be co-leaders.

Promoting the emission control equipment and facilities – laboratory capacity, equipment for inspection and monitoring are in shortage for the concerning agencies to carry out their respective tasks. First of all, both Ministry of Public Works and Transport and Ministry of Environment should conduct a need assessment study to identify key priorities to be addressed. By 2015, the need assessment report should be ready which should be the basis for building laboratory capacity and proposal preparation for international support and for promoting public-private partnerships.

2.4.3 Brief Summary of Project Ideas for International Support (Details in Annex 3)

Emission from energy sector has increased constantly with economic development, with transportation (significantly road transportation) accounting for the largest share in the sector's emission. While transport sector development is considered as a priority by the Government in its official plans and policies; the current budgetary constraints do not allow it to fully realised. To support the government policies and plans for the transport sector, the following project ideas are proposed:

5. Promoting urban public transport in Phnom Penh
6. Public transport planning and travel demand management
7. Enhancing vehicle emission control, inspection and maintenance in large cities.

2.4.4 Other External Barriers

The development and implementation of these proposed projects can be achieved only if external funding becomes available. The capacity of the key stakeholders in absorbing the funds will need careful consideration.

2.5 Summary

Urban mass transportation and vehicle emission standards are the mitigation technologies prioritized through stakeholder consultations. The implementation of these technologies relies on MPWT, MOE as well as other key government institutions, including MEF and MOI. The inadequacy of physical infrastructures, the lack of clear guidelines and policies for the promotion of public transportation, and the preference for private modes of transport are the barriers for the transfer and diffusion of this technology. Barriers for vehicle emission standards are limited capacity of government officers, lack of vehicle inspection and maintenance, lack of coordination between key agencies and insufficient investment in facilities and equipment. A number of possible solution are suggested including the refinement of existing legal tools, reinforcement of rules and regulations, public mass transportation as a demonstration activities for behavior change and promotion of private investment. It is crucial that international support in terms of funding and technical knowledge be available to make the proposed projects possible.

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Annexes

ANNEX I. TECHNOLOGY FACTSHEETS

Factsheet 1: Bus Rapid Transit and Transport Management System

Sector	ENERGY
Subsector	Transport
Technology name	Bus Rapid Transit and Transport Management System
Scale	Medium to large scale
Availability	Short to Medium term
Technology to be included in prioritization	This type of technology is prioritized nationally and is being considered in various transport-related plans.
Background/notes	Intelligent Transport Systems (ITS) apply information and communication technologies to vehicles and to transport infrastructure. This may increase the reliability, safety, efficiency and quality of transport systems. An increase in the efficiency of the transport system usually also leads to reduction in associated GHG emissions. Some ITS applications are already being used in traveler information systems and electronic road pricing. More advanced systems for traffic management, eco-driver assistance, intermodal freight management, and public transportation are being developed and demonstrated around the globe. Barriers for implementation include technological complexity, capital costs and privacy protection.
Implementation assumptions	ITSs are technologically complex which requires careful planning and public consultation and monitoring. Barriers to implementation include: High initial investments and chicken-and-egg problem, i.e. decision makers only recognize the need for investments once they experience the benefits of a fully functional ITS system; Complex implementation process due to roll-out to large numbers of end-users; Technological complexity; Uncertainty regarding costs, benefits and public acceptance; Protection of privacy, security and legal issues; High data requirement for ITS operations.
Impact Statements (how this option impacts the country development priorities)	
Country social development priorities	Bus Rapid Transit can make an important contribution to sustainable urban transport system. It is more energy efficient than conventional bus systems per person-kilometer due to the higher speeds and higher capacity buses. Also it may improve the modal split towards more use of public transport. Thereby, it contributes to the following aspects of sustainable development: Social equality and poverty reduction by providing affordable high-quality transport; Economic prosperity by reducing travel times and congestion.
Country development priorities	Energy efficiency is a priority of the Cambodian Government with regards to energy security, reducing dependency on imported energy, reducing poverty in society. Public transportation

	contributes to reduction of energy consumption and promotes social equity.
Country environmental development priorities	This type of technology can help: Reduce air pollution; Reduce GHG emissions; Reduce congestion; and Increase energy supply security due to reduction of imported oil.
Other consideration and priorities such as market potential	The RGC recognizes and supports efforts in environmental protection, addressing climate change, and improving efficiency of energy resource use.
Costs (US$)	
Capital costs over 10 years	Estimates for investment cost for BRT systems vary widely. Depending on the required capacity, urban context and complexity of the project, BRT systems can be delivered for $ 1 - 15 million per km (IPCC, 2007), with most existing BRTs in developing countries in the lower part of this range (ITDP, 2007). These figures are substantially lower than those for rail-based systems, which cost approximately $ 50 million per km (IPCC, 2007). For China, the incremental cost of implementing BRTs have been estimated at 2.6 $/$tCO_2$ (CCAP/Tsinghua, 2006). For Latin American cities, costs for BRTs were estimated to be 14-66 $/$tCO_2$, depending on the policy package involved (IPCC, 2007).
Operational costs over 10 years	N/a
Other costs over 10 years	N/a

Factsheet 2: Vehicle Emission Standard

Sector	ENERGY
Subsector	Transport
Technology name	Vehicle Emission Standard
Scale	Medium to large scale
Availability	Short to Medium term
Technology to be included in prioritization	This type of technology is prioritized nationally and has been considered in various transport-related plans. Vehicle emission standards could be implemented locally (for example at the city level), regionally (at the provincial level), nationally (for the whole of Cambodia).
Background/notes	The general goal of a vehicle emission standards program is to reduce emissions and control pollution from motor vehicles in use. A comprehensive strategy may include the following components: stricter emission standards for new vehicles, specifications for clean fuels, proper maintenance of vehicles in use.
Implementation assumptions	It is assumed that air quality problems are related to vehicle emissions, which are the main contributors to pollution in urban area. Private cars, commercial vehicles and motorbikes are the main modes of transportation in Cambodia. In the absence of reliable mass public transport, motor vehicles will continue to be the main contributor of the transport mix in Cambodia in the foreseeable future. The main obstacles to the implementation of vehicle emission standards in Cambodia are: the availability of higher quality fuels (level of lead and sulphur) which are dependent on imports from neighboring countries, the low level of awareness of consumers which may see stricter standards as costly in terms of vehicles to be purchased (newer versus second hand) and cleaner more expensive fuels. In order to maximize current catalyst technologies (which reduce CO, HC and NOx), sulfur concentrations in gasoline need to be limited to 500 ppm. Future technologies may require even lower concentrations of 30-50 ppm such as in Europe, the USA and Japan. It will be necessary to phase in stricter standards year by year and step by step as the average fleet age of vehicle decreases (following the examples of Europe, California, Japan, China etc).
Impact Statements (how this option impacts the country development priorities)	
Country social development priorities	Fuel quality standards should be set not only to reduce GHG emissions but also because they contribute to improved public health and cleaner environment.
Country development priorities	Stricter vehicle emission standards will promote higher efficiency and is a priority of the Cambodian Government with regards to

	energy security, reducing dependency on imported energy. Reduced air pollution will improve public health and improve environmental conditions.
Country environmental development priorities	Vehicle emission standards can help Reduce air pollution; Reduce GHG emissions; Increase energy supply security due to reduction of imported oil.
Other consideration and priorities such as market potential	The RGC recognizes and supports efforts in environmental protection, addressing climate change, and improving efficiency of energy resource use.
Costs (US$)	
Capital costs over 10 years	N/a
Operational costs over 10 years	International studies of costs and fuel indicate opportunities to achieve further fleet fuel economy gains from more stringent standards, even in Europe and the US. Savings potential in Cambodia would be significant due to the old age of the vehicle fleet. However, without regulatory emission standards the market will not necessary adopt cleaner vehicles (hybrid, electric, etc), as buyers may trade economies in fuels for larger and more powerful vehicles. Basing stringency decisions on existing standards elsewhere requires careful consideration of differences between the home market and compared markets in fuel quality and availability; fuel economy testing methods; types and sizes of vehicles sold; road conditions that may affectthe robustness of key technologies; and conditions that may affect the availability of technologies, for example,availability of sophisticated repair facilities.
Other costs over 10 years	N/a

Factsheet 3: Compact Fluorescent Lamps (CFL)

Sector	ENERGY
Subsector	Energy efficiency
Technology name	Compact Fluorescent Lamps (CFL)
Scale	Small scale
Availability	Short term
Technology to be included in prioritization	This type of technology has been considered in energy efficiency options listed in the national mitigation study.
Background/notes	Replacing incandescent bulbs with CFLs lowers the electrical bill for lighting up to 75%. If 20 incandescent bulbs of 75-watt capacity are replaced by 23-watt CFLs, it would save 1,040 watts for every hour that the lamps are used. At five hours per day, this means saving over 2,000 kWh or about $208 back in the pocket every year (Replace them with a 20-watt CFL and save more - but slightly less light).
Implementation assumptions	A nationwide awareness raising campaign on the benefits of CFLs is required prior to the commercial mass introduction of CFLs. Incentive schemes may also be necessary to promote the use of CFLs among public (such as lower prices for CFLs in case incandescent light bulbs are brought for exchange with CFLs).
Impact Statements (how this option impacts the country development priorities)	
Country social development priorities	The project directly benefits individual households through the installation of CFLs which will result in energy savings and lower expenditures, and contribute to national objectives to reduce poverty.
Country development priorities	Renewable energy and energy efficiency development are the priority of the RGC.
Country environmental development priorities	The major benefit of energy-efficient CFLs lies in the improved energy efficiency, which has socio-economic benefits in terms of increased energy security and environmental benefits, i.e. lower GHG emissions, and lower environmental impact of electricity generation. In addition, CFL lead to cost-savings for the consumer over the life-cycle of the appliance, and improve local air quality. All these are in line with the country's environmental development priorities.
Other consideration and priorities such as market potential	This technology is proven and available in Cambodia. Itsmarket can be considerably increased if enabling environment is in place (awareness, financial incentive, policy and regulation, etc.).
Costs (US$)	
Capital costs over 10 years	The cost of CFL varies with the design features, materials used, application, etc. In the United States, a CFL has a higher purchase price than an incandescent lamp, but can save over US$40 in electricity costs over the lamp's lifetime. Average cost of a basic branded CFL in Cambodia is less than $2 for a 10W bulb.
Operational costs over 10 years	N/a

Other costs over 10 years	N/a

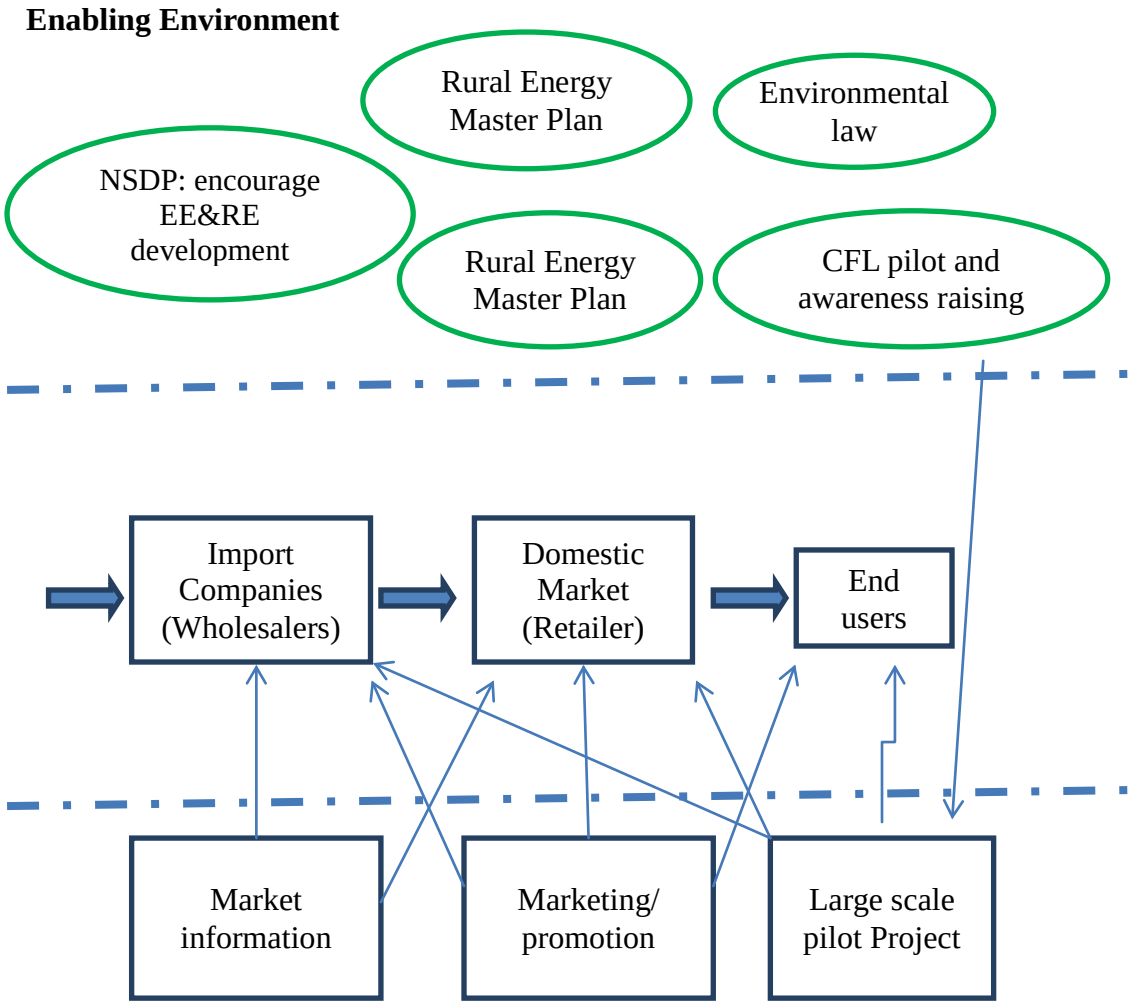
Factsheet 4: Solar Water Heater

Sector	ENERGY
Subsector	Renewable Energy
Technology name	solar water heater
Scale	Small to medium scale
Availability	Short term
Technology to be included in prioritization	This type of technology has been studied and listed in the national mitigation study.
Background/notes	Solar thermal technology can be used to provide hot water for domestic or industrial uses. Recently, 'combi' systems have been introduced which can provide both space and water heating. Advances in the technology have provided so-called *solar assisted air conditioning*. The systems can be tailored to different needs and circumstances, such as industrial applications and domestic use.
Implementation assumptions	The markets in China, Australia, New Zealand and Europe are the fastest growing with a 25% growth rate in China and Taiwan followed by 19% in Australia and New Zealand then 13% in Europe. Swimming pool applications also recorded an increase. With a view to the application of the technology in Russia, where presently no market development is taking place, a meeting was organised by EREC and the Russian Energy Technology Centre in May 2007 on 'Perspectives for solar thermal energy in Southern Russia'.
Impact Statements(how this option impacts the country development priorities)	
Country social development priorities	In terms of economic and social benefits, the technology can contribute to sustainability especially as it is relatively simple and could be delivered by locally trained installers with local supply chains in the main. This would lead to jobs and to a better quality of life, as well as minimize energy bills and dependency on fossil fuel imports with their corresponding vulnerability to price fluctuations. It is a safe technology avoiding fire and other health risks. It is particularly applicable to developing countries for space cooling and hot water.
Country development priorities	Energy efficiency is a priority of the Cambodian government in intention of energy security; reduce dependency of imported energy, reducing poverty in community society.
Country environmental development priorities	In terms of benefits for the environment the technology avoids the use of fossil fuels and their emissions, while being a silent technology.
Other consideration and priorities such as market potential	Applying such technology is also potential for clean development mechanism.

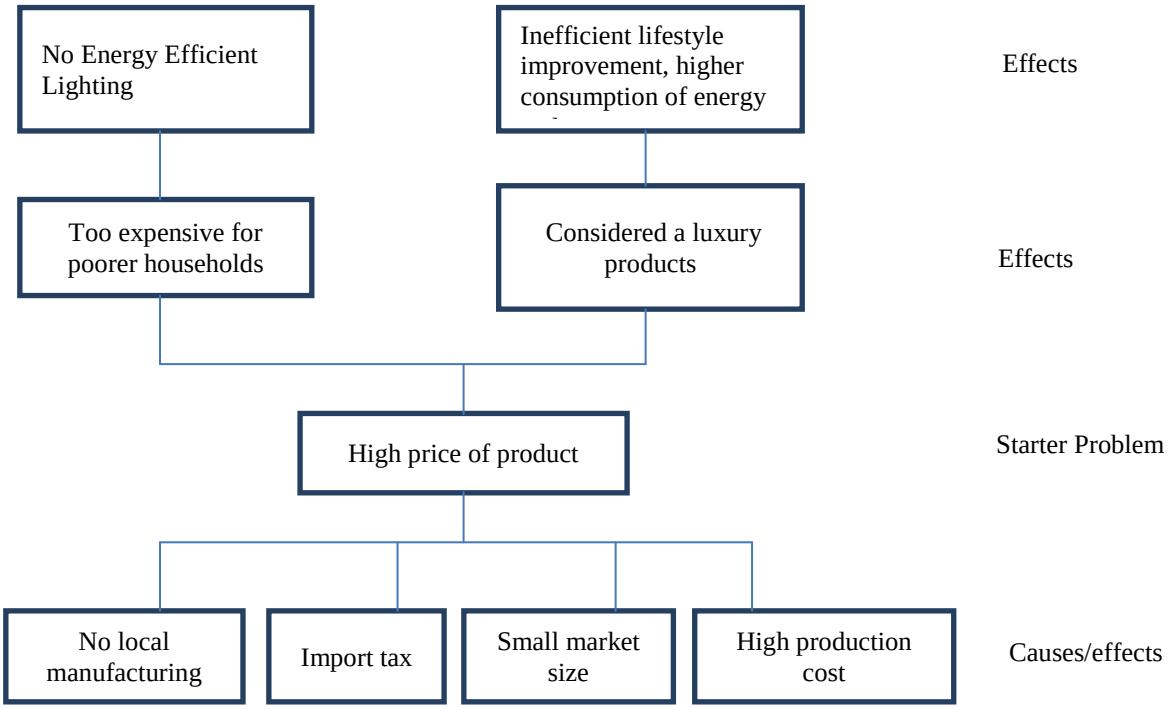
Costs (US$)	
Capital costs over 10 years	Some examples below can be used for reference in term cost requirement consideration. According to Philibert (2005), costs of SWH systems can vary greatly from country to country. In Greece a domestic solar thermal hot water system for a one-family unit (2.4 m2 collector area and 150 litre tank) costs € 700, but in Germany with a 4-6 m2 area and 300 liter tank it costs € 4,500. Conversely, a system for space heating will provide greater savings in the north than the south. In northern France, savings of €730-900 per year are quoted compared to € 120-180 in the southern part of the country. Capital costs of solar air conditioning systems tend to be several times that of conventional systems. However, cost figures per unit of energy improve if a combined heating and cooling system is used. In general, for solar thermal systems, depending on the system, the application, and locality, there is a wide range of cost efficiency from savings schemes to systems where economies of scale are still required for some systems though not the existing standard systems. In the EU, the subsidies currently given to coal-based and nuclear energy amount to more than € 28 billion/year without including external costs. Funding at that level together with the energy savings would enable renewables to replace fossil fuel-based and nuclear energy without additional burdens on the economy (ESTIF, 2006). The EU calls for 100 million m2 of solar thermal surface by 2010 helps to stimulate interest and the market but sub-national programmes are available. For example, the German Solarthermie 2000 plus aims to increase the annual solar contribution to hot water and heat production from individual installations from 10-30% to 60%. Seasonal storage is targeted with grants of up to 50%.
Operational costs over 10 years	n/a
Other costs over 10 years	n/a

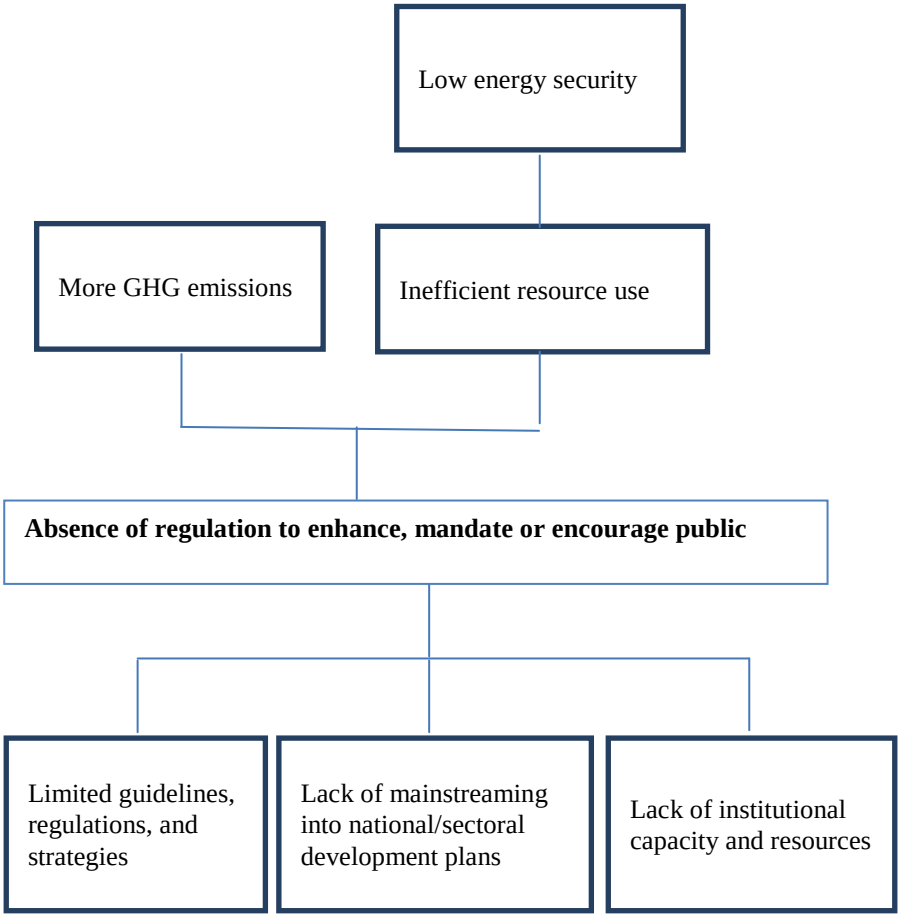
ANNEX II. MARKET MAPS FOR TECHNOLOGIES AND PROBLEM TREES FOR CFLS

Market Mapping for CFLs



Problem Tree for CFLs




Low energy security
Effects
More GHG emissions
Inefficient resource use
Effects
Absence of regulation to enhance, mandate or encourage public
Starter Problem
Limited guidelines, regulations, and strategies
Lack of mainstreaming into national/sectoral development plans
Lack of institutional capacity and resources
Causes/effects

ANNEX III. PROJECT IDEAS

PROJECT IDEA NOTE 1: Promoting energy efficient lighting through demonstration and outreach

Sector	Energy
Subsector	Energy Efficiency
Technology name	Compact Fluorescent Lamp (CFL)
Project name	**Promoting energy efficient lighting through demonstration and outreach**
Background	About 80% of the Cambodian population live in rural areas and 75% of households have no grid electricity. Energy efficient lighting is commercially available in the local markets; however, low awareness of the technology's benefits and higher cost when compared with less efficient alternatives are significant barriers.
Purpose and objectives	- To increase public awareness of energy efficient lightning and its benefits - To demonstrate energy efficient lighting practices at the household level
Relationship to national sustainable development objectives	- Reduce energy consumption and ensure energy security - Reduce GHG emissions - Improve livelihoods and reduce poverty
Project deliverables	- Awareness and training materials produced - Number of people reached or trained on energy efficient lighting - GHG emission reductions
Project scope	- Target beneficiaries are residential households - Project site in Kandal Province
Timeline	3 years
Budget/resource requirements	US$600,000
Measurement/Evaluation	- Number of energy efficient lamps distributed - Amount of GHGs reduced - Number of trainings and public awareness campaigns achieved - Behaviour changes of local people towards energy efficiency
Challenges	- Low public awareness - Low public participation and interest - No labelling in Khmer of energy efficient lamps - Lack of financial support
Responsibilities and Coordination	Ministry of Environment, Ministry of Industry, Mines and Energy, Universities

PROJECT IDEA NOTE 2: Mainstreaming energy efficient lighting into sub-national and national development plans

Sector	Energy
Subsector	Energy Efficiency
Technology name	Compact Fluorescent Lamp (CFL)
Project name	**Mainstreaming energy efficient lighting into sub-national and national development plans**
Background	The NSDP update 2009-2013 confirmed that the government fully supports renewable and energy efficiency development in order to achieve sustainable development. However, the is currently no national plans for the development of energy efficient lighting
Purpose and objectives	- To mainstream energy efficient lighting into development plans at national and sub-national levels - To promote energy efficient lighting activities at national and sub-national levels - To build the capacity of national and sub-national staff to carry out energy efficient lighting activities
Relationship to national sustainable development objectives	- Promote energy efficient lighting which contributes to the achievement of NSDP - Ensures energy security through the reduction of energy consumption - Reduce GHG emissions - Improve livelihoods and reduce poverty
Project deliverables	- Energy efficient lighting included in the sub-national and national development plans - Capacity development for the target beneficiaries
Project scope	- Provincial Department of Industry, Mines and Energy, Provincial Department of Environment are the target beneficiaries - Project sites in Sihanoukville, Battambang and Siem Reap
Timeline	2 years
Budget/resource requirements	US$600,000
Measurement/Evaluation	- Integration of energy efficiency lighting into development plans - Energy efficient lighting implemented at the provincial level - Government staff trained
Challenges	- Limits capacity of provincial officers - Lack of financial supports
Responsibilities and Coordination	Ministry of Environment, Ministry of Industry, Mines and Energy

PROJECT IDEA NOTE 3: Energy efficiency labelling in Cambodia

Sector	Energy
Subsector	Energy Efficiency
Technology name	Household energy efficiency appliances
Project name	**Energy efficiency labelling in Cambodia**
Background	All of the electric appliances imported and sold in Cambodia are labelled and rated for energy efficiency following internationally accepted standards. However, these labels are in foreign languages and do not follow national guidelines that still need to be designed.
Purpose and objectives	- Design and development of an energy efficiency labelling system in Cambodia, following international standards - Rate imported electric appliances sold in Cambodia following the new labelling system - To promote the use of energy efficiency labelling among importers of electric appliances, retailers and consumers
Relationship to national sustainable development objectives	- Support the NSDP (2009-2013) in promoting energy efficiency and national energy security - Promote energy efficient appliances which lead to low carbon development - Reduce the number of illegal and unsafe electric appliances sold in Cambodia
Project deliverables	- Energy Efficiency Labelling for Cambodia - Capacity Development associated with the labelling system - Public and private awareness raising and involvement - Household electric appliances rated according to their efficiency, following international standards and in Khmer language
Project scope	- The project focus on the most popular appliances sold in Cambodia including air conditioners, water heaters, refrigerators, ovens, cookers, fans, televisions. - The project site will be in Phnom Penh and target national importers, wholesalers and consumers,
Timeline	2 years
Budget/resource requirements	US$600,000
Measurement/Evaluation	- Energy labelling system established - Number of products labelled - Capacity building for staff of responsible agencies
Challenges	- Lack of private sector involvement - Lack of technical staffs - Limited capability of technical staff - Lack of financial resources
Responsibilities and Coordination	Ministry of Environment, Ministry of Industry, Mines and Energy

PROJECT IDEA NOTE 4: Promoting research and development in low cost energy efficient household appliances

Sector	Energy
Subsector	Energy Efficiency
Technology name	Household energy efficient appliances
Project name	**Promoting research and development in low cost energy efficient household appliances**
Background	All of the electric appliances sold in Cambodia are imported from abroad since there is no local production capacity. Due to low market demand, there have been limited local private investments in the sector. The project promotes research and development activities in research institutions, universities, NGOs towards the development of low cost energy efficient appliances made in Cambodia.
Purpose and objectives	- To encourage research and development activities associated with energy efficient appliances in Cambodia - To capitalize on local research and development capacity for the development of affordable energy efficient appliances
Relationship to national sustainable development objectives	- Support the NSDP (2009-2013) in promoting energy efficiency and national energy security - Promote energy efficient appliances which lead to low carbon development
Project deliverables	- Publications of the research findings - Institutional capacity building and institutional strengthening at research and academic institutions
Project scope	- Household electric appliances
Timeline	3 years
Budget/resource requirements	US$1 million
Measurement/Evaluation	- Number of household appliances designed and developed - Number of research publications completed - Number of institutions and firms involved in research and development
Challenges	- Participation and interested from research institutions, local NGOs and private sector firms - Limited local technical capacity to conduct product research and development
Responsibilities and Coordination	MOE, MIME, Universities, NGOs, research institutions, private companies

PROJECT IDEA NOTE 5: Promoting urban public transport in Phnom Penh

Sector	Energy
Subsector	Transport
Technology name	Urban Mass Transport
Project name	**Promoting urban public transport in Phnom Penh**
Background	Private transport in Cambodia, especially in major cities like Phnom Penh, is dominated by motorcycles and private passenger cars. There is an increasing number of private vehicles on the roads, in particular affordable second hand imports. This is the root cause for traffic congestion, high air pollution and GHG emissions.
Purpose and objectives	- To reduce travel by private vehicles in Phnom Penh in favour of public transport - To enhance transport security and public health - To promote low carbon emission development
Relationship to national sustainable development objectives	- Promote energy efficiency in the transport sector - Support green growth and low carbon development - Improve traffic management and reduce traffic accidents - Energy efficiency is a priority of the Cambodian government as it leads to energy security, reduced dependency on imported energy.
Project deliverables	- Establishment of transport authority - Implementation plan for urban public buses - Number of private vehicles reduced - GHG emission reduction - Lesson learnt for future improvements and replication in other cities
Project scope	- Phnom Penh and adjacent areas will be targeted for demonstration - Current modes, regulations and opportunities for fixed route public bus service
Timeline	5 years
Budget/resource requirements	US$30 million
Measurement/Evaluation	- Master plan for urban public transportation - Establishment of transport authority - Prioritization of fixed route for public service - Number of passengers using the public bus service - Behaviour change of the population in accepting the public service as a viable mode of transport - Traffic congestion reduced
Challenges	- International financial support required due to high investment costs - Limited local technical capacity - Acceptability of public transport versus private transport for local users

Responsibilities and Coordination	MWPT, MOE, Phnom Penh Municipality, MOE, donors

PROJECT IDEA NOTE 6: Public transport planning and travel demand management

Sector	Energy
Subsector	Transport
Technology name	Urban Mass Transport
Project name	Public transport planning and travel demand management
Background	The rapid growth in population, urbanization and motorization in Phnom Penh and other large Cambodian cities has led to widespread traffic congestion. The situation has reached a crisis point in the capital city and is a major concern for government. A comprehensive transport and urban planning master plan needs to be designed, covering road network improvements, public transport and traffic management.
Purpose and objectives	- To develop a master plan and action plan with the integration of public transport into land-use - To forecast traffic demand and plan for the promotion of urban mass transportation
Relationship to national sustainable development objectives	- Promote energy efficiency in transport - Support green growth and low carbon development - Improve traffic management and reduce traffic accidents
Project deliverables	- Master plan and action plan promoting public transport service - Vehicle fleet and traffic counting on major roads
Project scope	- Phnom Penh and Battambang, Cambodia's two largest cities will be the target study areas - Integration of existing land-use with consideration for public transport services
Timeline	3 years
Budget/resource requirements	US$1 million
Measurement/Evaluation	- Master plans and action plans for urban public transportation - Traffic statistics database
Challenges	- International financial support required due to high investment costs - Limited local technical capacity - Complexity of planning for land use and transport trade-offs
Responsibilities and Coordination	MWPT, MOE, Phnom Penh Municipality, Battambang Municipality, MOE, donors

PROJECT IDEA NOTE 7: Enhancing vehicle emissions control and inspection & maintenance in large cities

Sector	Energy
Subsector	Transport
Technology name	Vehicle Emission Standards
Project name	**Enhancing vehicle emissions control and inspection & maintenance in large cities**
Background	Unsafe vehicles operate freely on Cambodian roads as there are no mandatory legal requirements for owners to get their vehicles inspected on a regular basis. This has a potential impact on the number of accidents caused by unsafe vehicles and on an increase of pollution from vehicles which exceed acceptable emission standards. The Environmental Strategic Plan 2004-2008 requires air pollution emitted by movable sources to be controlled and monitored. However, there are currently no basic roadside measurements in the major Cambodian cities because of a lack of equipment and gaps in staff technical knowledge.
Purpose and objectives	- To ensure all vehicles are properly inspected and comply with national emission standards - To expand emission control and inspection & maintenance to all major urban areas in Cambodia - To enforce vehicle inspection and maintenance regulation - To upgrade staff technical capacity in inspection and maintenance for the key concerned agencies
Relationship to national sustainable development objectives	- Support the RGC in reaching the Cambodian Millennium Development goals by improving air quality, improving the public health and protecting the environment - Promote energy efficiency in the transport sector
Project deliverables	- Capacity building of technical staff - Enforcement of emission control, inspection and maintenance - Number of inspection and maintenance check points established - Number of vehicles inspected and checked
Project scope	- The project covers the cities with the largest vehicle fleets: Phnom Penh, Kampong Cham, Battambang and Siem Reap
Timeline	3 years
Budget/resource requirements	US$3,000,000
Measurement/Evaluation	- Number of the inspection and maintenance check points increased - Number of the vehicle inspected increased - Number of technical staffs trained
Challenges	- International financial support required due to high operating costs - Limited local technical capacity

	- Participation and interest of the general public
Responsibilities and Coordination	MWPT, MOE, Municipalities of Phnom Penh, Kampong Cham, Battambang and Siem Reap, donors

ANNEX IV. LIST OF STAKEHOLDERSINVOLVED AND THEIR CONTACTS

No.	Name of Institution	Contact DetailsAddress
1.	Department of Climate Change, MoE	2nd Floor, room 303B, Ministry of Environment #48, Samdech Preah Sihanoul Blvd, TonleBassac, Khan Chamkarmon Phnom Penh, Cambodia
2.	Department of Energy Technique, MIME	#45, Preah Norodom Boulevard, Phnom Penh, Cambodia
3.	Council for the Development of Cambodia	Wat Phnom /Sisowath Quay, Phnom Penh, Cambodia
4.	Ministry of Economy and Finance	St.92, Sangkat Wat Phnom, Khan Daun Penh, Phnom Penh, Cambodia
5.	Ministry of Public Works and Transport	Corner Norodom Blvd/Street 106, Phnom Penh, Cambodia
6.	Ministry of Rural Development	Corner Street # 169 and Russian Boulevard, Phnom Penh, Kingdom of Cambodia
7.	Phnom Penh Department of Environment	#13, Str. 163, Sangkat Olimpic, Khan Chamkarmorn, Phnom Penh, Cambodia
8.	Phnom Penh City Hall	# 69, Preah Monivong Blvd, Sangkat Srah Chak, Khan Daun Penh, Phnom Penh, Caombodia
9.	Electricity Authority of Cambodia	#02, Street 282, Sangkat Boeung Keng Kang 1, Khan Chamkarmon, Phnom Penh, Cambodia.
10.	Electricitė Du Cambodge	Str. Preah Yuk Khanthor, Sagnkhat Wath Phnom, Phnom Penh
11.	Department of Environment, RUPP	Russian Confederation Blvd, Toul Kork, Phnom Penh, Cambodia
12.	Institute of Technology of Cambodia	Russian Confederation Blvd, Phnom Penh, Cambodia
13.	UNIDO Operation Office	#53, Rue Pasteur, Phnom Penh, Cambodia
14.	Japanese International Cooperation Agency	Nº. 61-64, Norodom, Corner Street 306, 6th Floor, Borita Building, Phnom Penh, Cambodia
15.	Korea International Cooperation Agency	Nº. 38, Street 322, Phnom Penh, Cambodia
16.	National Biodigester Programme (NBP)	Department of Animal Health & Production, MAFF, Phnom Penh, Cambodia
17.	SME Renewable Energy Ltd.	#06, St 288, Beung Keng Kang I, Phnom Penh, Cambodia
18.	SNV Cambodia	#184 (2nd Floor), St. 217 (Monireth), Sangkat Tumnub Tek, Khan Chamkarmon, Phnom Penh, Cambodia
19.	GERES Cambodia	# 350, Street 350, BoeungKeng Kang 3, Khan Chamkarmorn, Phnom Penh, Cambodia
20.	Comin Khmer Co. Ltd,	#8B, Down Town Road 7, P.O. Box 28, Phnom Penh, Cambodia
21.	Khmer Solar	No.71, Norodom, Corner Street 154, Phnom Penh, Cambodia

ANNEX V. GROUP DISCUSSION

Barrier Identification

Technology	Barriers	Decomposition of main barrier
Energy Efficient Lighting	- Low purchasing capacity - High price - Lack of knowledge - Limited public awareness - No incentive - No regulation to enhance publics to use EEL - Expensive to replace existing installation - Behavior change issue - Small market size - No Feasibility Study	
Energy Efficient Household Appliances	- Low purchasing capacity - High price - No safety and technical standard - Lack of knowledge - Limited public awareness - No incentive - No regulation to enhance publics to use EEHA - Expensive to replace existing installation - Behavior change issue - Small market size - No buy-back-service - Many used products are imported - No feasibility study	
Energy Efficient Urban Mass Transport	- No master plan - High investment cost - Behavior change issue - Small size of existing roads - No regulation for specific public transport (terminal, parking, sidewalk) - Fluctuating demand - Limited human capacity - No incentive and policy to promote and support investment - No feasibility study	

Vehicle Emission Standards	- Limited regulation and law enforcement - Lack of coordination among law enforcement agencies - No regulation for importing used vehicles - Limited human capacity - Lack of monitoring and controlling equipment for different vehicles - No feasibility study	

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Barriers Classification and Selection

Sector	Technology	Economic and Finance	Market Failure/ Imperfection	Regulatory, Policy, Legal and IPR	Institutional and Organizational Capacity	Human and Technical skills	Information and Awareness	Social, Cultural and Behavior	Network Failures
Energy	Energy Efficient Lighting	-High price -Expensive to replace existing installation	-Small market size -Low purchasing capacity	-No incentive -No regulation to enhance publics to use EEL			-Lack of knowledge -Limited public awareness -No feasibility study	-Behavior change issue	
		-High price		- No regulation to enhance public to use EEL			- Limited public awareness		
	Energy Efficient Household Appliances	-High price -Expensive to replace existing installation		- No safety and technical standard - No incentive - No regulation to enhance publics to use EEHA - Many used products are imported			- Lack of knowledge - Limited public awareness - No feasibility study	- Behavior change issue	
		-High price		- No regulation to enhance publics to use EEHA			- Limited public awareness		
Trans-port	Energy Efficient Urban Mass Transport	-High investment cost		-No regulation for specific public transport (terminal, parking, sidewalk) -No incentive and	-No master plan	-Limited human capacity	-No Feasibility Study	-Behavior change issue	-Small size of existing roads

				policy to promote and support investment					
				- No regulation for specific public transport (terminal, parking, sidewalk) - Insufficient incentive and policy to promote and support investment	- No master plan				- Small size of existing roads
	Vehicle Emission Standards	- High price for monitoring and controlling equipment		- Limited regulation and law enforcement	- Lack of coordination among law enforcement agencies - Lack of monitoring and controlling equipment for different vehicles	- Limited human capacity	- No Feasibility		- Lack of network with national and int. specialize institutions
		- High price for monitoring and controlling equipment		- Limited regulation and law enforcement		- Limited human capacity			