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GREENHOUSE GAS MITIGATION ANALYSIS ENERGY AND TRANSPORT

Phnom Penh, June 2001

GREENHOUSE GAS MITIGATION ANALYSIS ENERGY AND TRANSPORT

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Front cover photos: (1) Early morning fumes at a Phnom Penh power station (Climate Change Project), (2) Skylights in front of the Project Office. These six skylights could save about 1,300 kWh of electricity or US$ 200+ for three years of project implementation (Climate Change Project), (3) Charcoal being transported to Phnom Penh along Route No 5 (ETAP/UNDP).

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ABBREVIATIONS

ADB	Asian Development Bank
AIT	Asian Institute of Technology
APA	Angkor Prosperous Agriculture Company Rice Mill
ATM	Air Traffic Management
BTU	British Thermal Unit
AUSAID	Australian Agency for International Development
CCEAP	Cambodia Climate Change Enabling Activity Project
CCGT	Combined Cycle Gas Turbine
CDC	Council for the Development of Cambodia
CDM	Clean Development Mechanism
CFL	Compact Fluorescent Lamp
CFC	Chloroflourocarbons
COGEN	COGEN, AIT, Bangkok, Thailand
CO_2	Carbon Dioxide
CRDB	Cambodian Reconstruction and Development Board
CSE	Cost of Saved Energy
DMC	Developing Member Countries
DSM	Demand-Side Management
EAC	Electricity Authority of Cambodia
EDC	Electricité du Cambodge
EIA	Environmental Impact Assessment
EMF	Electromagnetic Field
ENERTEAM	Energy Conservation Research and Development Center, Vietnam
ESCOs	Energy Service Companies
EU	European Union
G	Gauss
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS	Geographical Information System
GJ	Gigajoules
GWh	Gigawatt-hour
GWP	Global Warming Potential
HC	Hydrocarbons
ICAO	International Civil Aviation Organization
ICS	Improved Cook Stove
IDA	International Development Association
ILO	International Labor Organization
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IRP	Integrated Resource Planning
ITC	Institute de Technologie du Cambodge
ITEs	International Technical Experts
JICA	Japan International Cooperation Agency
KV	Kilo Volt
LEAP	Long-range Energy Alternatives Planning System
LEPNRM	Law on Environmental Protection and Natural Resources Management
LTO	Landing/Take-Off cycle (aircraft)

MBIs	Market-Based Instruments
MEF	Ministry Economy and Finance
MIME	Ministry of Industry, Mines and Energy
MOA	Memorandum of Agreement
MoE	Ministry of Environment
MW	Megawatts
MWh	Megawatt-hour
NGO	Non-Government Organization
NO_x	Nitrogen Oxide
NTEs	National Technical Experts
NTC	National Technical Committee
PDF	Project Development Facility
PPA	Power Purchase Agreement
ppmv	Part per Million by Volume
PPTA	Project Preparatory Technical Assistance
PREGA	Promotion of Renewable Energy, Energy Efficiency and Greenhouse Gas Abatement Projects
UNCHR	United Nation Commission on Human Rights
UNDP	United Nations Development Programme
REEs	Rural Electrification Enterprises
REF	Rural Electrification Fund
RGC	Royal Government of Cambodia
SEDPII	Second Five-Year Socioeconomic Development Plan (2001-2005)
SSCA	State Secretariat of Civil Aviation
TA	Technical Assistance
TED	Technology and Environmental Database
T&D	Transmission and Distribution
U.S. DOE	United States Department of Energy
WB	World Bank

UNITS

1 tonne = $1x10^6$ grams

Net Calorific Values:

Diesel Oil

1 liter = 36.3 megajoules (MJ)
0.85 kilogram (kg)

Fuel Oil

1 liter = 38.6 megajoules (MJ)
0.949 kilogram (kg)

Multiple	Prefix	Symbol
10^3	kilo	k
10^6	mega	M
10^9	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E

PREFACE

Climate change is a global problem which has brought countries throughout the world to work together to mitigate the problem under an international convention called the United Nations Framework Convention on Climate Change (UNFCCC). The Kingdom of Cambodia ratified the Convention on 18th December 1995 and the Convention entered into force on 17th March 1996. Through an agreement between the Government of Cambodia and the United Nations Development Programme (UNDP)/Global Environment Facility (GEF), Cambodia has received funding from UNDP/GEF to implement a three-year project called *Enabling Cambodia to Prepare its First national Communication in response to the UNFCCC* (Climate Change Enabling Activity Project: CCEAP). This project started in January 1999 with an aim of assisting Cambodia in preparing its First National Communication in response to the UNFCCC.

The first National Communication under the UNFCCC is mandatory for countries that have ratified the convention. For Cambodia, the activities that need to be carried out in the preparation for this communication are: (i) establishment of a national greenhouse gas (GHG) inventory; (ii) assessment of GHG mitigation options; and (iii) assessment of the vulnerability of Cambodia to climate change and development of adaptation options to cope with the climate change.

The GHG mitigation analysis of energy and transport sectors was carried out by the National Technical Committee (NTC), members of which are representatives from the Ministry of Environment; Ministry of Agriculture, Forestry and Fisheries; Ministry of Public Works and Transportation; Ministry of Water Resources and Meteorology; Ministry of Industry, Mines and Energy; and Royal University of Phnom Penh. This report discusses some of the potential GHG mitigation options in the energy and transport sectors in Cambodia.

In the preparation of this report, we have received support from many organizations and individuals. We would like to take this opportunity to sincerely express our thanks to all of them. Our special thanks are due to Dr. Charlie Heaps of the Stockholm Environment Institute, the author of the LEAP 2000 program that was used in this study, who generously gave his precious time in personally providing technical advice and for allowing us to use the program free-of-charge. Support provided by the consultants from the Philippines (Ms. Mila Jude) and Indonesia (Dr. Rizaldi Boier) is greatly appreciated. Their technical and practical support has been very valuable to this study and to building capacity of the government counterparts. The COGEN team in the Asian Institute of Technology, Bangkok, has also provided advice on cogeneration technology. We thank the staff of the National Communication Support Programme and UNITAR for their technical review, advice and support in organizing a training on GHG mitigation. We also thank the UNDP Office in Cambodia for its continuous and valuable support to the project.

Finally, we realize that many things still need to be done in the future. We are always open to any constructive inputs. We believe that with the inputs, we could improve our future studies.

August 2001

Dr. Mok Mareth
Minister for the Environment

EXECUTIVE SUMMARY

INTRODUCTION

Climate change is one of the most complex and challenging environmental problems the world is facing. The complexities include the wide range of greenhouse gas (GHG) emissions by source and removal by sinks. Carbon dioxide is one of the GHGs in the atmosphere that absorbs long wave radiation which regulates the earth's temperature. Without the presence of GHGs in the atmosphere, air temperature during night time might drop down to 184^{o}C below zero. Thus these GHGs are very important for earth's life. During the period 1850 to 1998, approximately 270 (±30) Gt of carbon was released into the atmosphere as carbon dioxide (CO_2) as a result of fossil fuel burning and cement production (67%), and land use and land use change (33%), predominantly from forested areas. About 40% of these emissions remain in the atmosphere while the other 60% was absorbed by the ocean and terrestrial ecosystems. Carbon dioxide that is dissolved into the oceans is transferred progressively to the deep ocean, and the carbon content in this reservoir is continuously increasing. Thus, during the period 1850 to 1998, the atmospheric CO_2 concentration increased by about 28%, i.e. from 285 ppmv at the end of 19th century to 366 ppmv at the end of 20th century. This increased CO_2 concentration is believed to be causing an increase in global temperature.

Under the UNFCCC, developed countries (Annex 1 Countries) agreed to reduce GHG emissions from the source sides and increase GHG uptake by sinks, while developing countries could participate in reducing their emissions or increasing the uptake on a voluntary basis using national, multilateral or bilateral funds.

This study is undertaken to identify and analyze the potential measures to abate GHG emissions in the energy sector. This activity is a part of the UNDP/GEF funded project "Cambodia Climate Change Enabling Activity Project (CCEAP)", with the Ministry of Environment (MoE) as the implementing agency.

The energy sector in Cambodia is composed of transport, household, service and industry. The household sub-sector accounts for the highest consumption of energy at 86.4%, followed by transport at 12%. Service and industry accounts for a very low 1% and 0.6%, respectively.

The energy data from MIME are the major source of data used for the analysis of GHG mitigation options. These data were converted into a format suitable for input into the energy-environment modeling program called LEAP 2000[1]. The LEAP 2000 program not only serves as a database but also as a forecasting and policy analysis tool. It also simulates and assesses the physical, economic and environmental effects of alternative energy programs.

The four scenarios evaluated are: i) the **Reference** Scenario, ii) the **Government Plans** Scenario, iii) the **GHG Mitigation Options** scenario, and iv) the **High Scenario** (Government Plans and the GHG Mitigation Options Scenario).

[1] The LEAP 2000 is the Long-range Energy Alternatives Planning (LEAP) system, a scenario-based energy environment-modeling tool. This program is used to evaluate the GHG mitigation options considered in this study. LEAP 2000 is a user-friendly software developed by the Stockholm Environment Institute (SEI) - Boston Center at the Tellus Institute.

The Baseline or Reference Scenario in this study was obtained from the final report of the ADB-financed advisory technical assistance (TA)[2] implemented by the Department of Energy of the Ministry of Industry, Mines and Energy (MIME). In this scenario, the total GHG emissions accumulated from 1994 to 2030 is 251,593 Gigagram (Gg) of CO_2-equivalent.

The Government Plans Scenario. The Royal Government of Cambodia (RGC), together with major donors and NGOs have developed energy policies and energy supply projects such as high voltage power transmission lines, hydropower development, improvement of mass transit, improved cook stoves, etc. These policies and projects were not identified as GHG mitigation projects, but if implemented will actually reduce the GHG emissions of the country. Furthermore, these plans were not considered in the MIME study, which was used as the basis of the baseline scenario in this study because the above plans were only finalized after the completion of the MIME study. Given this, a scenario called "Government Plans" was created in this study to describe these projects in detail. LEAP 2000 can calculate the Global Warming Potential (GWP)[3] emissions and reductions and the Cost of Saved Energy (CSE)[4] of these projects, depending on the availability of data. The Government Plans scenario has reduced the GHG emissions by 14% from the reference scenario (Table 1).

The GHG Mitigation Options Scenario lists all other options aside from the projects already identified by the government under the "Government Plans" scenario. This scenario has reduced the GHG emissions by 10% from the reference case (Table 1).

The High Scenario is composed of the "Government Plans Scenario Plus the GHG Mitigation Options Scenario". The scenarios "Government Plans" and "GHG Mitigation Options" both describe a future that is essentially similar to that of the Baseline or Reference Scenario, in respect to overall economic and social trends, except that both scenarios assume policies or programs that will be implemented to encourage adoption of measures that will reduce GHG emissions or enhance carbon sinks.

Table 1 shows the GWP reduction of each mitigation option for the years 2003 to 2030. The reduction in GWP under this scenario, when summed up amounts to 59,650 Gg of CO_2-equivalent (24% reduction from the baseline or reference scenario), accumulated from 2003-2030. Coincidentally, this amount of reduction is almost equal to the total 1994 GHG emissions calculated in 1994 inventory report, which is 59,708 Gg of CO_2-equivalent. In the analysis, only the mitigation options with sufficient data were evaluated in the calculations of the GWP emissions and reduction.

Some of the criteria used in screening potential mitigation options are: a) potential for large impact on GHG, b) consistency with the national development and environmental goals, c) potential effectiveness of implementation policies, d) sustainability of an option, and e) data availability for evaluation. Based on these criteria, the most attractive option is the Improved

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2 TA 2241-CAM: *Strengthening the Institutional and Legal Framework for the Energy and Mineral Sectors"* approved on 14 December 1994 for $595,000.

3 **The Global Warming Potential (GWP)** is expressed in tons of CO_2 equivalent emissions per tonne of GHG emissions. Methane (CH_4) has 21 tonnes of CO_2 equivalent per tonne of methane emitted. Nitrous oxide (N_2O) has 310 tonnes of CO_2 equivalent per tonne of N_2O emitted. The methane and nitrous oxides emissions were converted to tonnes of CO_2-equivalent by multiplying the methane emissions by 21 and the tonnes of nitrous oxides emissions by 310.

4 The Cost of Saved Energy (CSE) expresses the incremental cost of an efficiency measure per unit of its energy savings. The incremental cost of a measure is how much more (or less) a new technology costs relative to the standard equipment that it replaces.

Cook Stove (ICS), with a negative incremental cost (which signifies a "no regrets" option) and has a large potential GHG emissions reduction. The next most attractive option is the Compact Fluorescent Lamp (CFL), followed by the Mass Transit (Rural) and the Phnom Penh City Shuttles.

Table 1: GWP Reduction

SCENARIO	GWP Reduction (2003-30) Gg of CO_2-Equivalent	% Reduction (of total GWP)	Incremental Cost* $'000/Gg CO_2
A. GOVERNMENT PLANS			
1. Combined Cycle Gas Turbine	19,980	41.9	9.32
2. Hydropower	12,390	25.9	10.32
3. Phnom Penh City Shuttles	2,300	4.8	1.29
Total Reduction (14%)	***34,670***	***100.0***	
B. MITIGATION OPTION			
1. Improved Cook Stove (ICS)	13,060	52.3	-1.02
2. Compact Fluorescent Lamp	7,320	29.3	-2.48
3. Mass Transit (Rural)	4,600	18.4	1.29
Total Reduction (10%)	***24,980***	***100.0***	
C. HIGH SCENARIO (A+B) (24% Reduction)	***59,650***		

* Incremental Cost taken from the ALGAS Report.

THE "GOVERNMENT PLANS" SCENARIO

Hydropower Plants

The Government recognizes that the high cost, unreliability, and limited geographic availability of electricity still constitutes a major hindrance to private sector and rural development. The high cost reflects the almost total dependence on imported oil-based fuel as the primary energy source, and the lack of a high voltage transmission system. The state-owned utility, Electricité du Cambodge (EDC), will therefore undertake the rehabilitation of the 10 MW hydropower plant in Kandal province. The other hydropower plants identified in the study "Power Transmission Plan and Rural Electrification Strategy", and adopted by the MIME, were all evaluated in this study.

Shift to Cleaner Fuel in Power Generation - Use of Combined Cycle Gas Turbine (CCGT)

The Japan International Cooperation Agency (JICA) funded a study on the "Feasibility of a 180 MW Combined Cycle (Gas Turbine) Power Plant at Sihanoukville (2000)". This is scheduled to be established at Sihanoukville in 2007. The bases for calculations are in Attachment A.

Phnom Penh City Shuttles[5]

The "Phnom Penh City Shuttles" is part of the "Transport Master Plan of the Phnom Penh Metropolitan Area in the Kingdom of Cambodia" which was prepared with JICA support. This

[5] The Transport Master Plan of the Phnom Penh Metropolitan Area in the Kingdom of Cambodia, JICA, 2001.

bus system with co-existence of motorcycles was proposed as a flexible mode of transport to cope with the future traffic demand. The implementation period of this Master Plan is from 2001 to 2015, at an estimated cost of 57.4 millions US dollars.

THE GHG MITIGATION OPTIONS SCENARIO

The following policies and projects are recommended in this study, and are in addition to those already identified by the government under the "Government Plans" GHG mitigation options described above.

Improved Cook Stove (ICS)

In Cambodia, like many developing countries today, the most important energy service in the household is cooking food. In rural areas, traditional fuels like wood and crop residues are the primary fuels used for cooking. The final energy use figure of Cambodia for cooking is high since a considerable quantity of fuel is wasted in inefficient fuelwood use. In rural areas, biomass is likely to continue to be the fuel of necessity for cooking for many years to come. According to MIME (1996), 95.3% of rural households rely on firewood as the main fuel for cooking. The number of rural households relying on charcoal for cooking is only 0.9%. These make a total of 96.2% of rural households depending on biomass fuels for cooking. Less than one percent of rural households have access to publicly provided electric lighting.

Countrywide, 96.4% of Cambodian households depend on biomass fuels for their cooking and other energy needs, of which 92.1% are firewood and 4.5% are charcoal (MIME, 1996). The GWP for cooking and water heating using wood and charcoal is 37,000 Gg of CO_2 equivalent from 1994 to 2030. This is 95.9% of the total GWP for cooking (38,600 Gg of CO_2 equivalent) for the same period. The project of the Cambodia Fuelwood Saving Project (CFSP) can be replicated. More artisans can be trained to manufacture the ICS, in collaboration with the NGO implementing this project.

Efficient Lighting

The use of Compact Fluorescent Lamps (CFL) can reduce electricity use by 75%. For example, a 16 W CFL can replace a 75 W incandescent lamp. The CFLs consume only 25% or even less electricity to produce the same amount of light as incandescents. There is also a synergistic effect of the use of CFL to the use of air conditioning. There is a saving of one third for every kilowatt saved in lighting. It is recommended that in the short-term, the government implement a pilot project using CFLs and information campaign showcasing the energy savings generated by using CFLs. Funding can be requested from international financial institutions such as GEF, ADB and WB for such energy efficiency projects.

Rural Mass Transit

The energy efficient bus should be used instead of motorcycles in the rural areas once roads are repaired or built. The Phnom Penh City Shuttles can be replicated in the rural areas.

OTHER GHG MITIGATION OPTIONS

The following projects or initiatives have potential for reducing GHG emissions but due to lack of data and time constraints, were not evaluated in the LEAP 2000 program.

Under Existing Government Plans

The Royal Government of Cambodia has approved or realized the following projects or initiatives which, however, do not have sufficient data needed to evaluate the GHG emissions reduction in the LEAP 2000 program:

i) Institutional, legal and regulatory initiatives (establishment of the Electricity Authority of Cambodia (EAC), the Council for the Development of Cambodia (CDC) and the Law on Environmental Protection and Natural Resources Management (LEPNRM));
ii) Electricity supply improvement;
iii) National transmission system;
iv) Electricity trading with neighboring countries;
v) Regulatory reform action - establishment of power sector regulatory framework;
vi) Rehabilitation of the electricity system;
vii) Provincial and rural electrification;
viii) Improvements in the EDC;
ix) Commercialization of the supply of electricity;
x) Renewable energy project[6]; and
xi) Improvement in the transport sector.

GHG Mitigation Options Recommended by this Study

Policy Reforms

The following policy reforms are recommended to reduce GHG emissions:

i) Implement a study on the privatization and restructuring of the EDC and power utilities;
ii) Implement a project to formulate the framework for Integrated Resource Planning (IRP)[7] and Demand-Side Management (DSM)[8] programs;
iii) Tax relief for renewable energy projects;
iv) Fund for renewable energy projects;
v) Development of mini-hydropower plants (101 kilowatt to 10 MW);
vi) Energy efficiency building codes;
vii) Efficiency improvements for existing and new building shells;
viii) Stimulating building retrofits;
ix) Passive solar building design;
x) Establishment of energy service companies (ESCOs);

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6 The World Bank-MIME project "Cambodia Renewable Energy Promotion Project" proposes several renewable energy technologies, which will result to 286,500 tons of CO2 equivalent emissions reduction. Due to time constraints, this project was not evaluated using the LEAP2000 program.

7 Integrated Resource Planning (IRP) - is the combined development of electricity supplies and demand-side management (DSM) options to provide energy services at minimum cost, including environmental and social costs.

8 Demand-Side Management (DSM) - is the planning implementation, and monitoring of utility activities designed to influence customer use of electricity in ways that will produce desired changes in a utility's load shape (i.e., changes in the time pattern and magnitude of a utility's load).

xi) A government program that encourages utilities and industries to voluntarily reduce GHG emissions[9];
xii) Establishment of a "fuel and appliance testing laboratory"[10]; and
xiii) energy pricing (remove subsidy).

Enhancing National Capacity

The following projects, while enhancing national capacity, will also ensure a reliable evaluation of GHG mitigation options and improve the country's capability to reduce GHG emissions:

i) Improvement of energy database;
ii) Develop procedure to ensure consistency of classification of energy data with the economic data (GDP);
iii) Wind energy map;
iv) Capacity building;
v) Training;
vi) Energy audit;
vii) Inter-agency cooperation; and
viii) Fund for salary supplements of national experts.

Transport

In road transport, the following GHG mitigation options are recommended:

i) Energy-efficient mass transit system;
ii) Infrastructure for road traffic management;
iii) Penalty for traffic violators and strict implementation by traffic enforcers;
iv) Road improvement in urban areas;
v) Institutional framework in the transport sector;
vi) Driver training and education on proper driving habits;
vii) Energy efficient and pollution control technology; and
viii) Planting more trees along the roads and preserving existing trees.

Improvement of rail transport, water transport, and of air transport is also important for both economic development and GHG emission reduction.

Household

Energy efficient standards for appliances need to be formulated and later imposed on importers or local manufacturers to promote energy saving and contribute to GHG emission reduction.

Industrial Sector

The following GHG mitigation measures are recommended for the industrial sector:

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[9] In 1998, the UNEP launched the "International Declaration on Cleaner Production", a voluntary public statement of commitment to the practice of cleaner production. This strategy, also known as eco-efficiency, promotes the elimination of pollution before it is created.

[10] The Philippine Department of Energy has a "Fuels and Appliance Testing Laboratory" that conducts tests on the energy efficiency of electrical equipment and labels them accordingly, for the information of the consumers.

i) Information dissemination on energy efficient measures in industries;
ii) Voluntary agreements and incentives to reduce industrial energy use;
iii) Efficient industrial motor drive;
iv) Solar water heaters for hotels;
v) Rice husk as fuel for cogeneration in a rice mill plant; and
vi) Energy efficiency in the brick and tile manufacturing industry.

CONCLUSION AND RECOMMENDATIONS

The GHG mitigation options recommended will generate at least a 24% reduction of the GHG emissions in the Reference Scenario. If there is sufficient data, the study will be able to calculate the reduction in GHG emissions of the other recommended projects, which will greatly increase the GHG reduction.

It is recommended that in order to produce a comprehensive analysis of the GHG mitigation option, the following concerns should be addressed: i) a reliable and detailed database on energy should be established and updated regularly by the MIME and ii) full support of other government agencies, in terms of sharing their data, is vitally needed. Data collection should also be done, in order to evaluate the projects under the "Government Plans Scenario", which presently lacks data but will greatly reduce GHG emissions, if implemented.

The baseline or reference scenario is based on the prevailing low economic activity in the energy sub-sectors (household, transport, industry and service) of Cambodia. A proposed mitigation option would appear as a contributor to the GHG emissions, since it is compared to a baseline scenario where there was no activity of the particular option. For example, if an efficient power plant like a CCGT were to be built in a place where there was no electricity, it would appear that there is no GWP reduction but rather an increase in GWP emissions. This case should be carefully evaluated, bearing in mind that the comparison should be the option of building a diesel-fueled power plant instead of a CCGT.

The LEAP 2000 program is user-friendly, and can be updated as soon as reliable data is available. It is recommended that this will be continuously updated, as there is a big potential for determining substantial GWP reduction and to solve for the CSE, given enough time to collect data and input to the program. In this study, only 6 mitigation options were evaluated and it calculated a GWP reduction of 59,650 Gg of CO_2 equivalent (24% reduction) for the period 2003-2030[11]. The two (2) NTC experts who worked in this study are capable of updating the LEAP 2000 program. It is further recommended that these experts be given further training in energy data analysis and more members of the NTC be trained in using the LEAP 2000 program.

[11] The year 2003 is assumed to be the year that the proposed GHG mitigation options will be fully operational.

I. INTRODUCTION

This study was undertaken to identify and analyze the potential measures to abate greenhouse gas (GHG) emissions in the energy sector. It is part of the United Nations Development Programme (UNDP) – Global Environment Facility (GEF) funded project "Cambodia Climate Change Enabling Activity Project (CCEAP)", with the Ministry of Environment as the implementing agency.

The guidelines of the Intergovernmental Panel on Climate Change (IPCC) "Technologies, Policies and Measures for Mitigating Climate Change" (November 1998) and other IPCC publications, such as the "Methods for Assessment of Mitigation Options, Appendix IV: Mitigation Assessment Handbook" were used as references.

I.1. Methodology

Before any analysis could be done, the available energy demand data were first reviewed and analyzed. These data were then converted into a format suitable for input into the energy-environment modeling program called LEAP 2000. The LEAP 2000 program not only serves as a database but also as a forecasting and policy analysis tool. It also simulates and assesses the physical, economic and environmental effects of alternative energy programs.

The energy intensity is calculated by dividing the energy demand by the number of activities (number of households, GDP, etc.). Energy intensity is expressed in gigajoules (GJ) per number of household, or GJ per GDP. The following is the formula for calculating the energy intensity:

$$\text{energy intensity} = \frac{\text{energy demand (in GJ)}}{\text{activity level (number of households, GDP, etc.)}}$$

The bases and assumptions for each mitigation option are listed in Attachment A. After the energy demand is calculated, the corresponding emission factors are "linked" to the energy demand data. The LEAP program then calculates the Global Warming Potential (GWP) by multiplying energy demand and its corresponding emissions factor.

The four scenarios evaluated are: i) the **Reference** Scenario, ii) the **Government Plans** Scenario, iii) the **GHG Mitigation Options** scenario and iv) the **High Scenario** (Government Plans and the GHG Mitigation Options Scenario).

I.2. Baseline or Reference Scenario

The **Baseline or Reference** Scenario in this study was obtained from the final report of the ADB-financed advisory technical assistance (TA) implemented by the Department of Energy of the Ministry of Industry, Mines and Energy (MIME). The Baseline or Reference scenario projects energy use and emissions over the time horizon selected, reflecting the assumed development of the national economy and energy system if no steps are taken to reduce emissions. In this scenario, the total GHG emissions accumulated from 1994 to 2030 is 251,593 Gigagram (Gg) of CO_2 equivalent (Table 2).

Table 1: Energy Demand in Million Gigajoules (Reference Scenario)

Sector	1994	%	2000	%	2010	%	2020	%	2030	%
Household	79.475	86.4	90.106	80.6	113.979	71.7	142.118	61.4	166.287	48.0
Industry	0.522	0.6	0.868	0.8	2.254	1.4	4.866	2.1	14.711	4.2
Service	0.918	1.0	1.418	1.3	3.183	2.0	7.816	3.4	20.056	5.8
Transport	11.072	12.0	19.337	17.3	39.453	24.8	76.694	33.1	145.288	41.9
Sum	91.987	100.0	111.728	100.0	158.869	100.0	231.494	100.0	346.342	100.0

Table 2: GWP in Gg of CO_2 Equivalent (Reference Scenario)

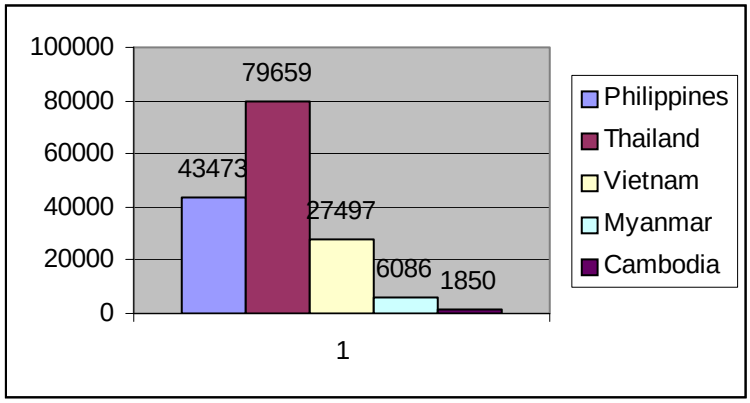
Sector	1994		2000		2010		2020		2030		1994-2030	
	Gg	%	Gg	%	Gg	%	Gg	%	Gg	%	Gg	%
Households	685	37.0	775	29.6	980	20.5	1,219	13.9	1,421	8.7	38,438	15.3
Industry	6	0.3	11	0.4	28	0.6	61	0.7	187	1.1	2,024	0.8
Service	4	0.2	6	0.2	11	0.2	25	0.3	54	0.3	729	0.3
Transport	789	42.6	1,374	52.4	2,799	58.6	5,444	62.1	10,329	63.0	151,665	60.3
Transformation	369	19.9	456	17.4	962	20.1	2,012	23.0	4,416	26.9	58,737	23.3
Total	1,853	100.0	2,622	100.0	4,780	100.0	8,761	100.0	16,407	100.0	251,593	100.0

The Household sub-sector has the highest energy demand at 86.4% in 1994 (Table 1), but in Table 2, it is only second in GWP emissions at 37%, transport being the highest at 42.6%. This is due to the fact that Households use mainly biomass, which is not accounted for in the GWP calculations since its CO_2 emissions are considered to be absorbed by the forest.

Comparing the 1994 GHG emissions of Cambodia in the energy sector (1,853 Gg of CO_2 equivalent) to the 1990 emissions of Vietnam (27,497 Gg of CO_2 equivalent), Myanmar (6,086 Gg of CO_2 equivalent), Philippines (43,473 Gg of CO_2 equivalent) and Thailand (79,659 Gg of CO_2 equivalent), Cambodia has the lowest emissions in the region (Figure 1).

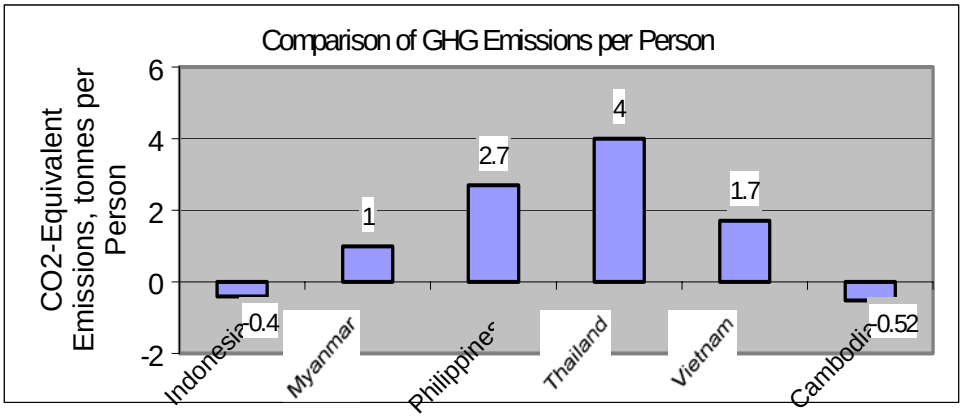
The total country GHG emissions per capita in Figure 2 shows that Cambodia and Indonesia both have negative emissions of 0.52 and 0.4 tonnes of CO_2-equivalent per person, respectively. The negative figures mean that both are net carbon sink countries, where their respective forestry sectors were able to absorb all the CO_2 emissions and have excess capacity to absorb more.

Figure 1: 1990 GHG Emissions in Gigagram (Gg) of CO_2-Equivalent



Source: ALGAS Report, September 1998
Note: With the exception of Cambodia, all the countries are members of the ALGAS project. Cambodia's data is for 1994.

Figure 2: 1990 GHG Emissions per Capita in CO_2-Equivalent, tonne



Source: ALGAS Report, September 1998
Note: With the exception of Cambodia, all the countries are members of the ALGAS project. Cambodia's data is for 1994.

I.3. "Government Plans" Scenario

The Royal Government of Cambodia (RGC), together with major donors and NGOs have developed energy policies and energy supply projects such as high voltage power transmission lines, hydropower development, improvement of mass transit, improved cook stoves, etc.. These policies and projects were not identified as GHG Mitigation projects, but if implemented will actually reduce the GHG emissions of the country. Furthermore, these plans were not considered in the MIME study, which was used as the basis of the baseline scenario in this study because the above plans were only finalized after the completion of the MIME study. Given this, a scenario called "Government Plans" was created in this study to describe these projects in detail. LEAP 2000 can calculate the GWP emissions and reductions and the Cost of Saved Energy (CSE) of these projects, depending on the availability of data. The Government Plans scenario has reduced the GHG emissions by 14% from the reference scenario (Table 3).

Table 3: GWP Reduction

SCENARIO	GWP Reduction (2003-30) Gg of CO_2 Equivalent	% Reduction (of total GWP)	Incremental Cost* $'000/Gg CO_2
A. GOVERNMENT PLANS			
1. Combined Cycle Gas Turbine	19,980	41.9	9.32
2. Hydropower	12,390	25.9	10.32
3. Phnom Penh City Shuttles	2,300	4.8	1.29
Total Reduction (14%)	***34,670***	***100.0***	
B. MITIGATION OPTION			
1. Improved Cook Stove (ICS)	13,060	52.3	-1.02
2. Compact Fluorescent Lamp	7,320	29.3	-2.48
3. Mass Transit (Rural)	4,600	18.4	1.29
Total Reduction (10%)	***24,980***	***100.0***	
C. HIGH SCENARIO (A+B) (24% Reduction)	***59,650***		

* Incremental Cost taken from the ALGAS Report.

I.4. GHG Mitigation Options Scenario

The GHG Mitigation Options Scenario lists all other options aside from the projects already identified by the government under the "Government Plans" scenario. The projects in this scenario have reduced the GHG emissions by 10% from the reference case (Table 3).

I.5. High Scenario

The High Scenario is composed of the "Government Plans Scenario Plus the GHG Mitigation Options Scenario"**.** The scenarios "Government Plans" and "GHG Mitigation Options" both describe a future that is essentially similar to that of the Baseline or Reference Scenario, in respect to overall economic and social trends, except that both scenarios assume policies or programs that will be implemented to encourage adoption of measures that will reduce GHG emissions or enhance carbon sinks.

High Scenario. Table 3 above shows the GWP reduction of each mitigation option for the years 2003 to 2030. The reduction in GWP under this scenario, when summed up amounts to 59,640 Gg of CO_2 equivalent, accumulated from 2003-2030, and amounts to **24% reduction** from the baseline or reference scenario (Table 2 and 3). In the analysis, only the mitigation options with sufficient data were evaluated in the calculations of the GWP emissions and reduction. The projects which contributed to the reduction in GWP (the ones with sufficient data for LEAP 2000) are the Compact Fluorescent Lamp (CFL), the Phnom Penh City Shuttles (Bus), the Improved Cook Stove (ICS), the hydropower project, the 180 to 600 MW Combined Cycle Gas Turbine (CCGT) and the Mass Transit in Rural Areas.

The World Bank project "Cambodia Renewable Energy Promotion Project"[12] proposes to meet rural energy needs through the following renewable energy technologies (promoted by GEF as alternatives): a) 6 MW of grid-connected small hydropower schemes (1 to 2 MW), b) 700 kW of village/community level minihydropower systems (50 to 200 kW) and, c) 320 kW of photovoltaics (PV) in the form of solar home systems (40 Wp systems on average). These projects will result in 286,500 tonnes CO_2-equivalent reduction over the project's duration 2002-

[12] Jan Van der Akker, Report on "Cambodia Renewable Energy Promotion Project", 28 June 2001.

2007and an estimated 1.3 million tonnes of CO_2 abatement indirectly as a result of sustained investment in these technologies after the project has ended.

The incremental cost for the above project is US$5.765 million, for GEF, not including Project Development Facility (PDF) costs and costs of monitoring and evaluation.

Due to time constraints, the above World Bank project was not evaluated in this study. Given enough time, the NTC staff can evaluate the GHG reduction using the LEAP program and add to the results in Table 3 above, under the Government Plans scenario.

I.6. Criteria in Selecting GHG Mitigation Option

Some of the criteria used in screening potential mitigation options are: a) potential for large impact on GHG, b) consistency with the national development and environmental goals, c) potential effectiveness of implementation policies, d) sustainability of an option, and e) data availability for evaluation.

Based on the above criteria, the most attractive option is the Improved Cook Stove (ICS), with a negative incremental cost, which signifies a "no regrets" situation. The next most attractive option is the Compact Fluorescent Lamp (CFL), followed by the Mass Transit (Rural) and the Phnom Penh City Shuttles.

II. "GOVERNMENT PLANS" SCENARIO

II.1. Hydropower Plants

The Government recognizes that the high cost, unreliability, and limited geographic availability of electricity still constitutes a major hindrance to private sector and rural development. The high cost reflects the almost total dependence on imported oil based fuel as the primary energy source, and the lack of a high voltage transmission system. The state-owned utility, Electricité du Cambodge (EDC), will therefore undertake the rehabilitation of the 10 MW hydropower plant in Kampong Speu province. The other hydropower plants identified in the study "Power Transmission Plan and Rural Electrification Strategy", and adopted by the MIME, were all evaluated in this study.

II.2. Shift to Cleaner Fuel in Power Generation - Use of Combined Cycle Gas Turbine (CCGT)

JICA funded a study on the "Feasibility of a 180 MW Combined Cycle (Gas Turbine) Power Plant at Sihanoukville (2000)" which is scheduled to be established in 2007. The bases for calculations are in Attachment A.

II.3. Phnom Penh City Shuttles

The 'Phnom Penh City Shuttles' is one of the components in the JICA project "The Study on the Transport Master Plan of the Phnom Penh Metropolitan Area in the Kingdom of Cambodia". The Municipality of Phnom Penh introduced a trial bus system (started in June1 to end-July 2001), as a part of a 15-year transportation plan. Only cars and buses were allowed during the month-long test. The experiment included two bus lines. The first one ran along Monivong from

the Japanese Bridge to Chbar Ampov Market. The second line connected Norodom, Kampuchea Krom, Nehru and Sihanouk boulevards.

More than 20 air-conditioned buses ran along the two lines from 5:30 a.m. to 7:30 p.m. daily (14 hours). Each bus had a seating capacity of 29 seats[13]. Buses departed every 5 to 10 minutes. The bus fare ranged from 500 to 800 Riel. Ho Wah Genting Co., which runs buses from the capital to the provinces, operated the system.

The plan is expected to cut down on traffic accidents, which increased nearly 40% last year. The long-term plan is to extend bus routes covering 71 km. by 2005, 102 km by 2010 and 135 km by 2015.

At the end of August 2001 the Municipality stopped the experimental operation of the City Bus for financial reason for an unknown period. JICA representatives, other experts from Japan and city officials studied the results of the trial bus system and presented the final report of the project evaluation to the Project Steering Committee, and concerned organizations/individuals in Phnom Penh in September 28, 2001. The final report recommends a policy favoring bus operation with coexisting 2-wheel vehicles, as the most appropriate transport system approach in view of traffic flow condition, system efficiency, environmental impact and social acceptance.

III. GHG MITIGATION OPTIONS SCENARIO

The following policies and projects are recommended in this study, and are in addition to those already identified by the government under the "Government Plans" scenario in Section II.

III.1. Improved Cook Stove (ICS)

In Cambodia, like in many developing countries today, the most important energy service in the household is cooking food. In rural areas, traditional fuels like wood and crop residues are the primary fuels used for cooking. The final energy use figure of Cambodia for cooking (79.475 million GJ) is high since a considerable quantity of fuel is wasted in inefficient fuelwood use. In rural areas, biomass is likely to be the fuel of necessity for cooking for many years to come. According to MIME (1996), 95.3% of rural households rely on firewood as the main fuel for cooking. The number of rural households relying on charcoal for cooking is only 0.9%. These make a total of 96.2% of rural households depending on biomass fuels for cooking. Less than 1% of rural households have access to publicly provided electric lighting.

Countrywide, 96.4% of Cambodian households depend on biomass fuels for their cooking and other energy needs, of which 92.1% are firewood and 4.5% are charcoal (MIME, 1996). The GWP for cooking, water boiling and for the production of palm sugar using wood and charcoal is 37,000 Gg of CO_2 equivalent from 1994 to 2030. This is 95.9% of the total GWP for cooking (38,600 Gg of CO_2 equivalent) for the same period. The project of the Cambodia Fuelwood Saving Project (CFSP), which has been implemented in selected provinces with the objective of promoting the production and use of efficient fuelwood cook stoves, can be replicated. More artisans can be trained to manufacture the ICS, in collaboration with the NGO implementing this project.

[13] Based on the 29 seating capacity and 20 buses operating every 5-10 minutes for 14 hours (between 5:30 to 19:30 hours), it is estimated that 48,720 passengers can be serviced in one day, assuming full capacity.

III.2. Efficient Lighting

The use of Compact Fluorescent Lamp (CFL) can reduce electricity use by 75%. For example, a 16 W CFL can replace a 75 W incandescent lamp. The CFLs consume only 25% or even less electricity to produce the same amount of light as incandescents. There is also a synergistic effect of the use of CFL to the use of air conditioning. There is a saving of one third for every kilowatt saved in lighting. The air conditioners will use less energy if the lights have low wattage. It is recommended that in the short-term, the government implement a pilot project using CFLs and information campaign showcasing the energy savings generated by using CFLs. The international institutions such as GEF, ADB and WB can be requested to support such a program.

III.3. Rural Mass Transit

The energy efficient bus should be used instead of motorcycles within the rural areas when roads have been built or rehabilitated. The Phnom Penh City Shuttles can be replicated in the rural areas. Although there are buses plying the route between provincial towns and Phnom Penh (example: Phnom Penh to Kampong Cham to Phnom Penh), at present there is no efficient mass transit system within the rural areas.

IV. HIGH SCENARIO

The High Scenario is composed of the "Government Plans Scenario Plus the GHG Mitigation Options Scenario"**.** The scenarios "Government Plans" and "GHG Mitigation Options" both describe a future that is essentially similar to that of the Baseline or Reference Scenario, in respect to overall economic and social trends, except that both scenarios assume policies or programs that will be implemented to encourage adoption of measures that will reduce GHG emissions or enhance carbon sinks.

Table 3 showed the GWP reduction of each mitigation option for the years 2003 to 2030. The reduction in GWP under this scenario, when totaled amounts to 59,640 Gg of CO2 equivalent, accumulated from 2003-2030, and amounts to **24% reduction** from the baseline or reference scenario (Table 2). In the analysis, only the mitigation options for which sufficient data was available, were evaluated in the calculations of the GWP emissions and reduction. The projects which contributed to the reduction in GWP (the ones with sufficient data for LEAP 2000) are the Compact Fluorescent Lamp (CFL), the Phnom Penh City Shuttles (Bus), the Improved Cook Stove (ICS), the hydropower project, the 180 to 600 MW Combined Cycle Gas Turbine (CCGT) and the Mass Transit in Rural Areas.

V. OTHER GREENHOUSE GAS MITIGATION OPTIONS

These projects do not have the data needed to evaluate in the LEAP 2000 program, but they have potential to reduce GHG emissions.

V.1. UNDER EXISTING GOVERNMENT PLANS

V.1.1. Institutional, Legal and Regulatory Initiatives

With the establishment of the Electricity Authority of Cambodia (EAC), power project contracts are to be awarded through competitive bidding. The Royal Government has decided to follow a new approach for the development and approval of private investment projects in the power sector in Cambodia, which includes competitive tendering for all sizeable power projects and to make the selection process of IPPs transparent and competitive.

The Cambodia Investment Board (within CDC) approves private sector projects and CRDB (also within CDC) approves public sector projects. Line Ministries approve public sector projects not requiring a loan, and provincial governments approve projects that are outside the purview of the CDC.

The Electricity Act that was passed in February 2001, provides for the establishment of a national regulatory body and is aimed at encouraging private sector involvement in the power sector. The EAC was created by this Electricity Act, and will issue licenses to power suppliers and distributors, leaving EDC as a government supplier and MIME as the policy-making agency.

The Law on Environmental Protection and Natural Resources Management (LEPNRM), implemented by the Ministry of Environment (MoE) was enacted in 1996[14]. It codifies the State's obligation to protect the environment and ensure sustainable development of natural resources. It also calls for the assessment of the environmental impacts of new investment projects and provides for public participation in environmental decision-making. It extends the MoE oversight to industrial and urban environmental issues. The law provides for the Ministry of Environment to establish an environmental steering committee and project review teams for different sectors. MIME and EDC participate in both the steering committee and also in the relevant review team. The Government policy provides for sound environmental management of power projects through a systematic approach to protection against pollution of air, soil and water; protection against noise, vibration and radiation; and protection of flora and fauna in relation to power sector operations.

To assist private sector investors, a "Private Investors Rules and Guidelines on Private Investment" and "Procedures for Negotiating PPAs" has been prepared. This document is being updated to reflect the current policies of the Royal Government and will be made available by the end of the year.

Two environmental sub-decrees require activities/projects related to electricity generation to consider environmental protection aspects. One is sub-decree No. 72 on EIA Process, promulgated in 1999, which states that all power plant projects with an installed capacity exceeding 5 MW should have an EIA and that the EIA report should be submitted to the MoE for review and approval. The other is the sub-decree on Air Pollution Control and Noise Disturbance. This sub-decree requires that all immovable sources of air pollution, which power plants belong to, comply with emissions standards provided within this sub-decree.

Until recently, EIA in Cambodia was an ad hoc activity with the CDC providing environmental (as well as overall) clearance for major investment projects. EIA was largely limited to public

[14] Asian Development Bank, 'Environments in Transition: Cambodia, Lao PDR, Thailand, Vietnam – February 2001.

sector projects normally financed by organizations whose internal approval procedures mandated an environmental assessment (ADB, WB, EU, etc.). This is being changed. The process is now underway for: (i) transferring the responsibility for EIA from CDC to MOE; (ii) transferring the initiative for conducting EIA from outside development agencies to Cambodian authorities; and (iii) making EIA apply across all new and old activities in a systematic manner. The first step is virtually accomplished while the other two still require further substantial efforts. Today, the authority for EIA is squarely vested in the MoE, as provided for by the LEPNRM. The scope of EIA has been extended to all investment projects, proposed or existing. Environment units have been, or are being, created in all ministries having resource management functions (MIME, MPWT, MAFF, MRD, Tourism and Health). The approach to EIA is expected to be based increasingly on formalized links between MoE and these environment units. The Environmental Steering Committee (ESC), with membership from the line ministries, NGOs, and the Chamber of Commerce, was created in 1998 to advise MoE on issues relevant to EIA.

CDC remains responsible for approving loan-funded projects and despite the transfer of responsibility for EIA to MoE, the latter still needs to comply with CDC's approval process. The following environmental concerns should also be evaluated:

(a) Quality of Fuel Used

Fuels have varying carbon contents. Oil has a higher carbon content than natural gas. Since emissions of GHGs are directly related to carbon content, it follows that combusting oil produces more emissions than does burning the equivalent amount of natural gas. Roughly speaking, combusting natural gas produces 30% less carbon than oil on an equivalent energy (BTU) content.

One of the objectives of the Cambodian National Petroleum Authority (CNPA), which was formed in January 1999, is to establish a petroleum laboratory to provide physical and chemical data in the support of the supervisory, research, exploration and evaluation activities of the CNPA. This laboratory, once operational, can analyze the quality of fuel to be used in the power plants.

(b) Fuel Quality Testing Equipment

Fuel quality testing should be done in the power plant. The type, quality and consistency of fuels used at a power plant can affect its performance and, as a result, its emissions. Fuels that are high in quality (e.g., high heat rate, few impurities) combust more efficiently and more cleanly and result in less boiler down time. For boilers to operate as efficiently as possible, electric utilities can take actions to ensure that fuels fed to boilers are close to design specifications.

(c) Installation of Pollution Control Equipment:

The installation of pollution control equipment is recommended in order to reduce pollutants.

V.1.2. Electricity Supply Improvement

The Government recognizes that the high cost, unreliability, and limited geographic availability of electricity still constitutes a major hindrance to private sector and rural development. The high

cost reflects the almost total dependence on imported oil based fuel as the primary energy source, and the lack of a high voltage transmission system.

The state-owned utility, Electricité du Cambodge (EDC), will therefore undertake the following initiatives during SEDPII:

- Rehabilitation of the 10 MW hydropower plant in Kampong Speu province and of the 115KV transmission line to supply Kampong Speu town and Phnom Penh;

- Implementation of the agreement to establish the HV 220KV interconnection with Vietnam to supply Phnom Penh;

- Investigation of lower voltage cross-border transmission lines to supply towns close to the Thai and Vietnamese borders; and

- Investigation of a 115KV transmission line from Thailand to supply Serey Sisophon in Banteay Meanchey province, with possible later extension to Siem Reap and Battambang.

The $56.2 million investment program for the period 2001-2003 includes projects for extension of the power system, power rehabilitation in provincial towns, and rural electrification. The rehabilitation of Kirirom hydro plant is to be undertaken at a cost of $26 million by the China Electric Power Technology Import and Export Corporation.

V.1.3. National Transmission System

To meet the growth in demand, which is forecast to grow from 97 MW and 522 GWh in 1998 to 746 MW and 2634 GWh in 2016, the Royal Government has decided to develop a National Transmission System. This System will allow access to energy generated by efficient large-scale power stations to provincial centers and also allows Cambodia to access available hydroelectric sites inside Cambodia or in neighboring countries. It will significantly reduce reliance on imported oil for the energy generation and also the risks involved in oil transportation.

The total capital cost of transmission developments within the period (1999-2016) is about $365 million excluding contingencies. It is proposed that the transmission system be developed in three stages depending on the availability of funds. Details of this plan are in Attachment B.

A national transmission system can allow trading of electricity from systems that may have excess capacity, at a lower cost and may produce less GHG, for example, importing cheaper electricity from Vietnam. This transmission line can also be used to export electricity to Vietnam. In the case of large hydroelectric power plants, which are considered uneconomical if the demand is not enough to effect economies of scale, once connected to the grid this project will be economically feasible. A new and efficient transmission line will result in reduced transmission losses and will have reduced generation requirements, with subsequent reductions in GHG emissions. In order to ensure that these large hydroelectric power plants will not result in flooding of forests and communities, the government should strictly implement the submission of EIA and other environmental rules and regulations.

The 220 kilowatt high voltage transmission line will minimize transmission losses. 80% of the losses occurring during transmission and distribution are due to resistance, which is inversely related to voltage-therefore, the higher the voltage, the lower the transmission and distribution (T&D) losses. Electrical resistance losses in high voltage systems is low, making it well suited for bulk transfer of electricity over large distances.

V.1.4. Electricity Trading With Neighboring Countries

To improve system reliability and to reduce electricity costs, trading arrangements with neighboring countries will be negotiated. There are plans to purchase low level energy (22 kV) from Vietnam, Thailand and Laos. This power will be provided to provincial towns and districts close to the borders of the three countries mentioned.

There are also plans for low capacity transmission links (115 kV) from Aranyaprathet in Thailand to Banteay Meanchey, Battambang and Siem Reap and connection from Vietnam to Takeo. Large capacity transmission links (230 kV or 500 kV) dedicated to energy imports/exports with Vietnam is tentatively planned to take place between 2002 and 2008. Cambodia is negotiating with Thai authorities to create links in Western Cambodia, specifically Battambang, Siem Reap and Banteay Meanchey provinces, and both authorities have agreed upon the areas for the connections and are finalizing plans."

Power trade has already commenced with cross border connection to the Thai grid established to supply Koh Kong and Poi Pet and further local area cross border connections are in the planning stage for connections to the Thai and Vietnamese grids.

The Cambodia Daily reported on 17 April 2001 that: "the construction on the first national power transmission line between Phnom Penh and the Vietnamese border will begin later this month, bringing cheaper, more reliable power supplies to Cambodia. The power from Vietnam will help Cambodia solve its power shortage. Creating the $46 million power link with Vietnam is the beginning of a 10-year electricity and power project in Cambodia".

Cambodia plans to spend another $82 million to build a national power grid that will supply Cambodia and neighboring countries with electricity, reducing Cambodia's dependency on foreign electricity. Both the link from Vietnam and the power grid project will be financed with loans from the World Bank. The Cambodian-Vietnamese power link will include two connections. The first link is a medium voltage 15 or 22 kilowatt line that will benefit villages on both sides of the border. The second, larger union is a 220-kilowatt high-voltage transmission line that will run from the Vietnam border to Takeo town and then to Phnom Penh.

Most Cambodians in rural areas pay approximately $0.17 per kilowatt-hour, which is $0.10 higher than what most Vietnamese pay. The new electricity transmission line will reduce the price to around $0.11 - $0.12 per kilowatt-hour. The $0.11 or $0.12 will be a flat fee for 12 years and will offset the cost of the project. Businesses in Phnom Penh will also benefit from this power link. The cost of power for business and industries in Cambodia will drop from the current &0.21 per kilowatt-hour to between $0.11 and $0.14 per kilowatt-hour.

V.1.5. Regulatory Reform Action – Establishment of a Power Sector Regulatory Framework

The Royal Government announced, through Royal Decree on March 9, 1996, a decision to establish an Independent Regulatory Agency to improve the efficiency and the availability of

electric power services in Cambodia by increased private ownership and competition in generation of electric power. An Electricity Law was finalized and considered by Parliament. The Law will create the Electricity Authority of Cambodia (EAC) as an independent regulatory authority.

The Electricity Law was promulgated in early February 2001 and the establishment of the EAC has commenced with the appointment of the Chairman. There is a need for EAC, as a sector regulator, to be provided with assistance in setting up EAC and drafting of regulations and procedures. The Technical Assistance under the proposed World Bank Credit (2001) on Rural Electrification and Transmission Project will provide assistance in this aspect.

The MIME must divest itself of ownership of 7 provincial systems (Banlung, Kampot, Kampong Speu, Prey Veng, Sisophon, Stung Treng and Svay Rieng). MIME is to appraise if any provincial systems can be sold to the private sector. Other systems are to be transferred to EDC. ADB's PPTA for Provincial Power Supply 2 (2002) will provide assistance to this project.

The private sector is encouraged to invest in the industry but existing private systems are small and very poor quality. A fund should be available for Rural Electrification Enterprises (REEs) through a Rural Electrification Fund (REF) and commercial funds with longer terms. There is a proposed WB/GEF grant for Technical Assistance and an ADB Proposed Loan for provincial Power Supply 2 as possible contributors to the REF.

Regulations send important signals to electricity generators and end-users – they affect a utility's costs, profit and choice of equipment, all of which factor in the price of services (cost of electricity). Regulations can either "push" or "pull" the market. It can "push" the market through setting more stringent standards and penalizing those that do not meet the requirements – or "pull" the market by providing rewards or incentives. These usually result in efficiency measures in the operations of electricity generators and end-users, that will lead to the reduction of the use of inputs (materials, energy, etc.) and thereby reducing GHG emissions.

V.1.6. Rehabilitation of the Electricity System

The electricity system was virtually non-existent in 1990. In order to help Cambodia in the rehabilitation of its electricity system, AUSAID, ADB, World Bank and JICA provided funding and technical assistance. The ADB provided two loans: one on Special Rehabilitation Assistance Project (1992) and another loan on Power Rehabilitation Project (1994). The ADB also funded two TAs on Power Rehabilitation.

The AUSAID funded the study on "Power Transmission Master Plan (1996)" which is used by the MIME and EDC in planning. The World Bank funded the Distribution Rehabilitation in Phnom Penh (1995). JICA funded the Rehabilitation and upgrading of Phnom Penh electricity supplies (2000-2002).

V.1.7. Provincial and Rural Electrification

The MIME Directorate of Electricity is to be responsible for approving and implementing a comprehensive strategy that will ensure input from the provinces in the decision-making process. ADB's Technical Assistance "Strategy for Provincial Power Management (2000)" and WB's "Formulation of a Rural Electrification Strategy" will provide assistance in this area.

The World Bank has identified issues and problem diagnosis on limited electricity provision:

- Electricity demands in Cambodia is concentrated in Phnom Penh which accounts for 70% of the country's electricity consumption even though it accounts for only 12% of the population;

- Framework needed for public-private participation and foreign investment.

The World Bank's development partners are ADB, France and Japan. Their proposed strategies and measures are:

- Increase coverage and reduce costs of electricity supply;

- Establish rational tariff structure;

- Seek strategic partners in order to increase and improve services and improve financial performance of utilities;

- Encourage competition and private participation by establishing an enabling environment; and

- Privatization and/or concessioning of Electricité du Cambodge (EDC).

The International Development Association (IDA) supports the programs "Phnom Penh Power Rehabilitation", "Rural Electrification Project", "Country Framework Report on Private Participation in Infrastructure (PPI)" and " Rural & Provincial Infrastructure Operation".

V.1.8. Improvements in the Electricité Du Cambodge (EDC)

i. Human Resources Development and Training

A new salary structure is being implemented to motivate the EDC staff. In addition to this, a training center has been established in Phnom Penh, with the Asian Development Bank's assistance, and was ready for operation by October 1999. The World Bank sponsored a one-year training program for 24 EDC Executive Directors and senior staff. There is also a proposed ADB loan "Provincial Power Supply 2" to provide additional training for Operators and Managers of provincial power systems.

The training of power plant decision-makers is very important, as it is their performance, coupled with efficient power plant equipment that will determine the potential efficiency and cost-effectiveness of a power plant.

Understanding when equipment should be replaced, when units should be dispatched and the quality of fuels to be used are a few of the factors that will greatly influence the availability, reliability and performance of power plants. Experience has shown that power plant decision-makers who possess the tools and the capabilities to use these tools operate better-performing power plants. Techniques like benchmarking, plant audits, performance trending, fuel quality evaluation, asset management, and optimum economic performance are among the many tools available to power plant managers to help define performance targets and to prioritize equipment purchases.

These managerial and operational improvements will carry over to improvements in the ability to comply with environmental regulations. With improved management, environmental benefits will be realized by minimizing system losses and waste.

The availability of these tools, coupled with employee motivation and formal training programs, tying salaries and bonuses to plant performance, and team development, will contribute to improving human and power plant performance.

ii. EDC Management Decentralization to the Provincial Centers

The EDC now operates the systems in Phnom Penh and Kandal province, Sihanoukville, Siem Reap, Takeo, Kampong Cham and Battambang and by 2003 will take over 7 more provincial systems.

Performance Targets will be set by EDC Board but the strategy to meet these targets will be left to area managers. ADB's two Technical Assistance : "Strengthening of the Institutional and Legal Framework for the Energy and Minerals Sector (1994)" and the "Power Sector Manpower Development and Training (1994)" provided assistance in this aspect.

iii. Solution to EDC's Cash Flow Problems

One measure of the reliability of a power system is its good financial situation. EDC's serious cash flow problems can be solved by the implementation of an Action Plan for EDC's financial recovery including increases in residential tariffs, and direct payment by the Ministry of Economy and Finance (MEF) of bills of RGC Department and agencies. The Government of France funded a Technical Assistance and advisory services for planning, training, system losses and tariffs (2000) to help address this problem. The ADB also helped in the form of a policy dialogue during processing of the Loan for provincial Power supply project.

V.1.9. Commercialization of the Supply of Electricity

i. Commercialization of EDC and Marketing Strategy

A study has been carried out by the Electricité de France (EDF) to develop a marketing strategy and a new tariff structure to achieve the new commercial objectives. EDC and EDF have jointly developed a 1998-2000 marketing plan.

The World Bank has recommended entering into a contract with a foreign Utility to assist in turning EDC into a profitable Utility. EDC is in favor of having a consultant team to assist them in the fields of Customer Management, Marketing and Sales Development and is seeking the assistance of the French Government.

To develop senior staff skills in commercial management best practice, EDC and MIME senior staff and Executive Directors are participating in a year long training program concerning: Financial Management and Planning, Business Management, Strategic Planning and Project Financial Appraisal and Economics. The training program is conducted by the National Institute of Management and sponsored by the World Bank.

ii. Commercialization of Provincial Electricity Supplies

In January 2000, some senior staff of provincial electricity supply units commenced training in Business Management. This is the first stage of a program to implement a sound commercial management structure for provincial electricity supplies. A development grant will be sought to implement a structural reform program in all provinces. This program will establish commercial structures for management of electricity supplies and performance contracts for the management of all provincial supply networks. A separate Provincial Electricity Office will be formed at the national level to monitor performance and provide support to provincial offices.

EDC must employ market-oriented approaches and may require organizational restructuring and employment of new, customer-oriented services. Some steps that a utility can take are: a) improve internal management and responsiveness by creating a database of customer information including payment history; b) improve internal accountability system by implementing modern financial accounting methods; c) improve employee performance reorganize work schedule, employ teamwork, etc.; and d) other steps like public education that teach customers how to phone in complaints, implement methods for feedback from customers on company performance and services and provide 24-hour customer service.

V.1.10. Renewable Energy

i. Status of Renewable Energy Utilization[15]

Since about 85% of the total population live in the rural areas, the Government of Cambodia is placing great emphasis on the development of local energy resources to raise the standard of living of the rural population. Renewable energy sources, especially solar energy, have been identified as important sources of local energy, not only to raise the living conditions of rural villages, but also to develop local industries to stimulate economic growth.

The MIME and the government of Cambodia and the Institute de Technologie du Cambodge (ITC) are the main organizations involved in renewable energy activities in the country.

ii. Renewable Energy Technologies (RETs) in Asia: A Regional Research and Dissemination Program

The SIDA sponsored the two-year research programme which was coordinated by the Asian Institute of Technology and involved twelve (12) National Research Institutions (NRIs) from six Asian Countries: Bangladesh, Cambodia, Lao PDR, Nepal, the Philippines and Vietnam.

The overall objective of the programme was to promote the dissemination of a few mature or nearly mature renewable energy technologies in selected Asian countries through the adaptation of the technologies to local requirements and conditions. The programme covered: photovoltaics, solar drying, and biomass briquetting and briquette stoves.

[15] Source: Renewable Energy Technologies in Asia, "A Summary of Activities and Achievements in Cambodia", MIME and AIT, 1999.

iii. Rural Solar Support

Cambodia has a tropical climate with favorable conditions for the utilization of solar energy. Measurements during 1981-88 at Phnom Penh shows average sunshine duration of 6-9 hours per day, indicating considerable potential for solar energy utilization.

Application of PV systems is a relatively recent development in Cambodia. As in many other countries of the region, PV applications in Cambodia started with a few installations donated by international organizations and donor agencies such as UNICEF, NGOs, Red Cross, SIDA, and FONDEM. The main PV applications in the country have been in health centers and rehabilitation centers. Solar Home Systems (SHSs) and lighting systems have also been installed as demonstration units. Most of the applications of the solar PV installations are for pumping, lighting, fan, photocopier, refrigerator, radio, computer and telecommunications. There is a total of 21.73 kilowatts of PV installations, ranging in capacity from 110 watts to 3,696 watts.

The government has been promoting PV systems through reduced import duties and taxes on components and equipment. There are no local manufacturers of PV panels and accessories in Cambodia. All equipment including accessories are currently imported.

Drying is another area of solar energy application. Sun drying is the traditional method used by farmers in Cambodia for drying crops such as rice, maize, banana and tobacco after harvesting. Bamboo mats are used in some cases.

Currently, there are no private manufacturers of solar dryers in the country. A type of solar cooker is manufactured in Cambodia by an NGO and is sold at about US$70. Because of the high cost, the cooker has not yet found significant acceptance.

The Asian Energy News dated March 2001 reports that the Hun Sen Development Center gets solar power from the New Energy and Industrial Technology Development Organization (NEDO) of Japan. The Hun Sen Development Center in Phnom Chiso in Takeo province has become the first community in the country to meet its energy needs from solar energy. The project was undertaken with a $50,000 financial assistance from NEDO. The assistance was used to procure a battery charging station that will serve 42 families at the development center. The station can charge six batteries at one time.

V.1.11. "Cambodia Renewable Energy Promotion Project"

The MIME has submitted a project proposal for funding by the World Bank-Global Environment Facility (GEF), entitled "Cambodia Renewable Energy Promotion Project". The project duration will be for 6 years and the overall project objectives are to: a) eliminate the policy, institutional, financing and information barriers that impede the market development for renewable energy in Cambodia so that rural people can have increased access to electricity services and b) accelerate rural transformation by expanding electricity access by offering technical assistance and capacity building for key stakeholders and investments in renewable energy systems for isolated mini-grids using hydro sources and in off-grid solar and village hydro.

The goals of the project are: to achieve Cambodia's overall rural electrification goal of 70% of rural households by 2030 and build sustainable power generation mix in the country. Its specific targets are:

- 5% of generation capacity by renewable energy systems (6 MW);
- 3 strong renewable energy businesses;
- 3 mini-hydro projects supplying to grids on a commercial basis;
- 5,000 to 10,000 solar homes installed;
- 50 to 100 educated renewable energy employees.

The project will have two main components: technical assistance and investments.

V.1.12. "Promotion of Renewable Energy, Energy Efficiency and Greenhouse Gas Abatement (PREGA) Projects"

PREGA is a Technical Assistance (TA) co-financed by the ADB and the Government of the Netherlands. The MEF of Cambodia signed an agreement with ADB on April 5, 2001 to cooperate on the implementation of PREGA. Under this project, three government staff (MoE, EDC and MIME) attended a workshop in Manila on PREGA Initiation workshop on 18-20 April 2001.

The scope of this TA will include capacity building for National Technical Experts (NTEs), developing financing models, identification of policy and institutional barriers and other activities (full scope of the TA is in Attachment C).

This project will sponsor a 2-day national workshop in Cambodia to help prepare a Work Plan to implement the PREGA Project.

V.1.13. SEILA 2001-2005: Natural Resources and Environment Mainstreaming Strategy Formulation Process

Energy Development and negative impact on environment was stated in the 1997 Cambodia's NEAP as one of the six (6) Natural Resources and Environment areas of concern. The other areas of concern are forest policy, fisheries and flood plain agriculture, coastal fisheries management, biodiversity and protected areas and urban waste management. SEILA, a five-year (2001-2005) national programme with an objective to achieve poverty reduction through decentralized and deconcentrated local governance, can facilitate support for two components:

- Capacity Building (education and awareness raising); and
- Environmental Activity Fund.

The SEILA programme is funded by several donors and executed by the RGC.

V.1.14. Transport Sector

Good roads will reduce travel time and fuel use and thereby less emissions of GHGs. According to the World Bank, “motor vehicles cause more air pollution than any other single human activity”. The primary pollutants emitted by motor vehicles are hydrocarbons (HC) and nitrogen oxides (NO_x), the precursors to ground level ozone, and carbon monoxide.

Another impact on the global climate derives from the refrigerants used in vehicle air conditioners. The chloroflourocarbons (CFCs) persist in the atmosphere for a long time and deplete the stratospheric ozone layer, leading to increased ultraviolet radiation on the earth's surface (Dutt 1992 p. 84).

The SEDPII has the following Plans for Road Improvements:

The policy objective of rehabilitating and maintaining transport infrastructure is to be achieved by giving first priority to road rehabilitation and an associated improvement in operations and maintenance capability. The Five Year Road Master Plan has three main aims:

- To rehabilitate and reconstruct the main national roads, thereby improving land transport throughout the nation;

- To build road links to neighboring countries, thereby opening up some of the more remote areas of the country to international trade and tourism; and

- To develop a sustainable road maintenance program, thereby assuring that investment in road rehabilitation and reconstruction generates sustainable benefits.

During SEDPII, it is proposed to accelerate the rate at which the road network is rehabilitated and made serviceable by adopting a policy of staged construction, by simplifying contracting procedures, and by employing short-life (three-year) rehabilitation techniques. Early in 2001, external assistance for the rehabilitation of 1,400 km was secured. The planed target is to rehabilitate a further 4,700 km, giving first priority to the 2,800 km of the National Road system that connects Phnom Penh to the provincial towns. Second priority will be given to an additional 1,900 km of the National Road system that more directly links adjacent provinces and connects communes and villages with towns and cities.

The individual projects to be undertaken in the first three years of the Road Rehabilitation Program, 2001-2005 are presented in the *Public Investment Program, 2001-2003*. Ongoing projects will cost a total of $236.6 million. High priority capital projects amounting to $290.7 million will need to secure funding.

The Government recognizes the importance of a road maintenance program that will sustain the condition of the road network through effective integration into the annual budgetary process; and has estimated the costs of such a program at $13.1 million over the Plan period.

i. Road Improvement

The International Finance Institutions (IFIs) and some major donors such as the Asian Development Bank (ADB), the World Bank and JICA have supported grant/loan projects for road improvement.

The upgrading of sections of National Roads (NR) 5, 6 & 7 is using funds from the ADB Primary Roads Restoration Project. The project involves restoration of approximately 589 km of roads consisting of 260 km on Road Number 5 (RN5) between Phnom Penh and Sisophon, 112 km on RN6 between Skun and Kampong Thom/Siem Reap provincial boundary and 217 km on RN7 between Kampong Cham and Kratie.

The World Bank sees that there is an urgent need to improve access to markets and services and has identified the following issues and problem diagnosis in Cambodia on road upgrading:

- Most roads especially in rural areas are totally dilapidated resulting in high transport costs and travel times;
- Disproportionate focus on primary roads and neglect of "missing link" secondary roads;
- Insufficient public resources for road construction and maintenance;
- Poor condition of road hinders development potential (agriculture, fisheries, tourism, trade);
- The Ministry of Public Works and Transport has inadequate capacity to plan, manage and implement road construction;
- No transport sector policy.

The development partners of the World Bank in this project are the ADB, ILO, UNCHR, UNWFP, Australia, France, Germany, Japan, New Zealand and Sweden.

The proposed strategies and measures are:

- The development of a comprehensive transport policy, including financing, maintenance, vehicle safety and environmental safeguards;
- Rehabilitation and maintenance of primary, secondary and tertiary roads;
- Support to local construction industry (for maintenance); and
- Establishment of a road fund for maintenance.

The IDA supports the programs "Road Rehabilitation" and "Rural and Provincial Infrastructure Operation".

The US Office of Technology Assessment (OTA), an advisory agency of the US Congress, has reported that the energy efficiency of the passenger transport sector can be improved in three primary ways. First, the vehicles themselves can make use of technologies that increase energy efficiency. Second, their operational efficiencies can be improved by carrying larger loads (with consideration of safety standards) or through improved traffic management. Third, there could be increased use of those modes, such as buses and rail-based systems or walking/bicycling that use less energy per passenger mile. These modes already provide a significant share of trips in some areas, particularly in developing countries. Land use planning and other government policies strongly influence the viability of these mass transit or non-motorized modes (OTA 1992 p.161).

Transport Master Plan of the Phnom Penh Metropolitan Area. New and improved roads, bridges and traffic signals, an extensive bus system, well-trained policemen and a drivers' license system make up the $375.8 million 14-year transportation master plan presented to the

municipal government on September 28, 2001 by JICA (Cambodia Daily, October 1, 2001). This study is funded by JICA in close cooperation with the Municipality of Phnom Penh. The Master Plan is engineered to encompass the following plans to be integrated in such a way that they can complement and support each other:

- Road Improvement Plan
  - Pavement improvement
  - Development of road network
- Public Transport Plan
  - Bus operation
  - Provision of bus facility and terminal
- Traffic Management
  - Provision of traffic signal
  - On-street parking facility
  - Enforcement and education
  - Accident analysis system
- Traffic Legislation
  - Vehicle registration system
  - Drivers license system
  - Institutional and organizational development
  - Human resource capacity development.

ii. Airport Improvement

Improvements in Air Traffic Management (ATM) and other operational procedures could reduce aviation fuel burn by between 8 and 18%. ATMs are used for guidance, separation, coordination, and control of aircraft movements. Existing national and international ATMs have limitations which result, for example in holding (aircraft flying in a fixed pattern waiting for permission to land), inefficient routings and sub-optimal flight profiles. These limitations result in excess fuel burn and consequently excess emissions. For the current aircraft fleet and operations, addressing the above-mentioned limitations in air traffic management systems could reduce fuel burned in the range of 6 to 12%.

Operations of aircrafts are divided into two parts:

- **The landing/take-off (LTO) cycle**, which includes all activities near the airport that take place under the altitude of 1000 m. This therefore includes taxi-in and out, climbing and descending;

- **Cruise** which is defined as all activities that take place at altitudes above 1000 meters.

Airport construction projects at Pochentong and Siem Reap will be completed in 2001, and building of a third international airport is planned for Kampong Chhnang province in 2002. Construction of a regional airport at Sihanoukville is also planned for 2002. Major provincial airports such as those in Rattanakiri and Mondulkiri provinces will be upgraded.
The medium-term goal of civil aviation policy is to provide safe, high-quality, and cost effective civil aviation services in a competitive environment, so as to maximize the contribution of civil aviation services to economic growth and international and regional cooperation.

The Government's supporting objectives are: (i) to establish a legal and regulatory framework through enactment of a Civil Aviation Code and preparation of empowering regulations; (ii) to develop commercially-oriented airports; (iii) to develop and where appropriate privatize air navigation services; (iv) to develop human resources to cater to the specialized economic, technical, and operational requirements of civil aviation; (v) to transform SSCA from a single centrally-controlled Government agency into separate autonomous civil aviation entities; and (vi) to develop information technology.

The Civil Aviation Development Framework adopted by the Government in 1998 will be updated early in the Plan period.

The *Public Investment Program 2001-2003* provides for an allocation of $27.1 million to civil aviation, or 7.6 percent of the total PIP allocation. The major projects are the completion of the on-going upgrading of Siem Reap Airport, and strengthening and further development of the air traffic control system.

The ADB approved a loan agreement with the RGC on December 1996 for the upgrade of the Siem Reap airport. The objective of the Siem Reap Airport Improvement Project was to provide enhanced civil aviation infrastructure to support reliable and safe all-weather operations at the domestic and international airport over flight traffic in accordance with the International Civil Aviation Organization (ICAO) standards.

Another ADB project is the Expansion and Modernization of the Pochentong International Airport. The new 3,600 meter runway will be designed to receive B747 400s in keeping with ICAO recommendations and French standards as is the case for the entire facility. Some of the improvements will be on the ancillary facilities like internal service and access roads with connections to National Highway 4, resulting in an optimized road network, power plant with Uninterruptible Power Supply (UPS) and generator sets.

iii. Rail Transport Upgrade

JICA has approved a $11.5 million loan for improvement of the railroad from Phnom Penh to Sihanoukville. The French Government has approved a 6 million Euros for the acquisition of efficient locomotives. The ADB has provided a $1.5 million loan for railroad improvement.

The Royal Cambodian Railways Strategic Plan has five policy objectives:

- Continued rehabilitation of physical infrastructure;
- Increased income generation in order to support rail operations;
- Promotion of competition with other transport modes in the context of a market economy;
- Establishment of other rail services and increasing the connections with major customers in order to promote the transport of containers and petroleum; and
- Investigation of the possibility of constructing a Singapore-Kunnming rail link that would integrate Cambodian rail into the regional railway system.

For the short- to medium-term, four key activities are identified: rehabilitation of the Phnom Penh - Sihanoukville line; reconstruction of the Sisophon-Poi Pet line (48 km); repair and rehabilitation of rolling stock, stations, signal facilities and communication systems, modernizing equipment where appropriate; and rehabilitation of the Phnom Penh – Battambang – Sisophon line.

The *Public Investment Program, 2001-2003* allocates a total of $108.5 million for rehabilitation and reconstruction of the rail lines.

iv. Water Transport

The four main navigable waterways converging in Phnom Penh remain important means of moving cargo and people. The *Public Investment Program 2001-2003* includes provision for feasibility studies leading to projects that involve dredging of the Mekong Channel, development of a Mekong GIS database, and improvement of the entrance to the Tonle Sap Great Lake.

A study for urgent rehabilitation of the Sihanoukville port has been undertaken that proposes an investment package of $42.6 million, with $40.8 million allocated in the *Public Investment Program, 2001-2003*. Following rehabilitation of the two Phnom Penh port sites in 1996, there are no investment projects planned for SEDPII.

V.2. ADDITIONAL GHG MITIGATION OPTIONS RECOMMENDED BY THIS STUDY

The following policies and projects are recommended in this study, and are in addition to those already identified by the government under the "Government Plans" GHG mitigation options. These recommended policies and projects, however, can not be quantitatively evaluated in the LEAP 2000 program due to the lack of data.

V.2.1. Policy Reforms

i. Implement a Study on the Privatization and Restructuring of the EDC and Power Utilities

The privatization of EDC and Power Utilities is in line with the government plans (stated in the SEDPII) to support broad-based industrial development by improving the performance of State-Owned Enterprises through corporatization and privatization.

The Electric Industry Restructuring will have major goals such as: (i) greater economic efficiency, (ii) lower prices, (iii) increased consumer choice, (iv) preserved system reliability, (v) more transparent prices, and (vi) greater environmental protection. The basic idea of restructuring is to stop treating electricity generation as a monopoly, and instead to treat it as a competitive business. In order to make this shift, three basic changes are undertaken:

- Vertically integrated utilities[16] are broken up, either by the sale of generating plants, or by placing generation assets in separate, "unregulated" generating companies that remain utility subsidiaries;

- Markets are created into which the generating companies can sell, and from which others can buy; and

- Consumers of electricity are given direct market access, so that they can purchase their energy and capacity needs from anyone willing to serve them.

This study advocates restructuring to achieve a competitive market model with wholesale and retail competition[17]. Such reform will encourage sustainable private sector participation and maximize the benefits to consumers. Five major steps are suggested in implementing this approach, and their order of precedence. To some extent, these steps may proceed in parallel, but they should be considered sequential actions that will lead to the implementation of a competitive power market:

- Getting the investment framework right;

- Deciding on the goals of restructuring and the ideal industry structure;

- Preparing the players to participate in a competitive market;

- Privatizing existing and new assets; and

- Ensuring that the competitive market is implemented properly.

Best practices for power sector restructuring would include the following:

- Create an enabling legal and regulatory environment to support competitive markets in electricity;

- Unbundle the power sector into separate generation, transmission, distribution, and possibly retailing sectors to achieve the maximum benefits for customers;

- Privatization should include the sale of power distribution utilities as well as generation, and should include existing assets as well as new projects, using a transparent process;

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[16] Vertically integrated utilities are utilities where all of the basic utility functions like generation, transmission, distribution, billing and customer service - were provided by the same organization.

[17] Asian Development Bank, ”Developing Best Practices for Promoting Private Sector Investment in Infrastructure”, 2000.

- Open access to transmission and distribution wires, and the ability to trade power between buyers and sellers in an open market, are critical to achieve a competitive framework;

- Operate the generation and retailing markets competitively, with a large number of generators selling into a wholesale electricity market at prices which balance demand and supply throughout the day;

- Operate the transmission network as a concession on the basis of competitive bidding, or privatize it within a tight regulatory framework, controlling rates of return, prices or gross revenue;

- The independent regulator should mainly oversee prices and incentives for transmission and distribution operations; and

- Restructuring should proceed at a pace consistent with the development of a competitive and unbundled system.

ii. Implement a Project to Formulate the Framework for Integrated Resource Planning (IRP)[18] and Demand-Side Management (DSM)[19] Programs

Electric utility IRP and DSM programs are responsible for a substantial fraction of the energy efficiency improvements already realized in the buildings sector. When public utility commissions, like EAC for Cambodia, allow utilities to recover the costs of lost energy sales and administrative overhead from energy efficiency programs, utilities would be able to profit from successful energy-efficiency programs, ranging from rebates for purchases of efficient light bulbs and air conditioners, to efficient design services provided by utilities to architects, builders and consumers (Rosenfeld et al, 1995).

iii. Tax Relief

Tax relief on new capital investments is one reform measure under the Market-Based Instruments (MBIs)[20] that should be considered for implementation. One specific policy reform measure is a **law** that gives renewable energy projects incentives like income tax holidays and duty free importation of equipment. One of the barriers of renewable energy projects is its high capital cost. It will make the project economically feasible if an income tax holiday is given (for example seven years of exemption from paying income tax, in some countries such as Vietnam, tax holidays of up to 12 years is provided) and duty free for the purchase of imported

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[18] Integrated Resource Planning (IRP) - is the combined development of electricity supplies and demand-side management (DSM) options to provide energy services at minimum cost, including environmental and social costs.

[19] Demand-Side Management (DSM) - is the planning implementation, and monitoring of utility activities designed to influence customer use of electricity in ways that will produce desired changes in a utility's load shape (i.e., changes in the time pattern and magnitude of a utility's load).

[20] Market-Based Instruments. Conventionally, policy frameworks have been seen as being based on two main types: regulatory measures and market-based instruments. Regulatory measures include (for example) the imposition of emissions limits, the setting of appliance efficiency and the requirement for best available process and end-of-pipe technologies. These types of measures are often called "command and control" instruments, and are portrayed by critics as inflexible and hence inefficient. Market-based instruments include emissions charges, taxes on resource use, subsidies for cleaner technologies, tax relief on new capital investments, and penalties for infringement of environmental regulation.

equipment. Such a tax relief can be easily implemented if the MIME and the MEF sign a Memorandum of Agreement, stating among others, that the MEF will acknowledge a MIME clearance given to a developer. This clearance will automatically give the developer the exemption of duties and taxes from the MEF.

iv. Fund for Renewable Energy Projects

The availability of a **fund** that is easily accessible to potential investors and reserved only for lending to renewable energy projects will also attract potential developers. This fund can be from cooperating banks and international donors and initiated, coordinated and supported by the government.

The World Bank[21] is supporting the development of a comprehensive rural electrification strategy, "*Rural Electrification and Transmission Project*". Associated is a renewable energy subcomponent that is currently under preparation with GEF support (PDF B, *Promotion of Renewable Energy Businesses in Cambodia*). Activities include the preparation work for the formulation of a *Renewable Energy Action Plan* and for setting up a ***Renewable Energy Development Fund***.

In accordance with the agreement reached in July 2001 in Bonn, Germany[22] , by the 6th Conference of Parties (COP6) on the rulebook for the 1997 Kyoto Protocol, a Special Climate Change Fund and a fund for least developed countries will be established under the 1992 Convention. These funds are set with the aim of helping developing countries adapt to climate change impacts, obtain clean technologies, and limit the growth in their emissions. In addition, a *Kyoto Protocol Adaptation Fund* will be established to finance concrete adaptation projects and programmes.

v. Development of Mini-Hydropower Plants (101 kilowatt to 10 MW)

According to MIME, the country has a hydropower potential of 8,000 MW, but no detailed studies have been done so far. It is recommended that mini-hydropower plants (from 101 kilowatt to 10 MW) be developed instead of the larger schemes that will require the building of dams. Most mini-hydro power plants require weirs instead of dams, and therefore will not adversely affect the environment. Cascading mini-hydropower plants is also an option, where the geography of the site permits the cascading scheme.

vi. "Energy Efficiency Building Codes"

A study should be initiated on the "Energy Efficiency Building Codes" which will evaluate the importance of the code to the country. A similar study is being done by the "Energy Conservation Research and Development Center (ENERTEAM)", the Consulting firm that is presently contracted to conduct the study on Energy Efficiency Building Codes project in Vietnam. The World Bank, in collaboration with the Ministry of Construction (Vietnam) and The Deringer Group Inc. from the USA, is funding this study in Vietnam.

Some selected information on energy efficiency are given below:

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[21] Source: Mr. Jan van den Akker's report on World Bank mission to Cambodia on WB-GEF " Cambodia Renewable Energy Promotion Project", 28 June 2001.

[22] Source: UNFCCC Secretariat, Press Release, 23 July 2001.

(a) Efficiency Improvements for Existing and New Building Shells

In a hot and humid country like Cambodia, electricity use for air conditioning can be substantial if cooling need is to be fully satisfied. Furthermore, as the country's economy develops, air conditioning needs will rapidly increase, thus increasing energy consumption. Moreover, uninsulated concrete blocks are commonly used for walls and few roofs are insulated. Energy required for air conditioning depends on the building characteristics and on the efficiency of the cooling equipment (air conditioning unit). Since building designers, contractors, and landlords generally do not pay the energy bills; there is little incentive to offer energy-efficient designs to those consumers who pay the energy bills.

In the short term, there is a need to create awareness of the energy efficiency measures among building owners, occupants and the building designers (architects and engineers). Once the public becomes aware of the benefits of energy efficient buildings, some would voluntarily implement these measures because of the potential economic and the environmental benefits that it would generate.

There is a need to look into the long-term for the possibility of incorporating energy efficiency measures as a mandatory building standard[23]. To complement building energy codes, financial incentives should be offered to stimulate the construction of some highly efficient new homes and commercial buildings.

The energy consumed for air conditioning can be reduced through, increases in the thermal integrity of buildings (improvement in walls, roofs, awnings and windows), increase in the efficiency of air-conditioning equipment, improved controls for air-conditioning equipment, design changes (use of passive solar design) and environmental changes (increased shading and wind breaks from trees and other vegetation).

The following measures are available for making both existing and new building shells more energy-efficient: the use of adequate levels of insulation for ceilings, walls, and floors; insulating glazing for windows; control of air infiltration shading devices or solar control glazing to reduce unwanted solar heat gains through windows and high-albedo materials, coatings, and paints to reflect shortwave solar radiation and thereby keep building surfaces cooler.

(b) Stimulating Building Retrofits

In the short-term, to promote energy savings in existing buildings, a set of energy performance targets for different types of buildings should be made and this should be disseminated to building owners and occupants for information. In the long-term, this set of targets should be coupled with a variety of inducements and services to encourage and/or require building owners to upgrade their buildings to meet these targets.

In order to encourage building owners to meet these performance levels, a combination of technical assistance and financing should be provided, to help owners identify and implement the most cost-effective efficiency measures.

[23] This study checked with the Ministry of Construction regarding the Building Code, and was informed that presently there is none.

(c) Passive Solar Building Design

A strategy for reducing the need for mechanical cooling is to make effective use of natural heating and cooling. The passive solar design seeks to utilize energy from the sun by proper placement of windows and use of natural ventilation and planting of trees to block the sun or wind.

Skylights and specially designed roof apertures are built for day lighting building interiors. This reduces electric lighting demand by admitting controlled quantities of daylight. Roof-top apertures have been designed to admit light without irritating glare, or excess solar heat. A principal benefit of day lighting is significant reduction in the mechanical cooling demand from the by-product heat of electric lighting. Day lighting used together with energy efficient electric lighting strategies can reduce electric power consumption in buildings by up to 90% according to recent studies.

It is recommended that in the short-term, voluntary goals accompanied by training and education will be introduced regarding energy efficiency in construction. There is some evidence that simpler building codes do receive greater compliance (IPCC 1996, p. 733).

vii. Establishment of Energy Service Companies (ESCOs)

Encourage the establishment of ESCOs[24] to perform the following activities[25]:

- **Energy Conservation and Efficiency** - identify, develop, support and implement projects in various sectors. Activities focus on energy audits and energy conservation implementation in buildings, industries, transportation and services. Promote projects on energy efficiency and pollution mitigation through cogeneration technologies.
- **Renewable and Clean Energy** - cooperate closely with the local and international organizations and consulting companies/agencies to promote the projects in the field of renewable and clean energy such as solar PV, solar thermal, biogas, micro and mini-hydro and wind energy.
- **Environmental Protection in Industry, Transportation and Service** - analyze practical technical options for mitigating environmental emissions from concrete technological systems in order to conduct feasibility studies of projects.

In cooperation with local and international organizations, conduct technical assistance projects; organize seminars, workshops and training courses in the field of energy and environment.

The ESCOs would be similar to eco-efficiency[26] businesses, which are now successfully operating in the United States, Brazil and other parts of the world. In its simplest terms, eco-efficiency means creating more goods and services with fewer resources, and less waste and pollution. One example of an eco-efficiency business is a company that helps industrial and public-works clients apply technology and building techniques in such a way that they can safeguard the environment, save money and earn a profit.

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[24] A similar study was conducted in Vietnam in collaboration with the Asian Institute of Technology, Thailand and GTZ (Germany).

[25] The activities mentioned are patterned from the ENERTEAM or "Energy Conservation Research & Development Center", an independent consulting institution in the fields of energy and environment in Vietnam.

[26] Eco-efficiency is a term coined by the World Business Council for Sustainable Development (WBCSD) in 1991.

It is recommended that for a start, a proposal can be prepared, for possible funding by international donors, on a "Study on the Need for and Potential Benefits of the Establishment of a National/Local Energy Conservation Center"[27], or an eco-efficiency business center.

For the long-term, **cleaner-technology centers**[28] can be established in strategic locations all over the country. These facilities raise awareness of cleaner-production strategies, disseminate information on cleaner technologies, enhance the capacity for pollution prevention, facilitate access to financial support and provide technical assistance, training and services.

Companies may see cleaner production as an additional cost, rather than as an investment that bring returns in both the short- and the long-term. However, the Government should support the movement toward eco-efficiency by giving the right price signals, making it more expensive to be inefficient.

viii. A Government Program that Encourages Utilities and Industries to Voluntarily Reduce GHG Emissions.[29]

This program can be patterned to the U.S. Department of Energy's (DOE) "Climate Challenge Program" in which more than 600 utilities have made voluntary commitments to reduce GHG emissions. The participating utilities commit to reduce, avoid, sequester a specified amount of CO_2 emissions and periodically report[30] to the DOE on their progress. More than 600 utilities are participants, and have committed to reduce a total of 44 million metric tonnes of carbon equivalent in the year 2000.

ix. Establishment of a "Fuel and Appliance Testing Laboratory"[31]

The SEDPII states , (page 174) that the Government will support broad-based industrial development by establishing, among others, a National Laboratory with the technical capacity to undertake physical, chemical, microbiological and mechanical analysis of products that establish the quality and specifications of these products. The Government will also support a National Institute of Standards that will ensure product quality that matches regional and international standards. Based on these government-supported policies, the following measures are recommended:

The laboratory will test the quality of fuels, and determine the energy efficiency of electric appliances and provide labels to guide the consumers about the energy efficiency of an appliance. Interested donors maybe approached to help establish such a center. For example,

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27 A similar study was conducted in Vietnam in collaboration with the Asian Institute of Technology, Thailand and GTZ (Germany).

28 In Brazil, a partner of the WBCSD has been working with the government to help establish cleaner-production centers.

29 In 1998, the UNEP launched the "International Declaration on Cleaner Production", a voluntary public statement of commitment to the practice of cleaner production. This strategy, also known as eco-efficiency, promotes the elimination of pollution before it is created.

30 The periodic report that was submitted in a uniform format is an effective way of data collection. The Philippines DOE has a similar project. There is a cash prize and recognition (published in important newspapers) of the winners with the highest energy savings. The energy consumption report is used to update the national energy demand database.

31 The Philippine Department of Energy has a "Fuels and Appliance Testing Laboratory" that conducts tests on the energy efficiency of electrical equipment and labels them accordingly, for the information of the consumers.

in the local market in Cambodia, there are different brands of CFLs, most are unknown and costs only US$1 but with no certified energy efficiency, as compared to the Philips[32] brand, which costs US$8. The consumers should be protected and be properly informed on the energy efficiency of the appliance/equipment that they are buying. Cambodia should not become a dumping ground for such inferior equipment.

In the long run, the testing laboratory and an authority (MIME) will set and upgrade appliance and equipment efficiency standards where technically and economically feasible. The MIME will set new standards on lighting ballasts, water heaters, clothes washers, air conditioners, transformers, refrigerators and freezers, furnaces and boilers, cooking gas ranges, and reflector lamps. A labeling program similar to the Energy Star of the U.S. should be established and will include labeling other appliances such as home electronics products, microwave ovens, and refrigerators.

x. Energy Pricing

Energy pricing should be modified to better reflect economic, social and environmental cost. This will include gradual removal of electricity subsidy. If the electricity price reflects its true cost, it will encourage energy conservation.

V.2.2. Enhancing National Capacity

The Environmental Management and Conservation portion of the SEDPII states that the Government recognizes the need for effective environmental protection and natural resources management and is committed to the implementation of the National Environmental Action Plan (NEAP). Some of the medium term objectives are to reduce urban and industrial pollution and build the environmental planning capacity of core institutions.

i. Energy Database

The accuracy of the inventory of greenhouse gases (GHG) depends on a comprehensive database. The results will not be reliable if there is no accurate and comprehensive database. Energy data is one of the vital information needed in the inventory. During the preparation of this study, the energy data available is the Final Report of the study implemented by the Department of Energy of the Ministry of Industry, Mines and Energy (MIME).

There is a need to update the energy data of the MIME. The projection for energy demand is from 1995 to 2010, with 1994 as the year with the actual data. The GHG inventory of the CCEAP[33] needs projections for 2020 and 2030 as well. In this regard, this project (CCEAP) requested MIME for an updated version or Annual Report and if there are projections for 2020 and 2030. The MIME informed CCEAP that there are no updates and the only energy data available is the above-mentioned 1996 study.

The MIME study has the following reports: “Cambodia’s Energy Supplies and Use, 1995”, the “1995 National Energy Balance”, the “Cambodian Energy Demand Scenario, 1995-2010” and the “Cambodian Energy Statistics Sources of Energy Data & Methods of Estimation, 1996”. One

[32] A study was done in the Philippines by the Department of Energy, testing the efficiency of known brands of CFLs like Philips, GE, Osram, etc.

[33] CCEAP - Cambodia Climate Change Enabling Activity Project, funded by the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF).

of the objectives of the MIME study is to provide the technical basis for the Energy Department to annually produce a much briefer descriptive Annual Report on Cambodia's energy situation (Cambodian Energy Statistics Sources of Energy Data & Methods of Estimation, 1996 page 1).

Using the 1996 MIME study would mean that the data on energy demand from 1996 onwards are estimates. In addition to this, in the absence of projections for 2010 and 2030 for energy demand, this study (CCEAP) initially tried to project the energy data using the MIME growth rate. As more reliable data becomes available, it is recommended that these projections be updated.

When the First Draft[34] of the Second Five Year Socioeconomic Development Plan, (2001-2005, SEDPII) became available on 5 March 2001, the growth rates for the population and the GDP were used to project these data. This Plan (SEDPII) is not yet final and will still be subject for comments from all stakeholders. The first discussion was held on 22 March 2001 and the initial comment was that there is a need for further consultation with the concerned government ministries. It is recommended that as the SEDPII is finalized, the final growth rates for the population and the GDP should be updated if there are any changes.

The Danish International Development Assistance (Danida) has a project "National Capacity Development" under the "Environmental, Peace and Stability Facility - Natural Resource and Environment Programme". The project is scheduled to start in November 2001 with a duration of 5 years. The Council for Development of Cambodia (CDC) will be the executing agency. The project aims at establishing capacity for sustainable management of natural resources and industrial development in Cambodia through technical assistance to:

- Strengthen the capacity of line ministries (MoE, MAFF, MIME, MOWRAM and MLMUPC) to collect, validate, interpret and manage quality Natural Resources and Environment (NRE) data;

- Strengthen the capacity of line ministries (MoE, MAFF, MIME, MOWRAM and MLMUPC) to integrate environmental concerns into their policies, planning and operations;
- Raise awareness at all levels on sustainable NRE management, based on State of the Environment and Natural Resources (SOENR) reports to be disseminated twice during the project period; and

- Strengthen aid coordination and environmental screening of projects.

ii. Develop Procedure to Ensure Consistency of Classification of Energy Data with the Economic Data (GDP)

There is a need to coordinate between the MIME, Ministry of Planning and the MEF on the consistency of classification on the industry and the service sector:

- *Data for the Industry Sector* - The MIME classified energy demand data as Large Industry, Small Industry and Electricity Generation, while the GDP of the Industry sector is classified as Mining & Quarrying, Manufacturing, Electricity & Water and Construction. Furthermore, the energy data for the industry sector in the MIME study, is not as detailed as the household and services sector. There are no

[34] The second draft of the SEDPII was released on March 31, 2001.

demand data for lighting and air conditioning which are very important in order to plan any GHG mitigation options.

- *Data for the Service Sector* **-** The energy demand data for the service sector are classified differently from the available economic data. The energy demand data are classified as: Shops, Offices, Banks, Schools, Hospitals, Restaurants, Hotels and Public Lighting; while the GDP is classified as (i) Wholesale & Retail Trade, (ii) Hotels & Restaurants,(iii) Admin, Education and Health, and (iv) Other Services.

iii. Wind Energy Map

The potential of wind energy in Cambodia has not yet been assessed (RETs Asia, 1999). The wind energy map is essential to determine which part of the country has the potential for wind energy[35].

iv. Capacity Building

One objective of the SEDPII is to ensure the sustainable management and use of natural resources and the environment. Natural resources underpin the quality of life and the potential for further economic development in Cambodia. The strategies for achieving the objective include:

- Prevention of environmental and resource degradation caused by policy distortions and market failures;

- Establishing and implementing the legal frameworks for natural resource management; and

- Enhancing the human resources capacity for natural resource management.

v. Training

National Technical Committee (NTC) - There is a need to train the staff of the NTC on energy data processing. It is very important that the staff involved in conducting energy-environment studies understand the basic concepts of energy, economics and environment. Training includes:

- Short-term (4 months) training courses on energy and environment are being offered by the Asian Institute of Technology (AIT) in Thailand, to which government staff may be given scholarships. A course on Energy Economics and Planning, Energy Technology and Environmental Technology and Management is being offered.

- Three-day training on LEAP 2000 by Dr. Charles Heaps, the designer of the program. Initial communications have been exchanged between Dr. Heaps and the CCEAP on the possibility of conducting a training in Cambodia. Training costs have been discussed. Funding is needed for this training.

[35] The Philippines has a Wind Energy Map, done by the U.S. NREL and funded by USAID.

vi. Energy Audit

(a) Training for MIME Staff to Conduct Energy Audit

Techniques like energy audits are available to quantify the energy losses at power plants, industries and other establishments that consume electricity. Methods are also available to perform cost-benefit analyses of options to reduce the losses. Many actions may be possible to reduce energy losses, and thereby carbon emissions, at very low, and in some cases, negative costs.

Presently, MIME has done energy audits in some industries.

(b) Energy Audit in EDC

EDC, as a power utility, is both an electricity generator and an end-user. In addition, they are part of an energy cycle that must be looked at as a whole to optimize system efficiencies. Utilities may undertake a variety of programs that result in improved end-use efficiency, improved air quality and/or minimized waste. These programs will likely also help to minimize GHG emissions.

Electric generating plants are just one part of the electric power fuel cycle and only one part of the GHG emissions equation. Energy is consumed and GHGs are emitted in: (1) the production and transport of fuels and other raw materials used by electric generators, (2) the handling of fuels and other raw materials fed to boilers, (3) other processes at or associated with generating plants, (4) the production, disposal and utilization of waste materials, and (5) the transmission, distribution and utilization of the electricity generated. Under a climate-constrained environment, any action, even the installation of pollution control equipment, must be assessed to determine how it will affect GHG emissions. Energy audits, performed by evaluating how energy is used throughout utility facilities and associated operations, are often the first step in identifying and qualifying the GHG emissions produced.

(c) Procurement of Equipment for Use in Energy Audit

Procurement of equipment for use in energy audit including a bus that can carry both the equipment and the engineers (MIME staff) who will conduct the energy audit in the industries.

vii. Inter-Agency Cooperation

There is insufficient awareness on available data and insufficient sharing of information among government agencies.

Developing a reliable database will involve cooperation with various government agencies as well as private agencies. There is a need to form a group composed of representatives from cooperating agencies and to formulate a Memorandum of Agreement, stating among others, that they will provide each other with information on any recent studies. This will enable each government agency to be aware of ongoing and recent studies and to avoid duplication of studies. This will also cut down the time spent on looking for data and requesting for one. DANIDA is currently implementing a project "National Capacity Development" to strengthen interagency cooperation.

viii. Fund for the Salary Supplement of National Experts

The SEDPII aims on improving the efficiency and effectiveness of the public sector through civil service reform. The establishment of "priority groups" of civil servants will be one of the Government's priority actions during the first year of the SEDPII period. Improving the efficiency and effectiveness of the public sector through civil service reform is one of the areas of governance reform in the preliminary Governance Action Plan.

The low salary scale is perhaps the most fundamental structural problem in Cambodia's public sector[36]. The problem of low salaries has a devastating impact on the functioning of the public sector, and spillover effects on other domains such as civil society and media. Likewise, it has serious implications for ongoing public sector reforms since inadequate public salaries affect all sectors. If the low salary scale issue is not addressed properly in the overall reform process, there is a high risk that this will remain a major obstacle to all governance reforms.

The US$24 average monthly wage for civil servants in 1998, which is far below the subsistence level, creates negative incentives for public officials - either to work outside government ministries, to work exclusively in aid-funded projects in return for salary supplements, or to abuse their authority to generate unofficial income. Under such circumstances, the quality of public services remains poor, and the public sector remains unaccountable.

A fund that will pay for the salary supplement of national experts needs to be established[37]. The fund will be an amount that will be able to pay the salary supplement of the national experts on a sustainable basis, that is, will be sourced only from the interest earned from the fund. The capital should not be withdrawn to provide for the sustainable source of salary supplement for the experts. This concept needs further study in the areas of: (i) identification of the source of fund and (ii) the amount needed to make it into a revolving fund.

This fund will be an incentive and a way to encourage the experts to stay in their jobs. The cost of not paying the experts this incentive is greater, since if they resign for a better paying job, the Government has to hire new staff and pay for his/her training. While the training is going on, the quality of work suffers due to the lack of technical expertise of the new staff.

V.2.3. Transport

The transport sector has the highest contribution of GWP, at 789 million kilogramme CO_2-equivalent and contributes 42.6% of the total GWP of the country's demand sector in 1994. Its sub-sector, the road transport, emits 716.8 million kilogramme CO_2-equivalent, i.e. 91% of the total transport GWP or 40 % of the total GWP in the energy sector.

Physical infrastructure serving the poor is inadequately developed and maintained. The secondary road network is so rundown that many rural areas are virtually isolated and many tertiary roads are impassable during the wet season. Illegal road taxation compounds the problem of poor, high-cost transportation.

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[36] Asian Development Bank (December 2000), Cambodia: Enhancing Governance for Sustainable Development.

[37] It is recommended that the National Technical Committee (NTC) of this project be included in the Priority Ministries that was identified to receive assistance for strengthening public financial management, under the Administration Reform Program, with assistance from the UNDP, World Bank and the European Commission.

The Government's overall development goal for the transport sector is to establish an efficient transport network that maximizes the contribution of transport services to economic growth and regional cooperation.

i. Road Transport

(a) Energy-Efficient Mass Transit System

Since the road transport sector contributes a substantial amount to the country's GWP, improvement in this sector is considered top priority in terms of the GWP reduction.

(b) Infrastructure for Road Traffic Management

Segregated bus lanes, traffic management systems, side walks, pavements or footpaths, bicycle paths, can result in smooth flow of traffic, thus increasing the average speeds necessary for more fuel efficient operation and making bus services more attractive to potential patrons. Pedestrian lanes or crossings should be provided at strategic places. Most pedestrians are forced to cross anywhere in the absence of pedestrian lanes. The traffic policemen rarely stop the traffic to allow pedestrians to cross. This chaotic system results in the disruption of smooth traffic flow and also causes accidents. Smooth flow of traffic results in less fuel use for vehicles, and also less use for car air conditioners, which uses fuel and emits chloroflourocarbons (CFCs)[38].

(c) Penalty for Traffic Violators and Strict Implementation by Traffic Enforcers

Making all users pay the full cost of accidental injury and death, environmental effects (ban smoke belching vehicles) and other impacts could also encourage more concern for road safety.

(d) Road Improvement in Urban Areas

Most of the road improvements under the government plan scenario are in the provinces. There is also a need to improve the roads in urban areas where there is substantial vehicular traffic as driving on bad roads results in more use of fuel.

The Department of Public Works and Transport (DPWT)[39] estimates that it will take a decade for Phnom Penh's streets to be paved under current conditions but with sufficient funds, it could be done in five years. Although road repairs may seem random to the travelling public, the city is following a five-year plan that includes repaving, improvements to the water supply and repairs to the dike systems encircling the city. Some of the work planned are:

- Repair to the outer dike, designed by Japanese engineers. The DPWT is organizing repairs to the inner dike, main thoroughfares and cross streets.

- In the next three years, the city plans to spend about $9 million on road and dike repairs.

[38] Another impact on the global climate derives from the refrigerants used in vehicle air conditioners. The chloroflourocarbons (CFCs) persist in the atmosphere a long time and deplete the stratospheric ozone layer, leading to increased ultraviolet radiation on the earth's surface (Dutt 1992, p.34).

[39] The Cambodia Daily, June 4, 2001.

- The biggest project, slated for 2002, involves repairs to the inner dike that loops from the Cambodian-Japanese Friendship Bridge to the Monivong Bridge.

- This year, 2001, the city will spend $770,000 to pave two main streets with asphalt and concrete. Five more streets are slated to get macadam paving, bringing the total expenditure to nearly $1 million.

- The total to be spent in 2002- in addition to the dike project is about $935,000.

- The city plans to spend $1.2 million in 2003, using asphalt-concrete on some major streets.

- The city's plans have been augmented by donor projects. The Japanese government, as part of its efforts to improve Phnom Penh traffic, has already paid for resurfacing some streets. JICA in close cooperation with the Municipality of Phnom Penh conducted "**The Study on the Transport Master Plan of the Phnom Penh Metropolitan Area"**. The Master Plan is engineered to encompass the following plans to be integrated in such a way that they can complement and support each other: new and improved roads, bridges and traffic signals, an extensive bus system, well-trained policemen and a driving license system. All these projects make up the $375.8 million 14-year transportation master plan presented to the municipal government on September 28, 2001 by JICA. The amount of $57.4 million is for public legislation which includes bus fleet ($52.2 million), bus terminal ($2.5 million), and the rest for bus stop, bus shelter, and bus depot.

(e) Institutional Framework in the Transport Sector

The Government acknowledges the need to develop the legal and regulatory framework for a multi-sectoral transportation administration, so that a comprehensive transport policy and plan may be formulated that establishes priorities for the use of limited funds.

(f) Driver Training and Education on Proper Driving Habits

In the short term, there should be information dissemination on proper driving habits. In the long term, drivers should undergo training and testing on proper driving. This training and test should be a requirement before driving licenses can be issued.

(g) Energy Efficient and Pollution Control Technology

There should be information dissemination on the following technologies:

- **3-way catalytic converter for vehicles -** the converter consists of a reaction chamber containing a catalyst added to the exhaust system of gasoline-powered vehicles which reduces NOx to nitrogen. Abatement efficiency is 90 percent.

- Measures to improve the fuel efficiency of cars also reduce the emissions by reducing the amount of fuel burned to provide traction.

- Commercially available technologies, many of which are widely used in the industrialized countries, could significantly improve transport energy efficiencies in the developing

countries. In freight transport, the existing developing-country truck fleet is generally older, smaller and less technologically sophisticated than the truck fleet of industrial countries. A wide range of retrofits such as rebuilt motors incorporating improved diesel fuel injection systems, cab mounted front air deflectors to reduce wind resistance, turbochargers, and radial tires are available. The rapid diffusion of these and other technologies could yield substantial energy savings.

- In passenger transport, automobiles and other modes could benefit from the use of commercially available technologies such as electronic control of spark timing, radial tires, improved aerodynamics, and fuel injection.

- The energy efficiency of the rapidly growing fleet of two and three wheelers could also be increased, notably through the use of improved carburetors, electronic ignition, and four-stroke rather than two-stroke engines (OTA 1992 P.145, 148).

One of the barriers to using energy efficient technologies is their costs . Most of these technologies have high capital costs due to them being imported. Another barrier is the existing poor infrastructure in Cambodia. The benefits of aerodynamic improvements and turbocharging accrue only at higher speeds, which are often not possible on most of the rough roads in Cambodia.

(h) Planting More Trees Along the Roads and Preserving Existing Trees

Trees can absorb the CO_2 emitted from the burning of fuels in vehicles. The lush vegetation along the streets in Singapore can be adopted, where the jungle and the ancient trees are preserved even if good roads are built through it. The overpass structures are planted with bougainvillea, and creepers are planted to grow on the concrete structures, creating a green surrounding amidst the modern infrastructure. Ancient trees are declared as National Heritage Trees and can not be cut down.

Phnom Penh has a lot of ancient trees that need to be preserved. More trees need to be planted, as it is the growing trees that can absorb the CO_2. This project not only reduces GHG emissions but also contributes to the aesthetic value of the country. Students and the whole population can be invited to join in the Tree Planting Activity (similar to the Arbor Day activity), either on a voluntary basis or as a requirement. This activity should be done in coordination with the Forestry sector action plan and with the relevant local government agencies.

ii. Rail Transport

The rail system is in need of major rehabilitation. The projects of the ADB, France and JICA will improve the railroad tracks and acquire energy efficient locomotives. With these projects, there is a need to maintain these structures and vehicles.

iii. Water Transport

There is a need to dredge canals and upgrade ports at Sihanoukville and Phnom Penh. Under the "Government Plans" scenario, the SEDPII identified studies that would lead to projects that will upgrade the port facilities.

iv. Air Transport

The Government has already identified several projects that will upgrade existing airports and build new ones. The details are in item B, Government Plans.

The goals for Civil Aviation under SEDPII includes, among others, to privatize air navigation services, to develop human resources to cater to the specialized economic, technical, and operational requirements of civil aviation; to transform SSCA from a single centrally-controlled Government agency into separate autonomous civil aviation entities; and to develop information technology.

V.2.4. Household Sector

The household sector remains dominant in Cambodia, where 85% of Cambodians have a subsistence form of living and modern forms of economic activity remain relatively undeveloped.

i. Formulate and Implement Standards for Appliances and Equipment

Efficiency standards to be formulated and later on to be imposed on importers or local manufacturers for appliances and equipment.

V.2.5. Service Sector

i. Solar Water Heaters for Hotels

Solar water heaters can be very cost effective and perform well in many areas. There are many technical approaches to water heating that greatly reduce fuel consumption and, from the societal perspective, can reduce capital costs and life cycle operating costs. The most simple, and perhaps the most readily applicable in developing countries, is the use of solar water heaters. Solar water heaters are the most inexpensive of the many ways to use solar energy.

A local supplier of solar water heater in Phnom Penh sells for US$800 a 200-liter capacity (heats up to almost 100^{o}C). For hotels, which need around 1000 liters, the supplier gives a 5 x 200-liter units.

V.2.6. Industrial Sector

The outlook is for a sustained expansion of the industry sector, which is projected to grow at 7 percent per annum in the SEDPII period. Textile and garment production is expected to continue to play a key role, growing at 6.5 percent per annum.

Some of the policies from the SEDPII, on Manufacturing and Mining, that can help in the GHG emissions reductions are:

i) The recognition of labor-intensive manufacturing development;

ii) Private companies offering investment packages that include technology and entrepreneurial and management skills must be attracted;

iii) The promotion of labor-intensive manufacturing will continue to focus on the textile and garment sub-sectors. Retaining and increasing market share requires the upgrading of

product quality, as well as greater productivity through improvements in technology and management. The development of better industrial relations within the established legal framework is needed; and ways of increasing the multiplier effect of garment manufacturing need to be investigated;

iv) The creation of industrial zones is aimed at facilitating export development and creating employment by providing the high-quality infrastructure and utilities needed to encourage investment.

The potential for minerals development is not fully understood, so that the first task of the SEDPII period is to undertake a re-evaluation of mineral deposits. A second major task is to draft, proclaim and implement effective mining laws and regulations that simultaneously protect private investors and the environment.

The level of investment programmed for the trade and industry sector in 2001-2003 is $22.0 million, which represents 1.3 percent of the total allocation. Programmed activities center on improving the provision of trade promotion and facilitation services, and making a better assessment of the development potential of mineral resources.

The Government recognizes that the process of privatization has been slow and needs to be revitalized during the SEDPII period. The Foreign Trade Bank is undergoing a process of restructuring and corporatization with a view to possible privatization by the end of 2001. In addition, eleven utilities and state-owned infrastructure enterprises remaining in the public sector will be corporatized.

The industry in Cambodia is grouped as follows:

- The industries classified as **large industry** are garment factories, wood processing factories, paper factories, tobacco factory, galvanizing factory, dairy/soft-drink factory, shoes production and others;

- The industries classified as **medium industry** are hotels, hospitals, battery and other recycling, major diesel powered generators, major fuel storage (agricultural chemical storage), quarries, plastic manufacture, construction materials manufacturers, agricultural machinery manufacturers, manufacturers of cooling equipment, printing/textile manufacturers and others; and

- The industries classified as **small/cottage industry** are car repair workshop, electronic repair workshop, bakery, handicraft, fish-sauce factory and others.

The industry sector needs more comprehensive data in order to plan any mitigation options. Based on currently available data, the following mitigation options are recommended:

i. Information Dissemination on Energy Efficient Measures in Industries

The following training courses and seminars are of high priorities that need to be conducted:

- Training course on the greening of the hotel industry through efficient resource management;

- Training course on efficient energy management in industries;
- Seminar on minimizing energy cost through energy efficiency and environmentally friendly measures in hotels;
- Seminar on energy conservation in buildings;
- Training on energy conservation techniques in industry;
- Workshop on the establishment of energy conservation centers in Cambodia; and
- Promotion of energy efficiency and pollution control through cogeneration.

ii. Voluntary Agreements and Incentives to Reduce Industrial Energy Use[40]

Voluntary agreements should be established between the government (MIME) and individual companies to stimulate energy efficiency improvements by industries. Companies or sectors would pledge to reduce their overall energy and carbon emissions intensities (energy and carbon per unit of output) by a significant amount, say at least 10-20% over 10 years. The government would encourage participation and support implementation by providing technical and financial assistance to participating companies, offering to postpone consideration of more drastic regulatory or tax measures if a large portion of industries participate, and by expanding government demonstration programs. Voluntary agreements of this type have resulted in substantial energy and carbon emission reductions in some European nations such as Germany, the Netherlands and Denmark. The Philippines also has a similar program and gives awards to industries with remarkable energy savings.

iii. Industrial Motor Drive

Industrial energy use is driven largely by the requirements for process heat (although electricity for motors is also substantial).

There is a need to compile an inventory of industrial energy efficiency technologies specifically on industrial motor drives. A spreadsheet based (EXCEL) analytical tool for assessment of the technical and economic potential for industrial GHG reductions should also be developed for each selected industry.

iv. Rice Husk as Fuel for Cogeneration

Rice is one of the major crops of Cambodia. Rice husk is the waste product in rice milling. The technology of using rice husk as fuel for cogeneration is in an advanced stage and is successfully used in Thailand[41]. The use of this technology will also solve the problem of the disposal of rice husk as a waste. This is ideal for rice mills, which are situated in places where there may be no electricity supply. Cogeneration will produce both heat and energy, which are both needed in the process of rice milling.

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[40] Patterned after the U.S.'s "Meeting America's Kyoto Protocol Target: Policies and Impacts" by the Tellus Institute.

[41] COGEN is promoting the use of cogeneration using biomass, and has several successful projects in SE Asia. COGEN is based at the Asian Institute of Technology, Thailand.

The book "Rice Milling Industry" for Cambodia by Rozemuller will provide some basic data on the rice milling industry of Cambodia. Coordination with the rice milling activities of CIAP/CARDI and AQIP (AUSAID) also need to be established. Due to time constraints, this coordination activities need to be done in future activities.

Cogeneration using rice husk as fuel in the new Angkor Prosperous Agriculture (APA) Company Rice Mill. Cogeneration using rice husk can be recommended to the APA rice mill. Based on the capacity of 10 tonnes per hour, the electricity potential is 2.5 MW. This recommendation needs further study, as rice husk is also used by brick factories as fuel for their kilns. Due to the logging ban, some brick plant operators have already begun to rebuild their kilns to switch to rice husk as fuel[42] (Rozemuller, page 34).

The APA rice mill is a new state-of-the-art rice mill that aims to bring Cambodia's rice export capacity into the 21st century by specializing in the production of chemical-free, organic rice[43]. Located in Ang Snuol District 15 kilometers west of Phnom Penh, the new APA rice mill will be able to process 10 tonnes of rice an hour and is aiming to export at least 45,000 tonnes of organic rice to the world market by the end of 2002.

Cambodia's rice production capabilities are poor compared to other countries but the government plans to compete with them by exporting chemical-free rice. The company has plans for the sowing of more than 40,000 hectares of agricultural land with ***neang malis*** rice seed in Kampong Speu, Kampot, Takeo and Kandal. APA provides free rice seed at a minimum price of 500 Riels per kilo, considerable higher than the 250-300 Riels per kilo that they get now. The company hopes that this project help revive Cambodia's rice export industry, which by the late 1960 was supplying more than two million tons of rice to foreign markets annually.

v. Energy Efficiency in the Brick and Tile Manufacturing Industry

The brick and tile manufacturing industry consumes wood and rice husk as fuel for their kilns. There are 446 brick factories in Cambodia[44] (MIME, page 43). The energy need of a small kiln is 60 cubic meter of firewood and the large kiln is 80 cubic meter of firewood per cycle.

A brick kiln factory also uses a diesel engine of 7 HP with a diesel consumption of 1.5 liter/hour (12 liters/day). Producing bricks and roof tiles is time a consuming process. Brick production cycle takes about 49 to 70 days with approximately 21-28 workers working full-time. The whole process is labor intensive.

It is recommended that further study should be done in the brick and tile manufacturing industry. There is a need to look at the MIME study "Brick Factories in Cambodia", 1997.

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42 H.B. Rozemuller, "An Overview of the Brick and Tile Manufacturing Industry in North West Cambodia".

43 Source: Phnom Penh Post, April 27-may 10, 2001.

44 Ministry of Industry, Mines and Energy "Brick Factories in Cambodia".

VI. CONCLUSION AND RECOMMENDATIONS

The GHG mitigation options recommended will generate at least 24% reduction of the GHG emissions in the reference scenario. If there is sufficient data, the study will be able to calculate the reduction in GHG emissions of the other recommended projects, which will greatly reduce GHG emissions. Most of the mitigation options evaluated are “win-win” options, exhibiting results of GHG reduction and at the same time generating financial and energy consumption savings.

It is recommended that in order to produce a comprehensive analysis of the GHG mitigation option, the following concerns should be addressed: (i) a reliable and detailed database on energy should be established and updated regularly by the MIME and (ii) full support of other government agencies, in terms of sharing their data, is vitally needed. Data collection should also be done, in order to evaluate the projects under the "Government Plans Scenario", which presently lack data but will greatly reduce GHG emissions.

The baseline or reference scenario is based on the prevailing low economic activity in the energy sub-sectors (household, transport, industry and service) of Cambodia. A proposed mitigation option would appear as a contributor to the GHG emissions, since it is compared to a baseline scenario where there was no activity of the particular option. For example, if an efficient power plant like a CCGT is built in a place where there was no electricity, it will appear that there is no GWP reduction but rather an increase in GWP emissions. This case should be carefully evaluated, bearing in mind that the comparison should be the option of building a diesel-fueled power plant instead of a CCGT.

The LEAP 2000 program is user-friendly, and can be updated as soon as reliable data is available. It is recommended that this program will be continuously updated, as there is a big potential of determining substantial GWP reduction and to solve for the CSE, given enough time to collect data and input to the program. In this study, only 6 mitigation options were evaluated and it calculated a GWP reduction of 59,640 Gg of CO_2 equivalent (24% reduction). The two (2) NTC experts who worked in this study are capable of updating the LEAP 2000 program. It is further recommended that these experts be given further training in energy data analysis and that more members of the NTC be trained in using the LEAP 2000 program.