

# Cambodia Energy Sector Strategy

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## INTRODUCTION

Cambodia's infrastructure, including the power sector, was severely damaged by years of war. After restoration of order in the country the Government has followed a program focused on rehabilitation and development of the basic infrastructure, with the aim of improving the socio-economic conditions for further step of development.

Cambodia is an agricultural country, where over 85% of the people in Cambodia live in rural areas with agriculture as the main profession of subsistence. Their livelihood depends mainly on agriculture: farming, fishing, livestock, forest and non-forest products. For heating, the majority of energy they use are fuel-wood, charcoal, agricultural residues collected mostly from forest areas close to their villages.

Cambodia has indication of deposits of energy natural resources such as fossil fuels, natural gas and coal, and over 84% of the primary energy consumption is contributed by fuel wood. Less than 9% of rural households have access to a grid-quality electricity services. Those who depend mainly on rechargeable batteries and small diesel-fueled isolated generation have paid with very high unit prices for electricity.

Rural electrification in Cambodia is increasing at a surprising rate in many districts and provinces serviced by Government coordinated electrification program. The basis for this progress is a ready market for the sale of electricity by the local entrepreneurs. But the state electricity companies alone can not meet the increasing electricity demand especially for the rural population almost poor in the near future. This situation encourages the provision of rural electricity by other appropriate solutions.

## PART A: COUNTRY PROFILE

### A-1 Geography

The Kingdom of Cambodia is located in the tropical region of Southeast Asia in the Lower Mekong region, with 800 Km border with Thailand in the west, 450 Km with Lao PDR in the north, 1,250 Km with Viet Nam in the east and a coastline of 440 Km long. The physical landscape is dominated by the lowland plains around the Mekong River and the Tonle Sap Lake. Of the country area 181,035 Km<sup>2</sup>, approximately 49% remains covered by forest. There are about 2.5 million hectares of arable land and over 0.5 million hectares of pasture land.

The climate in Cambodia is tropical and subject to both southeast and northwest monsoons. The southeast monsoon, which coincides with the rainy season, extends from May to October. The northwest monsoon brings a cool but drier period from November to April. The average annual rainfall is about 1500 mm, with the heaviest rainfalls of up to 4000 mm per year occurring in the southwest coastal line. The temperatures are fairly uniform in the central basin area with an average of about 27°C. The maximum temperatures in the region vary from 35°C to 38°C which are common before the start of the rainy season, but the temperatures very rarely fall below 10°C.

## A-2 Population and Administration

In 1998, the Ministry of Planning has completed a general population census of Cambodia, with assistance from the UN Population Fund (UNFPA). As the result, Cambodia has a population of 11.4 million with an annual growth rate of 2.5; about 85% of the people live in rural areas.

Administratively, Cambodia is divided into 24 provinces, including 4 municipalities, 183 districts, 1621 communes and 13,406 villages.

The Poverty Profile of Cambodia, based on 1999 data, shows that 36 percent of population is poor, four out of ten Cambodians are living below the poverty line, and the poverty rate is higher in rural areas (40%), which is four times higher than poverty in Phnom Penh (10%). Rural households, especially those for whom agriculture is the primary source of income, account for almost 90% of the poor.

The Royal Government of Cambodia (RGC), which has been created on the principles of free democracy and multi-party has made more efforts with high responsibility in the socio-economic development and the increase of wealth and well-being of the population, and has implemented the policies to accelerate pro-poor economic growth in conjunction with social programs that are keys to alleviate suffering of millions of Cambodians still living below the poverty line. The RGC has expressed its political will and good intentions to reform some crucial areas and to strengthen governance.

The RGC has achieved encouraging results in the implementation of the “Triangle Strategy”: the first side is the maintenance of peace, stability and security for the nation and people. The second side is Cambodia’s integration into the international community and normalization with the international financial institutions. And the third side is Cambodia’s development through the implementation of the reforms in important areas. The RGC has succeeded to strengthen the peace that the Cambodian people hoped for political and macro-economic stability in support of sustainable development. This achievement came from the Win-Win Policy in a spirit of love, peace and reconciliation.

The RGC is focusing on reforming the State and Good Governance, including the implementation of decentralization policy and election of commune councils, human resource development, demobilization program; the creation of new job, adequate remuneration and other program to accelerate economic growth, rural, energy and water development; and irrigation system development. Thus, we can come to the conclusion that Cambodia is creating a diamond opportunity for further development, with great hope for the bright and prosperous future.

The devolution of power carried out through decentralization and deconcentration will shift the focus of development towards the people with the view to implementing structural adjustment, strengthening grassroots governance, reducing inequality, and promoting gender equity at all levels, and especially to devolve power to newly created semi-autonomous elected governments at the commune level and move toward enhanced roles for provinces and municipalities as deconcentrated entities of the center.

In 2003, the RGC has adopted a comprehensive reform agenda, called “Rectangular Strategy” with good governance at its backbone. The strategy is based on four pillars: (i) creating high economic growth and enhancing Cambodia’s competitiveness; (ii) creating employment; (iii) improving social equity; (iv) increasing the effectiveness of the public sector. And the Enabling environment for successful implementation of this strategy includes: (i) peace, political stability and social order; (ii) partnership with development partners; (iii) macroeconomic and financial stability; (iv) Cambodia’s integration into the regional and economy. Cambodia has acceded to the World Trade Organization (WTO) in September 2003. The rectangular strategy

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identifies the following areas as the priority sectors: (i) strengthening agriculture as a viable sector; (ii) promoting private sector development and employment; (iii) building physical infrastructure; and (iv) stimulating human resource development.

### A-3 Economic Situation

The GDP recorded a growth of 4.5% in the year 2000 (lower than the 5.5% projected, but higher than the 4% in 1999, 1.8% in 1998, and 3.7% in 1997), and in 2001 and 2002, a growth respectively of 6% and 5.5%. Investments are financed predominantly by foreign savings, which accounts for 12% of GDP. More than half of them are made up by grants, with the remaining parts consisting of Foreign Direct Investment and soft loans. Public investment has increased 23% compared to 1999, with national budget and funding from the World Bank, Asian Development Bank (ADB), and assistance from other countries focusing on priority areas including agriculture, rural development, education, health care, and physical infrastructure.

The main ingredient of growth is investment, both private and public. The total investment jumped by 1% of GDP to 21% in 2000, compared to only 10% of GDP in 1990. The RGC considers the private sector, both domestic and foreign, as the major sources of investment, and thus an engine for growth. Consequently the RGC has doubled efforts to create favourable conditions and a climate of confidence for investors. Boosted by strong export performance, Cambodia is expected to sustain economic momentum in 2001 and 2002. Domestic exports grew by 40% to US\$ 996 million in 2000, of which garment exports totaled US\$ 915 million, 92% of total exports.

The Government's policies are directed towards strengthening macro-economic stability, promoting private sector development, sustainable development of the agriculture sector, advancing rural development, ensuring a sound natural resources management, and also encouraging income generation activities, embarking on land reform and increasing access to micro-finance for the poor. The RGC also gives due emphasis to the development of the industry and service sectors. Implementation of international and regional cooperation, especially the integration within ASEAN with partnership with China, Japan, South Korea and India, and the development of the Greater Mekong Sub-region.

Rapid development and participation of the private sector play an increasingly important role in development of power sector, job creation, thus, liberating people from the shackles of poverty and improving their living standard. And competition is the best way to avoid concentration of power, oligarchy, monopoly, corruption and other distortions. RGC has formulated a policy for micro-enterprises and small and medium enterprises (SMEs).

**Table - Trend of GDP growth in Cambodia**

Year	1995	1996	1997	1998	1999	2000
GDP(US\$ million)	3,079	3,115	3,054	2,797	3,054	3,090
GDP/capita (US\$)	304	300	281	247	260	253

Cambodia's economic performance was quite good in 2002 despite the severe drought that significantly reduced agricultural output. Real GDP growth was 5.5 percent, especially by the increase in garments exports to US.; and such during the first half of 2003 has been affected by the political developments such as national election and the SARS outbreak, and unfavourable external environment. the real GDP in 2003 is expected to decline to 4.75 percent. With the return of full peace, security and the restoration of macroeconomic stability, Cambodia has now the opportunity to make reform in all facets of economic and social life. The task will require strong commitment by all stakeholders to work in a coordinated way with the overall

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objectives of moving toward the Cambodia n MDG targets and the National Poverty Reduction Strategy launched in March 2003.

The government has made significant progress in decentralization especially after the election of the commune council to ensure effective decentralized governance. The deconcentration reforms have been implemented to ensure the delegation of the responsibility from line ministries to the provinces and provincial departments.

### **A-4 Energy Situation**

Cambodia's power supply facilities were heavily damaged by war. Cambodia has started its process of rehabilitation under support from the World Bank, ADB, Japan, USA and European Countries. At present, the electricity supply in Cambodia is fragmented into 24 isolated power systems centred in provincial towns and cities. All are fully reliant on diesel power stations. Per capita consumption is only about 48 kWh / year and less than 15% of households have access to electricity (urban 53.6%, rural 8.6%) and the amount of electricity consumption is as follows: Private sector 0.5%, Service sector 40%, Industrial sector 14%. The supply requirements are projected to increase in average by 12.1% per year, and the peak load is expected to reach up to 1,000 MW in 2020.

The largest system is Phnom Penh, which has a population of 11.4 million and more than 12,000 electricity customers. It accounts for 70 per cent of the country's electricity consumption, with a peak demand of 80 MW, and an available capacity of 129.2 MW (EDC 74.5 MW, IPPs 54.7 MW), the peak demand will increase to 170 MW in 2004 and in 2020 to 649 MW. As of 2000, the total energy generation was 415.14 GWh, including CUPL 208.28 and Jupiter 13.25.

The total installed capacity for provincial towns is estimated about 50 MW with the size ranging from 300kW to 5 MW, and the peak demand is expected to increase to 173 MW in 2010 and to 342 MW in 2020.

Due to the small size of generation dependent on high cost imported oil, the lack of a high voltage transmission system and the big losses in distribution, the electricity price is the highest in the region. According to data from 2000, the average tariff is about 14.6 US Cents / kWh in Phnom Penh, and 25 to 50 US cents / kWh in remote areas. Currently there are 7 MV cross-border connections with Thailand, by local private sector investors: Koh Kong provincial town: 2 MW; O-Smach of Oddor Meanchey: 2 MW; Kamrieng of Battambang: 1 MW; Phnom Proeuk of Battambang: 2 MW ; Sampeov Loun of Battambang: 1 MW; Poipet of Banteay Meanchey: 5.6 MW; Pailin: 2.5 MW, and in addition 4 MV connections with Viet Nam by EDC: Bavet of Svay Rieng: 0.6 MW; Memut of Kampong Cham: 1.9 MW; Ponhea Krek of Kampong Cham: 0.9 MW; Kampong Trach of Kampot: 1 MW .

### **A-5 Energy Resources and Production**

Cambodia has substantial hydropower resources and indications of oil, gas and coal deposits; there is an urgent needs to assess the extent of these energy resources. Other renewable energy sources are available and their use is being started, such as biomass, solar and mini-hydro. The problem is to diversify the sources of supply, and intensify the exploration for natural gas and the development of renewable energy resources.

#### **a- Oil and Gas**

All commercial fuels in Cambodia are imported in the form of LPG, gasoline, diesel and other petroleum products: in average 180,000 tons/year from 1985 to 1990, 250,000 in 1992-93, 535,000 in 1994-97 and 900,000 tons in 1998-2000. After the Peace Agreement in October 1991,

Cambodia determined to restart large-scale development, but the wells with commercial scale have not been found. In June 2001, Woodside planned to make explorations in new areas and expected recoverable gas reserves of 2.7 TCF which can serve the plan in more than 55 years. At present Thailand seems to be the most likely gas supplier to Cambodia, but the demand of natural gas is rather small. And the length of pipeline is so long, it needs a higher construction cost, and for economic viability a minimum electric generation would be around 300 MW. The developers of natural gas in Viet Nam have a plan to supply natural gas to a power station in the Mekong delta. They are seeking to supply to Cambodia as one of the feasible options. The price of natural gas would be around US\$ 3.5-4.5/MMBTU.

Cambodia should be connected to Trans-ASEAN Gas Pipeline for security of supply of natural gas, improving energy supply to industry and for capital investment and mitigate greenhouse gas.

**b- Hydropower Potential and Development:**

The hydropower potential of Cambodia was estimated in 1995 with the theoretical potential of about 10,000 MW exclude small streams and could therefore play a significant role in the long-term energy development. It needs technical and financial support for data collection and feasibility studies. Some part of the country micro/mini hydropower may provide opportunities for electrification to decrease the use of fuel-wood.

At present only two mini-hydropower plant are in operation: O Chum II mini-hydropower plant with the installed capacity of 1000 kW has been constructed and operated since 1993 . Kirirom I hydropower plant with 12 MW, was rehabilitated and operated by CETIC, a Chinese company, under Build Own Transfer (BOT) agreement for 30 years since mid 2002, together with the 120 km 115 kV transmission line to Phnom Penh.

There are also private owned micro hydropower plants with the installed capacity ranged from 1 kW to 50 kW in the northern provinces and the units are imported from Vietnam or China.

In respect to the Initiative on ASEAN Integration and the GMS focusing on base infrastructure development to enable the economic growth, primarily the power sector development and the hydro-electricity projects connecting to the ASEAN power grid should have the priority in this program.

**Hydropower generation candidates Cambodia:**

<b>Projects</b>	<b>MW</b>	<b>GWh</b>
Battambang I	24	36
Battambang II	36	187
Battambang III	13	77
Kamchay	180	558
Middle St.RC	125	668
St. Atay	110	588
Lower Sesan 2	207	1065
Lower Srepok 2	222	1176
St. Chay Areng	260	13
Kirirom III	13	70

**c- Renewable Energy Resource Development**

Renewable energy technologies (RETs) will be the most appropriate way in meeting the energy demand in rural and remote areas of developing countries, especially in off-grid areas. About 85% of the total population lives in the rural areas, the government of Cambodia is

placing great emphasis on the rural electrification, on-grid where possible, and off-grid by renewable energy, to raise the living standards of the rural population.

#### **d- Solar Energy**

Measurement during 1981-88, at Phnom Penh, showed an average sunshine duration of 6-9 hours per day with high average of 5 kWh/m<sup>2</sup>/day indicating considerable potential of solar energy.

The application of Photovoltaic system with total installed capacity of around 130 kW is a recent development in Cambodia, as donated by international organizations such as UNICEF, Red Cross, SIDA and FONDEM who installed demonstration systems on health and rehabilitation centres. Solar Home Systems (SHS) with an output of 12V, 50-70 Ah are being used for low income households in rural areas and require a US\$ 40 investment per household. The cost of energy generated is approximately 24.4 US cents/KWh.

The solar drying technology under controlled temperature and humidity make the crop drying reasonable with higher quality compared with the natural sun drying. The performance of these dryers was evaluated by the tests on banana, jackfruit, chilli, corn, other fruits and vegetables, fish and meat.

#### **e- Biomass and Biogas**

As in most ASEAN countries, biomass energy plays a major role in satisfying the rural demands in Cambodia. Besides fuel wood, an estimated 167Kto e of agro-industrial residues, such as rice, sugarcane, maize and cattle excreta, were also available as fuel. Biomass is also used in the industrial sector for copra drying and system generation, and the rice husks in bakeries, brickworks and other commercial establishments. However, no reliable estimates of the amount of biomass energy consumption are available; a study needs to be conducted for this purpose.

The proven, clean and efficient Cogeneration or Combined Heat and Power, the most economic measures for electricity generation that entails a fuel saving up to 50% compared with the facilities producing separately heat and power; the less environmental pollution, so it is very important in the context of global warming and the climate change to ensure the supply of heat and electricity to the industry, commercial and residential needs. The cogeneration and distribution of energy require less investment compared to traditional supply. But the government should have clear policies framework and objectives for the promotion through favourable electricity tariffs, tax advantages, initial grants / subsidies, towards predetermined national targets. The biomass coal and natural gas are applied most common for cogeneration fuels. Cambodia has joined the EC ASEAN Program 9 in August 2002 and now has one Full Scale Demonstration Project of 1.5 MW cogeneration plant using rice husk as primary fuel.

#### **f- Wind energy**

The potential of wind energy in Cambodia has not yet been assessed. We have obtained some data of the annual average wind velocity (m/s): Sihanoukville 5.06, Pursat 1.89, Inland 2.01, costal 2.65, and an annual average of 3m/s. There is a hope for few areas with 5m/s wind velocity: the southern of the great lake Tonle Sap, the southwest mountain areas and the southern coastal areas, especially Sihanoukville with wind velocity of 5m/s or greater, thus the introduction of wind power generation system in these areas is promising. The maximum system generated energy was 150.4 kWh in February, and the minimum was 60.5 kWh in September

Due to the inconsistency of wind patterns, a hybrid generation system with a base operating system of diesel or micro-hydro is ideal.

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Mechanical wind pumps are probably the best choice for using wind energy when the annual average wind speed is less than 4 m/s.

It is possible that small wind power systems or individual household wind power systems may be applicable in some areas, particularly along the south-west coast close to the Cardamoms mountains or in the high land along the Vietnam border.

Wind energy is relatively new to Cambodia. Wind conditions data in a complete set is not available. The studies on specific wind conditions should be carried out to have accurate data for formulating wind power program.

### **g- Traditional Sources**

**Coal:** During the period 1958-61, a mineral countrywide survey mission from China reported indication of coal in Kampot, Kampong Thom, Kratie, Stung Treng and Battambang provinces. One deposit in Phum Talat in Stung Treng province has been identified and the reserve has been estimated around 7 million tons, the exploitation might be feasible for application in cement production and for domestic fuel. The inventory and feasibility study of coal deposits in Cambodia are needed. The promotion of the Clean Coal Technology is an important strategy involving in coal-fired plants and the feasibility studies are needed for such generation at the coal mines, as well as for the coal import.

**Wood Energy:** Fuel-wood, including all sources of energy derived from wood (fuelwood and other woody-biomass) has played a crucial role in meeting the energy needs and is likely to continue to be an important energy resource for many years, no longer confined only to rural households and traditional industrial, commercial activities, but its use is growing also in many urban areas and different industrial, commercial activities. There is a need to develop a better understanding of the environmental impacts and to develop policies on replacing from time to time the use of wood by other renewable energy sources. And also on improving the efficiency of wood energy by using efficient stoves which reduce very significantly the consumption, by 50% compared with the traditional stove and by 30% by using a modified two-pot palm sugar distilling stoves.

Today, wood fuels may be available in solid (i.e. fuel wood, wood-chips, sawdust, pellets, briquettes, or charcoal), liquid (i.e. Black Liquor, Methanol and Pyrolytic Oil), or gasses (producer-gas) forms. With progressive advancement in technology, new wood fuels in the forms of charcoal, briquettes, dendro-thermal power, wood-alcohol and producer-gas are used to generate heat and power, through cogeneration. Recently, both woody and non-woody biomass is being utilized in wood and agro-industries for energy generation, by using modern bio-energy technologies for the production of landfill-gas, biogas, etc

Wood energy development needs to be addressed through inter-ministerial co-operation. This co-operation will examine the current status of the forestry, energy and environmental policies in order to identify the strengths and weaknesses in each in relation to wood energy development.

## **A-6 Power Sector Institutional Framework**

The main institutions involving in the Energy sector in Cambodia are the Ministry of Industry, Mines and Energy (MIME), Ministry of Economic and Finance (MEF), Electricité du Cambodge (EDC), the Electricity Authority of Cambodia (EAC), Provincial Electricity Utilities and private sector. EDC is owned and controlled by MIME and MEF.

**a- Ministry of Industry, Mines and Energy:** MIME has overall responsibility for policy formulation, strategic planning and Technical Standards. However, the oil and gas sector is handled by the Cambodian National Petroleum Authority (CNPA).

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As more specific responsibilities, the Ministry of Industry, Mines and Energy shall be responsible for setting and administrating the government policies, strategies and planning in the power sector.

The Ministry of Industry, Mines and Energy shall ensure the communication on a regular basis with the Authority and shall provide to the Authority the information on policies, strategies, planning of power sector and its decisions on:

- Investments in the rehabilitation and development of power sector in the short, medium and long term;
- Restructuring, private sector participation and privatization of Public Utilities;
- Promotion of the use of indigenous energy resources in the generation of electricity;
- Planning and agreements on the export and import of electricity;
- Subsidies to specific classes of customers and priorities regarding consumers of electricity
- Promotion of efficiency in generation, transmission, distribution and consumption of electricity and action taken to create a Comprehensive Electricity Conservation Program for Cambodia; and
- Electricity sector emergency and energy security strategies.

**b- General Directorate of Energy (MIME):** The main objectives of energy policy (1995) cover the provision of adequate supplies of least cost energy for households, and to all sectors of the Cambodian economy, whilst minimizing environmental effects. To assist national development, energy planners must consider all economic, financial, environmental and social factors.

The Department of Energy Development is the principal government agency for the energy sector planning and consumption and data collection, and has to work closely with other governmental departments.

For the sustainable development of energy, emphasis is given to hydropower and renewable energy sources. Therefore, better coordination with the Department of Forestry and ministry of environment, through a broader energy plan, encompassing the fuel mix of possible energy sources is needed to ensure adequate supplies of fuel-wood throughout the country.

**c- Regulatory Authority (EAC):** The Electricity Authority of Cambodia is the Regulatory Agency that was established according to the Electricity Law, and is becoming operational. The EAC performs the following duties: licensing, tariff setting, solving the disputes between producers/suppliers and consumers, setting up the uniform accounting standards, enforcing the regulation, review of planning and financing performance.

The EAC is responsible for regulating the provision of electric power services within Cambodia, as described in the Electricity Law:

- To issue, revise, suspend, revoke or deny the licenses for the supply of electricity services;
- To approve tariff rates and charges and terms and conditions of electric power services of licensees, except where the Authority consider those rates or charges and terms and conditions are established pursuant to a competitive, market-based process;
- To order to implement guidance procedures and standards for investment programs by licensees;
- To review the financial activities and corporate organization structure of licensees to the extent that these activities and organization directly affect the operation of the power sector and the efficiency of electricity supply;
- To approve and enforce the performance standards for licensees;

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- To evaluate and resolve consumer complaints and contract disputes involving licensees, to the extent that the complaints and disputes relate to the violation of the conditions of license;
- To approve and enforce a uniform system of accounts for all licensees;
- To prepare and publish reports of power sector and relevant information received from licensees for the benefit of the Government and the public interest;
- To prescribe fees applicable to licensees;
- To determine the procedures for informing the public about affairs within its duties, in order to ensure that the Electricity Authority of Cambodia complies with the principle of transparency as set forth in Article 3 of this law;
- To issue rules and regulations and to make appropriate orders, and to issue temporary and permanent injunction for electric power services;
- To impose monetary penalty, disconnect power supply, suspend or revoke the license for the violations of this Law, standards and regulations of the Electricity Authority of Cambodia;
- To require the electric power services and the customers to obey the rules relating to the national energy security, economic, environment and other Government policies;
- To perform any other function incidental or consequential to any of the duties as describes above; and
- To establish the terms and conditions of employment of the officers or employees including expert/advisors of Electricity Authority of Cambodia.

**d- Department of Forestry and Wildlife:** The department of Forestry and Wildlife established since 1979 as technical institution under the jurisdiction of the Ministry of Agriculture Forestry and Fisheries (MAFF) is currently responsible for implementing a government policy, in cooperation with other government departments to ensure the management and protection of the nation's forests, for the sustainable future and stability of forest biodiversity, through:

- Management of fuelwood
- Management of concession areas
- Reforestation in the concession forestry as well in the community forestry.

The strengths of the fuelwood coupe system were best illustrated before 1970, when the department of forestry, in cooperation with enterprises, operated under formal agreements to provide a sustainable supply of wood energy to Phnom Penh.

Today, the Department of forestry experiences great difficulties in regulating the forest areas due to the amount of illegal cutting trees by local communities and the insecurity within the forested areas. Anarchic cutting causes lower prices in the markets and fuelwood coupes cannot compete with the freely exploited wood energy.

The Department of Forestry, responsible for the supply of wood and forest and non-forest areas, prepares concession management plans, Included in the management, plan is a requirement for the stumps and crown of the trees to be removed from the concession areas. Access roads within the concession areas invariably open up previously inaccessible areas of forest to local communities, which in view of the difficulties of upholding regulations in the more insecure areas, is likely to lead to further illegal encroachment.

The RGC recognized the need for significant policy changes in order to facilitate development of sustainable forest management. The objective of the Royal Government of Cambodia is to mobilize the forest resources for socio-economic development ensuring a viable

forest industry, to ensure appropriate government revenue, and to meet the wood and non-wood product needs of communities and protect its ecological system.

In maintaining the system of firewood coupes, the Department of Forestry has recognized the ongoing demand for wood energy. The provincial forestry department submits land areas assigned for firewood coupes to the Department of Forestry on an annual basis. Auctions are then arranged in each province to sell the land to companies for exploitation and forestry officials provide technical advice in coupe management.

**e- Ministry of Environment:** The Kingdom of Cambodia had suffered for a long time war, illegal exploitation of natural resources and environmental catastrophes. The complex issues related to these problems must be addressed by the RGC's society in order to enhance the living standards of the population and to assist the country's development. The Ministry of Environment, an institution established in November 1993, after the National election, has a broad mandate to protect the natural resources of the country and to prevent environmental degradation, responsible for the sustainable management of national parks and protected areas. Although not directly involved in wood energy planning, the ministry must, within this mandate, be consulted about energy and forestry development. The long range goals of the ministry of environment include:

- Management and protection of natural resources to ensure sustainable environmental development.
- Strengthening cooperation with relevant ministries to control and improve environmental quality
- Control and review of the environmental impact assessment (EIA) of all development projects within the country.

### **A-7 Barriers: Review of Issues faced by Cambodia Power Sector**

In order to promote the decentralized, demand-driven approach in electrification and to facilitate private sector involvement, a number of serious barriers to overcome is summed up below:

**a. Lack of policy and legal framework:** The legal environment in Cambodia is not yet strong, with many of the laws still being drafted. There is little or no regulation of the rural electricity sector at present and the tariff fixation by private REEs is arbitrary and exorbitant, placing the consumers at a disadvantage.

The legal and policy framework needs to be put in place, e.g. concessionary duties and taxes concerning imported renewable equipment and “smart” subsidies, including a regulatory mechanism, to cover small power producing entities

**b. Access to financing of renewable energy devices:** The banking and financing activities for Small and Medium Enterprise (SME) – one of the pillars for ensuring the successful implementation of RE projects – belong to a relatively immature financial sector, which still lacks a complete legal framework “A lack of borrower and lender confidence and the laxity of the legal system, mean the sector which is increasingly seen as the key to economic growth”. Several micro-finance institutions operate in the rural areas providing credit for short duration with interest rates ranging from 40-60% per annum.

**c. Lack of information on market characteristics and resource potential:** There is still little documented information available on the characteristics of energy markets including their scope, potential and consumer characteristics. Few systematic studies exist for assessing the potential for energy resources in the country. There is a need to conduct detailed resource assessment studies.

**d. Institutional capacity for planning, implementation and maintenance:** Cambodia, relatively a young democracy, is still in the process of building its institutions and the infrastructure is still remains poor. Presently, management systems are weak. Technical know-how and maintenance skills are in short supply. Lack of experience in operation and maintenance and management; limited training possibilities; low volume of renewable energy installations so far and no network for service outlets and supply of spare parts are some of the factors causing institutional barriers.

Lack of coordination among concerned stakeholders (government, donors, NGOs, private sector, financial institution) also acts as another barrier in absence of a comprehensive policy on renewable energy development.

**e. Incentive Regime for Renewable Energy:** Given the above barriers, there is no sizable market readily available for renewable energy technologies, nor are conditions favorable in the short run to facilitate a completely commercial environment. Furthermore, the need to ensure social equity in providing access to electricity services also warrants that commercialization could not be the sole approach. Thus, RGC would put in place an incentive regime to give an impetus to the renewable energy sector while addressing the macro level issues. Such a regime would have two components:

- Direct, 'smart' subsidies to reduce the front-end costs and increase affordability, and
- Indirect incentives through a technical assistance initiative for pilot project, leading to awareness creation and capacity building for supporting a market infrastructure, and particularly for accelerating the implementation process of the RGC and other donors programs..

**f. Other Barriers:**

- Limited capacity of supply system
- Low reliability of supply
- Lack of access to low costs energy sources
- High technical and non-technical system losses
- Low load factor
- Low power factor
- Small-scale diesel-based generation used by EDC is not competitive with the self generation used by some industrial, commercial customers and hotels
- Very low electricity consumption per capita
- Tariffs favor domestic customers, cross subsidy of domestic customers by government, industry and commercial customers
- Very high electricity tariffs
- High bad debts
- Lack of interest in investment in power sector

The main financial issues interfacing with the proposed Rural Electrification (RE) program are as follows:

- The network of sources of financing for RE is characterized by financing difficulties because of its high capital cost, low revenue per connected household and limited financial ability of the parties concerned, although there has been significant private sector investment in recent years by the Rural Electricity Enterprises (REE)
- With funding required from a combination of loan finance, equity and subsidies in some cases, although with a labor contribution from the community, the difficulties are many to overcome in a weak domestic financial environment and limited equity available.

- None of the present financing institutions have both the financial capacity and structure required to support the overall RE program or to handle the individual loan sizes required.

Gaps in current data related to natural resources remain due to the lack of inventories. Whilst forest cover can be estimated from satellite imagery and aerial photography, there has been no ground-truthing or inventory of trees on different land types since 1969. As it is difficult to estimate the amount of wood available for harvesting on a sustainable basis, so it is difficult to determine the potential amount available for energy. Whilst such information is essential for forest management, it is evident that a large amount of wood fuel is consumed on an annual basis. However, wood fuels clearly originate from sources other than forests, policy makers and planners must recognize the importance of non-forest sources in supplying wood fuels without adverse impact. It is important for the Ministry of Agriculture (Department of Forestry) to develop an overview of potential supply and different demands on agro-residues, in order to assess its availability.

## **PART B: VISION POLICIES AND OBJECTIVES**

The Royal Government of Cambodia has formulated an energy sector development policy in October 1994. Its objectives are:

- (i) to provide an adequate supply of energy throughout Cambodia at reasonable and affordable price,
- (ii) to ensure a reliable, secure electricity supply at prices, which facilitate investment in Cambodia and development of the national economy,
- (iii) to encourage exploration and environmentally and socially acceptable development of energy resources needed for supply to all sectors of the Cambodian economy,
- (iv) to encourage efficient use of energy and to minimize detrimental environmental effects resulting from energy supply and use.

Power utilities in provinces are under the control of the Ministry of Industry Mines and Energy in collaboration with provincial authorities. According to the Royal Decree in March 1996, EDC has been corporatised and commercialised as an autonomous, commercial, legaland state-owned enterprise, with the responsibility for generation, transmission and distribution throughout Cambodia. The electric utilities in 6 provincial towns have been already integrated into EDC, and the remaining will be transferred in due course. Eight provincial towns have rehabilitated their power supply facilities in 2004 by the co-finance of ADB and AFD. For the rehabilitation of other provincial towns, it is planned to seek funding by soft loan and by the participation of private sector.

Energy security policy in Cambodia context forms part of the overall national energy policy that promotes not only energy sector growth and development but also overall economic growth and development. Cambodian government recognizes the paramount importance of energy security. On energy supply side, the policy is aimed at increasing indigenous energy reserves and resources and geared for their optimal utilization, to diversify fuel supply, to diversify the source of supply, to promote the increase in power supply, development of gas transport infrastructure and the investment in energy development. On the demand side, the government promotes energy efficiency to reduce energy demand, calls for the development of alternative transport systems to reduce the impact of the transport sector in the overall energy consumption, and integrate environmental concerns with development of energy.

## **B-1 Rural Electrification Policy**

Eighty five percent of the population of Cambodia is lived in rural areas and mostly do not have access to electricity. The provision of rural energy is a key factor in the rehabilitation and development of Cambodia, especially for the improvement of living standards, and for agricultural and small scale industrial development in rural areas.

The Government's power sector objectives are consistent with its overall policy for RE which includes the following:

- RE forms an integral part of Government's wider rural development and poverty alleviation agenda.
- RE contributes to rural development through supporting livelihoods, income-generating opportunities and improvement of social welfare, education and health.
- RE is to reduce regional inequalities in access to electricity supply.
- RE should provide all communities with the basic electricity service needed to satisfy the demand for lighting and productive applications.
- Within the electrified area, RE should aim to connect as many households as possible to the extent of affordability.

The Royal Government of Cambodia (RGC) in its pursuit to reduce poverty, improve the standard of living and foster economic development of nation, particularly in the rural areas, takes cognizance of the need to meet the basic needs of its marginalized rural people. Creating access to electricity infrastructure and services in rural areas is an integral part of this endeavor. RGC is committed to facilitate this process, together with an overall integrated rural development framework that includes policies on agriculture, industry, health, education, infrastructure, communications, pollution control, etc. It is also an instrument that upholds the RGC's principle of decentralization in providing public services.

The RGC recognizes that supply of non-electricity energy sources for domestic applications like cooking and heating (for instance, biomass and solar) are also critical in the rural areas, and shall endeavor to provide access to reliable, safe and environmentally clean electricity services to rural areas, at an affordable cost to the national community, act as a market enabler and encourage private sector participation in providing rural renewable electricity services, provide effective legal and regulatory framework for enabling access to reliable, safe and clean electricity services to rural areas, at an affordable cost to the communities, promote renewable electricity systems for rural applications, as part of least-cost to the communities of a national portfolio on grid and off-grid technologies, provided they are the least-cost option for the communities; and including renewable electricity systems for rural applications; and ensure adequate resources and appropriate institutional mechanisms to empower the poor, particularly those in rural areas.

Starting from the present low level of RE, Cambodia can make great strides in RE, subject to availability of sufficient funds for investment and adequate wealth within the rural community for the increased purchase of electricity. 70% of rural households plan to be electrified by the year 2030. It would also be appropriate to set a target electrification ratio for villages in addition to households as the social welfare objectives of RE will be well served by access to electricity for communal, health and educational purposes as distinct from the availability of electricity in individual households. A goal of 90% of villages electrified by the year 2030 would be appropriate. For progress to be measured against this target, the point at which a village would be considered 'electrified' must be defined – say when community facilities and more than 50% of households have electricity.

## **B-2 Wood Energy Policies**

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Energy policy in Cambodia should promote wood energy planning to achieve its aim of providing energy to all sectors of society as it the main energy consumed in the country. Therefore, there is a need for further research into wood energy supply distribution and consumption in order to successfully plan for future demand and supply. That is why the training of government staff in all institutions concerned about data collection and analysis in this field is necessary.

To allow effective wood energy development and management, an understanding of policy options is essential, on which informed decisions can be based. Wood energy policies cannot be allocated to one sector due its cross-sectoral characteristics. The following options relate mainly to the forestry and energy sectors, although linkages to other sectors must not be overlooked. The validity of the options must be considered in relation to current national policies, and capabilities of relevant staff to research, design and implement appropriate strategies. Sustainable wood fuel production and use requires a mix of policy options, to reflect the different wood fuel situations within and between provinces, and its changing nature. Options should be selected to optimize economic efficiency, equity, ecological sustainability and financial viability.

### **The Wood Energy Supply Side Policies include:**

- Wood energy supply policies,
- Sustainable forest management for wood fuel production,
- Wood fuel production in agro-forestry systems,
- Wood energy supply policies,
- Charcoal production and marketing For the demand side, the Wood Energy Utilization.

### **The wood Energy Demand Side Policy includes:**

- Improved stoves dissemination,
- Efficient wood energy use in traditional industries and enterprises,
- Modern wood energy technology applications,
- Fuel substitution using agricultural wastes,
- Fuel substitution to the fossil fuels, to improve local capacity in wood energy development,
- Improving local data and information base,
- Developing local planning, policy analysis and program formulation capabilities.

## **PART C: STRATEGIES AND PLANS**

### **C-1. Power Sector Strategy**

Cambodia faces a major challenge to develop an adequate and reliable source of electric power in the years forward. The RGC has formulated a power sector strategy for Cambodia to meet the growing demand for electric power over the next 15 years. Based on intensive studies of the best means of providing a national electricity supply network; the strategy consists of:

- Investment in the power sector,
- Interconnections with neighbouring countries and ASEAN Power Grid,
- Priorities for power generation and transmission,
- Establishment of the power sector's Regulatory Framework,
- Commercialisation of EDC and state-owned corporations,
- Private sector participation,
- Provincial and Rural Electrification,

- Raising rate access to reliable and good quality electricity services to 70% of rural households, by the year 2030
- 90% of villages electrified by the year 2030, a village being considered to be electrified when most community facilities and more than 50% of households have electricity.

### **C1-1 Load Forecast**

Electricity generation in Cambodia is expected to face a significant increase in demand in the years forward. Electricity demand in Cambodia is forecast to grow from 244 MW and 946GWh in 2003 to 991 MW and 3,478 GWh in 2020. While the majority of this growth will occur in Phnom Penh, there will be significant growth in provincial towns. Further details of the estimated generation output required to meet electricity demand growth are given in Table 1.

To meet this growth in demand, the Royal Government has decided to develop a National Transmission System. This System will allow provincial centers to access the energy generated by efficient large-scale power stations and to also allow Cambodia to access available hydroelectric sites and other low cost sources. It will significantly reduce reliance on imported oil for the energy generation and also the risks involved in transportation of oil. The electricity transmission and distribution system will require a major investment program and will be developed over many years; initial priorities will concentrate on the development of the first stage of the transmission system, the rehabilitation of local generation and expansion of the distribution system of provincial towns.

Eighty five percent of Cambodian people live in rural areas with subsistence agriculture as their main occupation. Cambodia has no indigenous sources of fossil fuels, and over 84% of the primary energy is contributed by fuel wood. Less than 9% of rural households have access to electricity services and those who depend mainly on connections to the EDC distribution grid (where available) or on isolated diesel power stations. Rechargeable, automotive-type batteries are commonly used in rural areas, for basic lighting, and powering radio and small TV sets.

The RGC plans to extend grid-based electricity supply to provincial and district towns in the near term. In rural areas, with no access to public grids, the RGC seeks to encourage investment for mini-grids based on diesel and/or renewable energy sources. The World Bank and ADB's Rural Electrification and Transmission (RE&T) Project aims to help the RGC achieve all these aims by implementing a wide range of activities including strengthening of Cambodia's existing generation, distribution and transmission capacity; technical assistance for capacity building, institutional strengthening and operational support; and implementation of the Rural electricity fund (REF).

### **C-1-2 Generation**

The generation strategy should be developed on the following criteria:

- Base load thermal generation will be located at the coastal areas to give independent access to imported oil and reducing the amount of oil transported on the Mekong and for efficient utilization of the GMS transmission line connecting Phnom Penh and Sihanoukville,
- Peak load thermal generation in Phnom Penh,
- Small and medium size diesel units for base and peak load generation in the provincial towns and cities,
- Hydropower development based initially on the easily accessible sites for the energy security and the indigenous energy development.

The generation plans are prioritised as follows:

#### **Stage 1 (5 years 2004-2008)**

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- 2004: Commissioning of 10 MW HFO power plant in Siem Reap (Japanese Grant),
- 2004: Commissioning of power supply in 8 provincial towns (ADB and AFD)
- 2005: Commissioning of 32 MW HFO (IPP- Khmer Electric Power),
- 2006: Commissioning of an additional 10 MW, HFO generation in C5 (Japanese Grant),
- 2007: Power import from Viet Nam 80 MW for the first step and from Thailand 20 MW.

### **Stage 2 (5 years 2009 - 2013)**

- 2009: Commissioning of Kirirum III 13 MW hydropower plant (IPP-CETIC),
- 2009: Extension of Power import from Viet Nam, capacity up to 200 MW,
- 2012: Commissioning of Battambang 1, 2&3 Hydropower plants, total installed capacity 73 MW,
- 2013: Commissioning of thermal plant 300 MW at the coast line area,

### **Stage 3 (5 years 2014 - 2018)**

- 2014: Commissioning of 180 MW Kamchay hydropower plant,
- 2015: Commissioning of 125 MW Russey Chrum hydropower plant,
- 2016: Commissioning of 110 MW Stung Atay Hydropower plant,
- 2018: Commissioning of 465 MW Sambor hydropower plant
- 2020: Commissioning of 207 MW Lower Se San 2 and 222 MW Lower Srepok 2 hydropower plants
- After 2020: Commissioning of 980 MW Stung Treng hydropower plant
- After 2020: Commissioning of Stung Chay Areng 260 MW hydropower plant.

### **C-1-3 Transmission**

The transmission system should be developed taking into account the following strategies to achieve Cambodia's electricity sector objectives:

- Reduce reliance on imported oil and the transport of oil on the Mekong River through Vietnam to Phnom Penh for energy generation in Phnom Penh (diversification of energy sources),
- Increase operational efficiency of the system (minimize losses), and reduce the environmental impact,
- Encourage least cost development of provincial load centers by a cost effective mix of grid expansion and local private generation,
- Increase competitiveness in power generation by providing access to competitive sources of imported electricity from Vietnam, Thailand and Laos,
- Maintain the reliability of power supply at the level required and financially supported by customers,
- Facilitate power trade in the region.

The transmission plans are prioritized as follows:

### **Stage 1 (5 years 2004 - 2008)**

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The scope of work includes implementation of the following projects:

- 2007: Single line interconnection 115 kV from Thailand to Banteay Meanchay, Battambang and Siem Reap terminals,
- 2007: Interconnection 220 kV double circuit from Viet Nam to Phnom Penh substation 220/115/22 kV (WPP) including substation 115/22 kV at East Phnom Penh (EPP),
- 2007: Establishment of 115/22 kV terminal substation at Phnom Penh (NPP) and stringing a second a 115 kV transmission circuit between GS1 and NPP,
- 2008: Establishment of Takeo to Kampot 230 kV transmission line including substation 230/22 kV in Kampot, Germany grant aid.

### **Stage 2 (5 year 2009 - 2013)**

The scope of work includes implementation of the following projects:

- 2009: 120 km single circuit 230 kV transmission line from Phnom Penh (WPP) to Kampong Cham including a substation 115/22 kV at Kampong Cham,
- 2010: Transmission line 260 km double circuit 230 kV between Phnom Penh (WPP) and Battambang via Kampong Chhnang and Pursat including substations in Kampong Chhnang and Pursat,
- 2011: Transmission line 230 kV from Sihanoukville to Phnom Penh (WPP) along National road 4,
- 2012: 122 km single circuit 115 kV transmission line from Phnom Penh to Svay Rieng via Neak Loeung including terminal substations at Neak Loeung and Svay Rieng,
- 2013: Transmission line 230 kV From Kampot to Sihanoukville.

### **Stage 3 (5 years 2014 - 2018)**

The scope of work includes implementation of the following projects:

- 2016: Double circuit 230 kV transmission line linking Stung Atay hydropower plant to Pursat substation,
- 2018: Connection of 230 kV line from Kampong Cham substation to Sambor hydropower plant,
- 2018: Transmission line 230 kV linking Kampong Cham to Siem Reap via Kompong Thom,
- 2020: Transmission line 500 kV linking Sambor, Stung Treng, Lower Se San 2 and Lower Srepok 2 and connect to ASEAN grid (power exchange between Cambodia - Viet Nam, Thailand and Laos).

### **C-1-4 Interconnection**

The Interconnection Master Plan in the field of energy for electricity and natural gas will be established through the ASEAN Power Grid (APG) and the TAGP cross-border projects by developing efficient power supply market, to facilitate economic generation and transmission of electricity, enhance security of power system and provide opportunities to private investment for future energy trading among ASEAN member countries.

The power interconnection offers several benefits compared to isolated systems for each country, but will imply investments in cross-border transmission lines and substations, and the national transmission systems may have to be reinforced. Strong interconnections between power systems reduce the total need for operating reserves because of the opportunity to share

reserves between countries. This reduces operating costs, but also reduces to some degree the need for installed peaking capacity. Hence, it will reduce the environmental impact. Strong interconnected power systems have high reliability resulting in low levels of energy not served.

Most of the power plants, hydropower as well as thermal, assumed implemented for domestic supply and for export are located in the south-western and north-eastern part and along the coastal areas of the country. These power plants will be connected to the national grid interconnecting Thailand, Cambodia, Viet Nam and Lao systems. In the near term, the power supply will be based on power import from Viet Nam to Phnom Penh and from Thailand to North-Western Cambodia: Banteay Meanchey, Battambang and Siem Reap provinces.

### **C-1-5 Distribution**

Formerly the power utilities in the Cambodian provinces were managed and controlled by the Ministry of Industry, Mines and Energy. A Royal Decree in March 1996 established Electricité du Cambodge (EDC) as an autonomous entity for power generation, transmission and distribution throughout Cambodia. EDC is controlling the power systems in Phnom Penh, Sihanoukville, Siem Reap, Takeo and Battambang and it is expected to transfer to EDC other 7 provincial power supply for the project under ADB loan and AFD grant (French) scheduled to be completed by end of 2004.

### **C-1-6 Provincial Electrification Strategy**

Power utilities in provinces are under the control of provincial office of Industry Mines and Energy in collaboration with provincial authority. It needs to restructure the power sector for efficiency and good governance, for improvement and performance of consumer services, restructuring of tariffs and management, and for the development of marketing plan. The utilities in 6 provincial towns had been already integrated into EDC, and the remaining will be transferred in the due course. 8 provincial towns have received the technical assistance from ADB for the feasibility study, ADB agreed to financial support for the implementation. This project now is under implementation and will be commissioned by end of 2004. For the rehabilitation of other remaining provincial towns, it is planned to seek funding by the ADB and the participation of private sector.

### **C-1-7 Rural Electrification Strategy**

Eighty five percent of the Cambodian population still lives in the rural areas, and less than 10% of the rural households have access to electrical grid-quality. Creating access to reliable electricity services in rural areas, at an affordable cost to the national communities, is thus an integral part of the governmental agenda of economic development and social upliftment. Electricity is very important for the improvement of living standards, for agricultural and small-scale industrial development in rural areas. As a reflection of this commitment, the RGC has set the goal of raising the access rate to the reliable, grid-quality and affordable prices electricity services to 70% of the rural households by the year 2030. Rural Electrification comprises the provision of electricity services needed in rural areas for the basic household demand (lighting, television and fan) and the basic village demand (public lighting and electricity supply to community centers, health clinics, schools) and local businesses; its main objectives being the provision of electricity to a certain proportion of villages for more balanced development in each province by the techniques with the highest cost/benefit ratio.

It is acknowledged that the long-term goal may be exceeded the possibility of electricity supply over the next 30 years. In the medium term, there is a need to develop a target for a 10-

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year target (2010) of 25% of households connected. The following criteria are proposed for the composition of the program:

- The composition should provide the least-cost, economically viable form of RE
- The composition should be matched to the most appropriate technology
- Areas with the best potential for economic development and higher levels of income are likely to be the most attractive. However, the Government should extend the electrification to as many villages as possible in order to achieve its broader development objectives.
- The composition should not be constrained by institutional structures
- The program must be flexible to take account of changing technology and circumstances.

Having taken these into account, two scenarios are presented for the final composition of the RE program. The first scenario reflects village location and population distribution. The second takes account of the high costs of network connections and shows a consequential shift in the mix of components to isolated systems and individual household systems.

The strategy and ten year program for rural electrification will incorporate:

- Grid extension from the existing,
- Cross-border power supplies from neighbouring countries,
- Rehabilitation of existing isolated grid systems in provincial towns
- Creation of new isolated grid systems
- Renewable energy such : solar, hydro(mini,micro), wind, biomass, biogas etc.
- Provision of batteries-based and stand-alone systems for dispersed remote customers.

The strategy needs to outline the necessary legal and institutional arrangements with continued liberalization of the energy market and volatile energy pricing. It consists of private generators ranging from 350 W to 1,000 kW, small mini grids supplied by either one or more diesel generators, hydro generation or a combination of both. The RE Strategy would consider the following categories of projects:

**Grid connected strategy**, least cost grid extension to customers located adjacent to existing grids. The priorities are the 22 kV cross-border supplies from Vietnam and Thailand, extension of the grid from planned substations at Takeo, Kampot, West Phnom Penh and Kampong Speu.

**Small hydropower stations for mini-grids**. These projects will be set up in relatively high concentration of demand to demonstrate electricity use for productive and income generating activities. Cost-effective designs, standards and management procedures will be introduced in order to lower the unit price for the consumers. These projects will be offered mainly to the private sector investment.

### **Hydro generation**

- Mini hydro 500 kW to 5 MW
- Micro hydro 100 to 500 kW
- Pico hydro 0.35 to 1 kW, generally run-of-river.

**Solar Photovoltaic Systems:** These will cover the following end-uses:

- Photo-voltaic Systems: for lighting, clean water pumping, refrigeration, television, telecommunications, office equipment: with capacity of 12 Wp, charge controller 5.6A, battery of 50 Ah, DC lamp at 12V/0.9A, to enhance the quality of life of domestic households, providing on near commercial terms including smart subsidies at least on the medium term basis,

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- Provide lighting and power for running small businesses (e.g. telecommunications), leading to income generation and rural employment;
- Meet energy requirements of community institutions like rural health centers, pagodas with religious and social functions, and residential primary and middle schools.

**Other Systems:** There is evidence of potential for exploiting wind and biomass resources. In this respect, resource assessment studies need to be conducted urgently to ascertain the potential and feasibility, particularly for rice husks in rice growing provinces such as Battambang, Banteay Meanchey, Siem Reap, Prey Veng, for combined Heat and Power plant.

The RGC has established four long-term targets for electricity-generating renewable energy technologies for the first five-year period:

- 5 % of new electricity generation, or about 6 MW, will be supplied by renewable electricity technologies, including 3 hydropower mini-grids, 3 viable renewable energy technologies (RET) businesses and 50-100 trained RET personnel,
- 100,000 households (HH) will be supplied by electricity from renewable technologies on a competitive basis. Of this volume, the goal is to get 45,000 households, electrified by the Rural Electricity Enterprises (REE),
- 10,000 households will be served by Solar Home Systems (SHS).

Cambodia has the initiatives in the development and utilization of new and renewable sources energy. The Government's policy on rural electrification is to substantially scale-up access for electricity services to rural areas for improvement of the standard of living, reduce poverty, and foster economic development.

Cambodia has abundant renewable energy resources. The potential of mini, micro and pico hydro is about 300 MW, however, only 1 MW has been utilized. Biomass potential about 700 MW and abundant solar energy are ideal for use in rural areas. The total capacity of the applications of PV in rural electrification, street lighting, rural health clinics, etc. are only around 300 kWp; the development of renewable energy technologies is moving very slow, mainly in research, development, and demonstration levels. There are a number of projects expected for development, namely: the rural electrification and transmission project, pre-feasibility study for micro hydro projects funded by New Zealand, Promotion of Renewable Energy, Efficiency and Green House Gas Abatement (PREGA) of ADB, CDG project on capacity building, SIDA NRE research program, and PV projects of NEDO Japan.

The Royal Government has decided to seek grants and soft loans from multilateral and bilateral agencies for rural electrification. It is estimated that \$10M per year will be required over a 10 year period.

The Rural Electrification Fund (REF) would be established in the middle of 2004. REF is needed for the provision of long-term finance for on-grid and off-grid RE projects. The cooperatives will be started and responsible for the construction, operation and management, including the revenue collection. Single wire earth return (SWER) should be considered, along with diesel plants. However, for the isolated villages, electrification based on micro hydro, solar or indigenous resources will also be considered.

The REF is headed by a Board, the Rural Electrification Board (REB), composed of 9 members representatives from different institutions MIME, MEF, MRD, EAC, Rural Electric Association (REA), representatives of donors, representatives of rural banks or micro-finance, representatives of private companies or NGOs and a representative of rural consumers and nominated by sub-decree proposed by MIME. The REF daily operation will be performed by the Rural Electrification Fund Secretariat (REFS). In the meantime a REF Project Management Unit (PMU) within the Ministry of Industry, Mines and Energy (MIME) will manage and facilitate the implementation of the REF.

The REF is being funded by donors and a levy on power transmission for subsidies to private investments. Besides the REF, the micro-finance institutions will be needed for the above purpose. Access to the REF is key for the power development in the provision of reliable and affordable electricity services to the rural people.

## **C-2 Wood Energy Strategy**

Following the policies on the wood energy above described, the strategy for wood energy is as below:

- To increase the efficiency of transformation processes
- To improve cook stoves for households
- To improve the efficiency of wood fuel use in traditional industries
- The substitution of wood fuel by other biomass, wood residue and agricultural residues.
- To identify the wood fuel distribution system, including market structures, resource flows, wood fuel types, volume estimates and prices.
- To outline the social and economic aspects of energy use, particularly in the residential sector.
- To promote the incorporation of wood energy analysis into relevant policy-related initiatives.
- To establish and demonstrate a capacity for wood energy research and policy analysis in key government agencies.

Data collection will be important for initial understanding of the wood energy related dynamics in the target zone. Most strategies are not based on hard data but on direct needs and interests of local communities, identified during the participatory assessment exercise. Pro-active strategies were elaborated according to the different ecological zones:

**C-2-1 Upland Forest:** The upland forest produces a variety of forest products like timber and poles and is a very important source of fuel wood. The low productivity of soils and increasing population pressure lead to the rapid conversion of forest into permanent agricultural land. The loss of forest area is enhanced by the common practice of slash and burn agriculture. The lack of ownership of state forest land as opposed to agricultural land, contributes to the rapid decline of up land forest cover

**C-2-2 Inundated Forest:** The population density along the lake shore is rather low. It is much higher at the maximum inundation level, than at the recession or dry season rice fields. Fuel wood supply is not a problem as long as it is limited to household consumption or fish smoking. These activities have been reduced due to rapid forest degradation, and degradation of forest fish habitat. Brick kiln operators have been encouraged to use fuel wood from up land forest. Commercial fuel wood collection is an important income generating activity during the dry season. It could become a serious problem with the increasing population pressure. Forest fires destroy important forest areas every year. The origin is often accidental. Fire is also used to convert forest into agricultural or grazing land and for wild life hunting.

**C-2-3 Reduction of forest fires and brush parks:** Intensive campaigns to prevent forest fires during the dry season, contributes to the protection of forest resources. These campaigns should target not only communities living in and around the forest but also people migrating from the up lands during the dry season.

Samras or brush parks, a traditional fishing method using branches to recreate a forest environment in open water, has a negative impact on forest resources and is illegal. To reduce the use of brush parks for fishing, contributes to forest protection.

**C-2-4 Tree planting in public areas:** Tree planting on road sides and other public places, contributes to decreasing the fuel wood deficit in the agricultural areas. It is important to organize tree planting campaigns in schools, pagodas and villages, to make people more aware of this problem. To identify and plant fast growing fuel wood species, adapted and fitting into Cambodia's environment, is an important component of the wood energy strategy.

**C-2-5 Agro-forestry or on-farm tree planting:** The promotion of agro-forestry or on-farm tree planting is similar to the previous strategy. It is important to focus on low cost technologies that can be replicated using farmer to farmer extension. Planning multipurpose trees can combine fuel wood production and livestock fencing, soil improvement, fruit/vegetable/fodder production, etc. A careful species selection is needed in order to enhance and not to reduce agricultural production.

**C-2-6 Village wood lot allocation for sustainable fuel wood collection:** Fuel wood collection is an important source of income for villages at the maximum inundation level. A sustainable harvest of fuel wood is therefore most important. Village wood lot allocation is one of the options to improve the sense of responsibility and ownership of forest areas. The RGC has introduced the community forest to improve access by the poor and benefit the rural population

**C-2-7 The Agricultural Zone:** Cambodian people have to buy or harvest additional fuel wood from low or up land forests. They also look at alternative fuel sources or how to reduce fuel wood consumption. Sugar palm and rice processing is an important fuel wood consuming activity. It is important to concentrate on this more accessible area, to reduce the fuel wood deficit and the pressure on up land and low land forest resources.

The promotion of alternatives to slash and burn agriculture can contribute to a more sustainable forest management. Agro-forestry systems, including fruit trees, timber trees, annual and shade tolerant perennial crops can lead to a more diverse and productive system and will reduce the loss in forest cover.

**C-2-8 Wood Energy Planning: Household Fuel Use:**

- Over 97% of wood energy is consumed by households either as fuel wood or charcoal.
- 84% of wood energy is consumed by rural households
- Almost all the remainder by urban households with Phnom Penh households consuming about 4% of supplies with about half as charcoal.
- Industry is only a very small consumer of wood: less than 1%
- The service sector consumes also charcoal but this represents less than 1% of fuel wood supplies.

The above needs to be qualified since it is based on a 1994-95 survey but it is unlikely that the general thrust of the finding will change much with more recent data since the rural energy situation will have changed little.

**C-2-9 Source of Fuel Wood Supplies:** In the past, Cambodian rural dwellers have gathered wood from around their homes on the large flood plains where most of the population lives. It is evident that increasingly the supplies are collected from natural upland forests but the impact on these upland forests has not been well assessed. Observations suggest that where rural communities are near to upland forests the impact is steadily increasing but no survey work has been undertaken to ascertain the magnitude of the impact.

The wood energy flow supply of Phnom Penh study provides some information on the sources of fuel wood and charcoal to Phnom Penh. It surveyed sources of supply in Kompong Speu, Kompong Chhnang, Kompong Thom, Kratie and Pursat. It found that these provinces were a source of supply of both fuel wood and charcoal to Phnom Penh. The survey was not

comprehensive and therefore not only gives an indication but it suggests that Kompong Speu, Kompong Chhnang and Kratie are probably the main sources of supply Phnom Penh.

Wood energy consumption in Cambodia in 1995 was 5.9 million tons out of a total national energy consumption of 7 million tons of wood equivalent (101,250 tetra-joules). There is little prospect at present that wood energy consumption will reduce without sustained efforts. The consumption is in fact likely to be increased. In the 1995 National Energy Balances it was estimated that wood consumption would grow for a number of years and then decline as other sources become more available.

A reduction in the rate of growth of wood energy consumption is needed to lessen the likely increased impact on natural forests but it is necessary at the same time to ensure that rural dwellers have sufficient wood energy to meet their basic needs for cooking and agricultural processing.

**C-2-10 Efficiency of Wood Energy Utilization:** A much greater effort is necessary on fuel-efficient stoves. A much greater effort is necessary on fuel-efficient stoves. This should mainly concentrate on household cooking stoves but also extend to other household based agriculture processing industries that are significant energy consumers. Their experimental findings are that efficient fuel wood stoves in households can reduce energy consumption in cooking very significantly: by 50% compared to the use of three bricks and by almost this amount in comparison to the use of the traditional three prong stove manufactured in Kompong Chhnang. They have also shown that a modified two-pot palm sugar distilling stoves can save up to 30% of energy.

Improved sugar palm and cooking stoves are used but can be promoted and improved. A good improved stove program should promote a range of models adapted to the activity, the size of the family, available funds and alternative fuel sources.

**C-2-11 LPG Substitution:** There are some prospects for substitution of wood energy by other sources particularly in Phnom Penh. Already since the 1995 survey there has been considerable substitution by LPG used for cooking represented about 3% of supplies in 1994 and risen now to 10% however this is not likely to have a great impact on the national level of fuel wood consumption as Phnom Penh only accounts for about 5% of total consumption.

**C-2-12 Biomass Substitution in Industry:** Biomass residues are widely used in small scale industries. There is evidence that biomass residues are being increasingly substituted for wood in urban based small scale industries, but there has been no detailed survey of the impact. Many industries in Phnom Penh and in some provincial capitals are increasingly using rice husks, such as bakeries, brickworks and other commercial establishments; rice husks are also exported to Thailand by truck, that have brought products to Cambodia. Formerly rice husks were available without payment, but now are sold commercially, that need to be used more efficiently for the possible substitution of fuel wood.. In Kompong Chhnang even a year ago rice husks were available free of charge but now costs half the price of fuel wood in energy terms. A detailed survey is necessary to assess the benefits of introducing biomass energy, efficient practice and technologies.

Although biomass accounts for over 80 % of the country energy demand, mainly wood fuel for cooking and for some brick and tile industry; there is not yet electricity production from biomass. Only EC ASEAN Cogen 3 Programme has promoted, since August 2002, the use of rice husk for a 1.5 MW cogeneration project in a rice mill, in Kandal province near Phnom Penh, in the context of a FSDP.

National rice production has grown over the last five years at 6% per annum providing increasing quantities of rice husks for energy and other uses. Furthermore this rate of increase in availability is forecast to continue. The rice area is estimated to grow by 16% between 1999-2000. The market survey for three rice growing provinces in the north-west has identified along

the national road some potential for rice husk cogeneration plants of the same size in other rice growing provinces.

**C-2-13 Efficiency of Charcoal Production:** Nationally 6.2% of wood is converted to charcoal. There is no detailed information available on the efficiency of conversion that is certainly low to what could be achieved by good practice. The NGOs concerned have introduced improved charcoal technology from Indonesia.

The improvement of the kilns for wood transformation to charcoal needs to be developed and the experimental investigations to be undertaken to evaluate potential savings, to lower the cost, increase demand and thus decrease the level of impact on the forests.

#### **C-2-14 Wood energy supply side program**

##### **a). Integration of wood fuel production into community forestry**

- The Community forest have been established in Cambodia since 1994, mainly through the NGO, and the government has recently recognized its importance for forest management strategy,
- The Department of Forestry will address wood fuel requirements of rural communities through community forests. A sub-decree is currently being prepared for the implementation of community forests,
- A study in Kampong Chhnang, shows that a large amount of wood fuel is collected from outside of the community. Forest law and legislation for land use rights, training in forestry management techniques and options for community leaders are required.

##### **b/. Sustainable forest management for wood fuel production**

- The sustainable forest management is essential for the future of natural resource,
- The Department of Forestry plans to develop fuel wood coupes to meet the demands of urban households, and industrial users. The areas of forest land were auctioned annually to companies for the provision of fuel wood and charcoal to urban areas. Fuel wood coupes are no longer economically viable due to competition in the market from freely produced wood fuels,
- The Department of Forestry has to revise the coupe system within forest areas, in this respect the information is required Appropriate sites need to be identified (to avoid watersheds, primary forests, protected areas, etc), and tree species need to be investigated. Further research regarding the amount of firewood supplied from forests (in relation to that supplied from non-forested areas) is required. Inventories should be conducted to provide reliable stock and yield tables for different land use types. A forest law with a means of enforcement, and improved security are required.

##### **c). Wood fuel production in agro-forestry systems**

- The large areas of agricultural and forest land are allocated to private developers for plantation schemes,
- A large amount of fuel wood is currently being produced from the areas cleared for plantations and agro-forestry systems. In the future fuel wood could be produced from pruning and from trees having reached the end of their production cycle. Within forest concession areas, waste wood in the form of branches should be cleared from the forest and could be used as fuel wood,
- The Department of Forestry or Ministry of Agriculture would prepare some regulation to assess the amount of wood fuel that could be produced from the agro-forestry systems. .

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Further information of current and proposed agro-forestry schemes and enforcement of concession management plans is required.

### **d). Charcoal production and marketing**

- A number of urban households and the service sector rely heavily on charcoal,
- The Department of Energy Development would consider the possibility of increasing the efficiency of charcoal production,
- The information is required to assess the local impacts by charcoal production, to identify the sources of the wood used for the production of the charcoal, and to study the marketing systems. If adopted, this option would require staff training in charcoal production, efficient techniques, appropriate species, etc.

## **C-2-15 Wood Energy Utilization Program**

### **a). Improved stoves dissemination**

- The utilization of improved cook-stoves will improve cooking efficiency and therefore reduce household wood use, and will also reduce the impacts of wood use on the health,
- The General Directorate of Energy is mandated to address energy efficiency. The Cambodian Fuel wood Saving Project (CFSP) has been working on the production of improved cook-stoves in the province of Kampong Chhnang, and thereby the information have been collected and analyzed, and staff trained,
- Improved cook-stoves could be introduced to urban areas, where users will obtain financial savings through reduced wood fuel use.

### **b). Efficient wood energy use in traditional industries and enterprises**

- Traditional industries rely heavily on wood fuel, and therefore increased efficiency will contribute to reduce the amount of wood required,
- The General Directorate of Energy is mandated to address energy efficiency CFSP and has successfully improved the efficiency of sugar palm stoves and disseminated in the province of Kampong Chhnang,
- Other traditional industries heavily reliant on wood fuel including brick and tile manufacturers, bakers, potters, sandalwood oil producers, fish drying, etc. require more information related to industrial users of wood fuel.

### **c). Modern wood energy technology applications**

- At present Cambodia needs to study the new technology for future applications, because it is still at the very early stage of wood energy development.
- The technical materials are required for the study.

### **d). Fuel substitution using agricultural wastes**

- Cambodia is primarily a rice producing country, with cattle as the main means of agricultural production,
- The use of agricultural wastes as a fuel will decrease the amount of wood fuels required,
- An assessment of the availability of agricultural wastes and appropriate technologies, applications and training are required for the utilization processes.

**e). Fuel substitution to the fossil fuels**

- Economic development of the country requires the reliable and affordable supplies of electricity, which is presently generated from imported oil, and higher income urban households are complementing wood fuels with LPG for cooking,
- In the future more electricity will be generated from hydro, large thermal plants and other renewable resources,
- In case of the expected exploitation of reserves of oil and gas in Cambodia, the fuel oil substitutions should be planned for the energy conservation and the environmental impact reasons.

**C-2-16 Policies to Strengthen Local Capacities in Wood Energy Development**

**a). Improving local data and information base**

- To develop policies on wood energy, strong information base at provincial/district level is essential, and should be continuously updated,
- The Department of Forestry has to organize the efficient data collection and analysis for formulation of the policy,
- It requires financial support for capacity building on techniques and research activities improving the current database, and close cooperation between the departments of energy and forestry.

**b). Developing local planning, policy analysis and program formulation capabilities**

- Policies and plans are required for the strategic planning and management of the wood energy,
- The local staff should have the capability to involve gradually in the policy and program formulation, in place of external consultants,
- Most of this work is concentrated at the central level, and the wood energy development is a multi-sectoral issue, so, staff from different sectors should participate in the training, to be able to involve in the policy development of the energy, forestry and agricultural sectors, and to be aware of the adverse effect on their policies and plans.

**D-Monitoring and Evaluation**

Monitoring and evaluation is the critical step integrated in the SPM to provide information about the progress in the implementation process towards the objectives, serving for periodic modification and improvement and for the sustainable development. The Department of Energy Development will be the core agency for these tasks, and report periodically to the SPM committee, through this way to the key stakeholders, which disseminate to other interested individuals and organizations, and receive the feedback for consideration. This means the broad participations of diverse stakeholders, civil society, private sector and the poor that create confidence through transparent manner.

The following activities of The Department of Energy Development, contributes to the efficient process such: data collection and statistics, progress report analysis, comparison with targets and indicators

The evaluation is to determine the real contribution of the strategy in changing the access to electricity services through the progress report that outlines the following:

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- Information about achievements in strategy implementation
- Involvement of stakeholders
- Proposal for modification on the strategy.

### **E- Environmental Policy**

Cambodia's energy primarily comes from fuel-wood and imported petroleum products, and electricity supply is widely used in the Capital, provincial cities and urbanize areas. The current system is not sustainable, in particular because of the negative effects of burning fossil fuels on the well-being of humans and eco-systems. The dependency on fossil fuels must be reduced gradually and to enhance safety and maintain clean and healthy the environment. To achieve the harmonization of the economic growth, the energy security and the Environmental protection, the diversification by the best mix of primary energy and the rational use of energy are very important contribution in the reduction of greenhouse gas emission according to Kyoto Protocol.

Cambodia has ratified UNCCC on the 18th December 1995; and signed Instrument of Accession to the Kyoto Protocol on July 2002. For this purpose, the Environment Protection and Natural Resource Management Law 1996 provide for all power projects to be subject to Environmental Impact Assessment (EIA) procedures. An Environmental Steering Committee and EIA Project Review Teams (PRTs) was established for protection against pollution of air, soil and water, protection against noises, vibration and radiation, protection of flora and fauna, through screening of environmental impacts on land use, natural resources, greenhouse gas reduction and air quality, historical and cultural sites to identify efficient mitigation measures.

Following the Governmental policy of the energy sector development, Cambodia has made efforts in implementing the sustainable energy efficiency program with the goal to meet the domestic energy demand, ensuring the clean development through CDM obligations, which needs the international assistance, especially the support from Japan and GEF, especially to build capacity and facilitate dealing with the climate change, and to get better understanding of greenhouse gas (GHG) and effective response measures, to prevent dangerous interferences with the climate system.

Some technological developments have been adopted that help enhance fuel efficiency and reduce both the emissions of local air pollutants as well as GHG. Legislation has been planned or introduced in many countries to promote the use of renewable energy in power generation. Under PREGA (Project on Renewable Energy, Energy Efficiency and greenhouse gas abatement) to promote investment switching to renewable energy, proper and renewable, avoids many harms and pollutions: gas emission, ashes production, wastes stocking; only the impacts on landscapes, birds, natural environments.

Wood is often consumed at a greater rate than it is replanted causing degradation of forest, and this is expected to continue to grow in the future. Energy efficiency must be improved, a sustainable fuel wood supply must be developed, and the promotion of the use of alternative energy sources is all very urgent measures to prevent negative impacts. However the development of hydropower may also have negative impacts on agricultural lands and the productivity of fish habitats. And commercial exploitation of offshore oil and gas will provoke risks of oil spills and other detrimental impacts on natural ecosystems. The audits on the compliance with the Environmental Monitoring Program and the instruction of appropriate corrective actions must be conducted thoroughly and regularly, in close cooperation with all stakeholders.

### **F- Private Participation Policy**

Because of the huge growth in power supply, the infrastructure requirements were not affordable and the government decided to create conditions to facilitate and encourage private

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participation, and transparent competition through direct and open process with the best incentives in the provision of effective-cost and reliable energy services in a wide variety of innovative and entrepreneurial ways. The situation in Cambodia has been significantly improved; laws have been promulgated in many fields especially in investment. Major positives signals have been observed such as the award of MFN to Cambodia and its membership in ASEAN and WTO.

The mode of participation of private investors, in particular for significant projects, follows the new approach for the development and approval of private investment projects through a one-stop service, in a transparent manner. The Government has put in place a new legal, institutional and regulatory framework especially the “Investment Law 1994” and is giving incentives for the benefits of investors by the following measures:

- Well organised authorization system to obtain the necessary permits, consents, approval and licenses,
- Investment in power sector will be carried through competitive procurement processes, in particular in the areas not already served,
- Implementing the purchasing mechanism to minimize cost especially in isolated areas, by Rural Electrification Enterprises with technical assistance and financial incentives for improved efficiency, quality service and consumer coverage,
- Ability to realize fair rate of return on investment.

The “Private Sector Forum”, as bi-annual dialog Government-Private Sector, with seven working groups including the group “Infrastructure and energy” has organized to create confidence and encourage participation of private sector in energy sector.

The Public Private Infrastructure Advisory Facility, a multi-donor technical assistance managed by World Bank, assisted to improve the quality of infrastructure through private sector participation in energy sector, based on transparent competition. A Sub-decree have been drafted for this purpose, to clarify the rules for private participation, the roles and responsibilities of public sector, and to establish a transparent and efficient procurement process.

## **G- Stakeholder Involvement**

The RGC has made effort in introducing the concept, in building capacity and establishing the management framework to encourage stakeholders participation in formulating and implementing the strategy and agreed actions. Successful implementation of the strategy will be determined by the degree to which all parts of the society adopt its vision and principles and contribute to achieving its goals and in monitoring and evaluation of the performance.

The stakeholders need to understand the potential benefits from the process of a sustainable strategy achieved by transparent organization of activities. It is important to strategize stakeholder involvement with a clear view of the roles and responsibilities and transparent process.

To recognize the rights of local communities to manage and use the forest, can contribute to better management and sense of ownership of these resources. Fishermen communities living on the lake shore are interested in forest protection for several reasons. They know the important relation between forest and fish. They want therefore to protect this important feeding and spawning habitat. Human settlements along the lake shore also need protection from wind and waves. To establish a forest belt around villages is the only possible option for their protection. To encourage a sense of ownership of the forest in the low lands, contributes to a more sustainable management of the forest resources outside fishing lot areas.

## H- Conclusion and Recommendations

The electricity sector is at an important stage of development. As already outlined, it presently provides only very limited services, and per capita consumption in Cambodia is the lowest in the region. The sector should be developed rapidly to contribute to a balanced and sustainable growth. Cambodia's main requirement is to identify alternative resources of energy, at a reasonable price.

The main problem is that the economy of scale necessary to deliver least cost energy are greater than Cambodia's level of consumption, but investment in large scale power station, both thermal and hydro, could be considered for energy export projects which would also contribute to reducing costs for domestic uses.

In summary, to achieve profitability, efficiency, innovation and social objectives, then a commitment and flexibility is necessary, and private participation is inevitable. The least cost suppliers will win the market and the national economy as a whole will grow rapidly. The structural reform, good governance and efficient sharing of responsibility are the key determinants of success in addition to the following requirements:

- The government (MIME) plays the role in making and implementing policy, strategy and planning, guidelines, rules and standards.
- EAC plays the role of regulator in licensing, setting prices, formulating guideline for good governance and transparent procedures, increasing competition.
- Strengthening the state-owned companies for the benchmarking, and to be an active partner and competitor with the private sector, and mainly to avoid monopolistic tariffs.

The main strategy is to provide the strong legal framework, the right incentives and the perfect competition for better performance.

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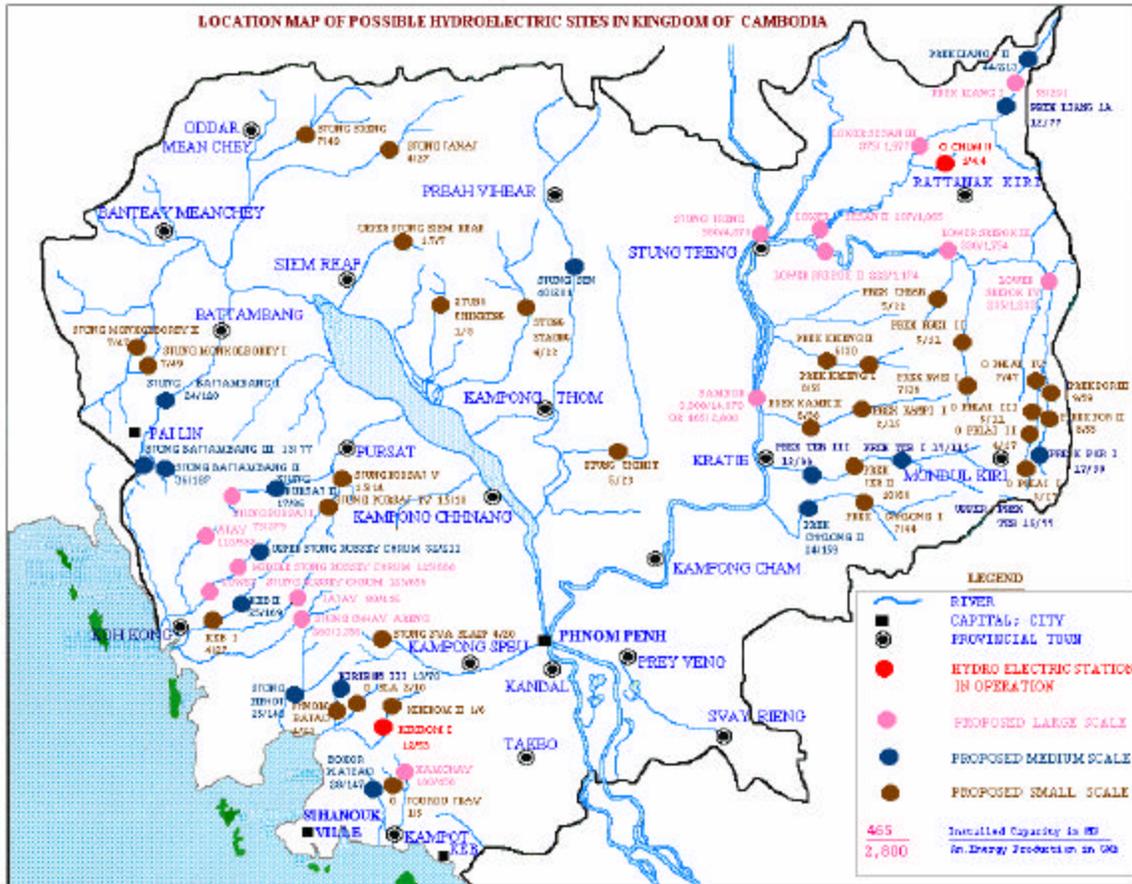
## References

Table 1 Expected Generation Output for Cambodia (MW) - Base Case

No	Provinces/Year	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
1	Banteay Meanchey	4.0	5.9	8.0	10.0	12.0	14.5	17.3	20	24	26	28	31
2	Battambang	3.5	5.7	8.6	12.0	15.0	18.5	22.4	27	31	33	35	37
3	Kampong Cham	4.9	7.8	10.5	13.0	15.2	17.9	20.5	23	26	29	32	36
4	Kampong Chhnang	1.1	1.6	2.2	2.8	3.4	4.0	4.7	5	6	7	8	10
5	Kampong Speu	1.0	2.0	2.9	3.8	4.7	5.9	7.2	9	12	16	21	28
6	Kampong Thom	1.5	2.4	3.4	4.5	5.3	6.4	7.5	9	10	11	12	13
7	Kampot	2.7	4.8	8.1	10.1	13.9	16.3	18.9	25	28	33	39	46
8	Kandal	2.2	3.9	5.5	6.7	7.9	9.2	10.6	12	13	15	17	20
9	Koh Kong	0.7	0.9	1.2	1.4	1.7	2.0	2.3	3	3	4	5	7
10	Kratie	1.9	3.2	4.4	5.7	6.8	8.0	9.4	11	12	14	16	19
11	Mondul Kiri	0.1	0.2	0.3	0.4	0.5	0.6	0.7	1	1	1	1	1
12	Phnom Penh	60	93	131	170	207	256	304	356	418	484	560	649
13	Preah Vihear	0.3	0.5	0.7	1.0	1.1	1.4	1.6	2	2	2	2	2
14	Prey Veng	1.7	3.0	4.4	5.5	6.6	7.8	9.0	10	11	13	15	18
15	Pursat	1.3	2.3	3.2	4.2	5.0	5.9	6.9	8	9	11	13	16
16	Ratanak Kiri	0.9	1.1	1.3	1.5	1.7	1.9	2.2	2	3	3	3	3
17	Siem Reap	3.0	4.2	5.6	7.1	8.4	10.0	11.5	13	15	17	19	22
18	Sihanoukville	2.9	3.4	4.1	4.8	5.5	6.3	7.3	8	10	11	12	13
19	Stung Treng	0.2	0.5	0.7	0.9	1.1	1.3	1.5	2	2	2	2	2
20	Svay Rieng	1.0	1.6	2.2	2.8	3.2	3.9	4.4	5	6	6	6	6
21	Takeo	1.5	2.4	3.4	4.2	4.9	5.8	6.7	8	8	9	10	11
	<b>TOTAL</b>	<b>97</b>	<b>150</b>	<b>212</b>	<b>273</b>	<b>331</b>	<b>404</b>	<b>477</b>	<b>558</b>	<b>651</b>	<b>746</b>	<b>860</b>	<b>991</b>

Table 2 Expected Generation Output for Cambodia (GWh) - Base Case

No	Provinces/Year	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
1	Banteay Meanchey	24.8	24.8	28.1	32.7	37.6	43.8	51.2	59.9	70.1	77.8	86.3	95.8
2	Battambang	22.5	28.8	36.0	43.5	50.6	59.6	69.8	81.5	95.1	102	109.4	117.3
3	Kampong Cham	28.8	34.0	39.3	44.8	50.3	58.1	65.3	73.1	82.9	92.9	104.1	116.7
4	Kampong Chhnang	5.1	6.1	7.3	8.3	9.5	11.0	12.6	14.4	16.4	18.2	20.2	22.4
5	Kampong Speu	8.0	9.4	11.0	12.7	14.3	16.8	19.6	23.4	29.6	38.8	50.9	66.7
6	Kampong Thom	7.4	9.1	11.1	13.3	15.1	17.5	20.3	23.5	27.0	30.9	35.4	40.5
7	Kampot	13.7	16.9	22.7	26.3	34.3	39.2	45.2	52.1	59.5	68.4	78.6	90.4
8	Kandal	16.0	21.0	27.5	34.0	41.1	49.6	60.0	69.9	82.1	95.6	111.3	129.6
9	Koh Kong	4.6	5.5	6.5	7.5	8.8	10.1	11.5	13.1	14.9	17.3	20.1	23.3
10	Kratie	8.7	11.2	14.3	17.6	20.7	24.3	28.4	33.1	38.4	44.6	51.8	60.2
11	Mondul Kiri	0.6	0.7	1.0	1.3	1.4	1.7	1.9	2.1	2.8	3.1	3.4	3.8
12	Phnom Penh	321	438	566	695	820	994	1,168	1,355	1,584	1,829	2,110	2,430.6
13	Preah Vihear	1.5	1.9	2.4	2.8	3.2	3.9	4.4	5.0	6.0	6.6	7.3	8
14	Prey Veng	10.6	12.4	14.5	16.3	18.2	20.8	23.7	26.7	30.0	33.5	37.4	41.8
15	Pursat	7.2	8.9	11.0	13.2	15.4	17.9	20.7	23.9	27.6	31.8	36.6	42.2
16	Ratanak Kiri	3.5	3.6	4.2	4.4	4.8	5.6	6.0	7.0	7.7	8.9	10.3	11.9
17	Siem Reap	12.5	15.2	18.2	21.1	23.9	27.5	31.4	36.2	41.4	47.3	54	61.7
18	Sihanoukville	10.2	11.9	14.0	16.2	18.3	20.8	23.7	27.0	30.8	35.4	40.7	46.8
19	Stung Treng	1.2	1.4	1.7	2.0	2.6	3.0	3.4	3.9	4.5	5.6	7	8.7
20	Svay Rieng	5.6	6.3	7.3	8.1	8.8	10.1	11.1	12.3	14.0	15.4	16.9	18.6
21	Takeo	8.6	10.4	12.3	14.2	16.2	18.4	21.6	24.6	27.4	31.6	36.4	42
	<b>TOTAL</b>	<b>522</b>	<b>678</b>	<b>856</b>	<b>1,036</b>	<b>1,215</b>	<b>1,454</b>	<b>1,700</b>	<b>1,968</b>	<b>2,292</b>	<b>2,634</b>	<b>3,028</b>	<b>3,478</b>



By Dr. BUN MARITH

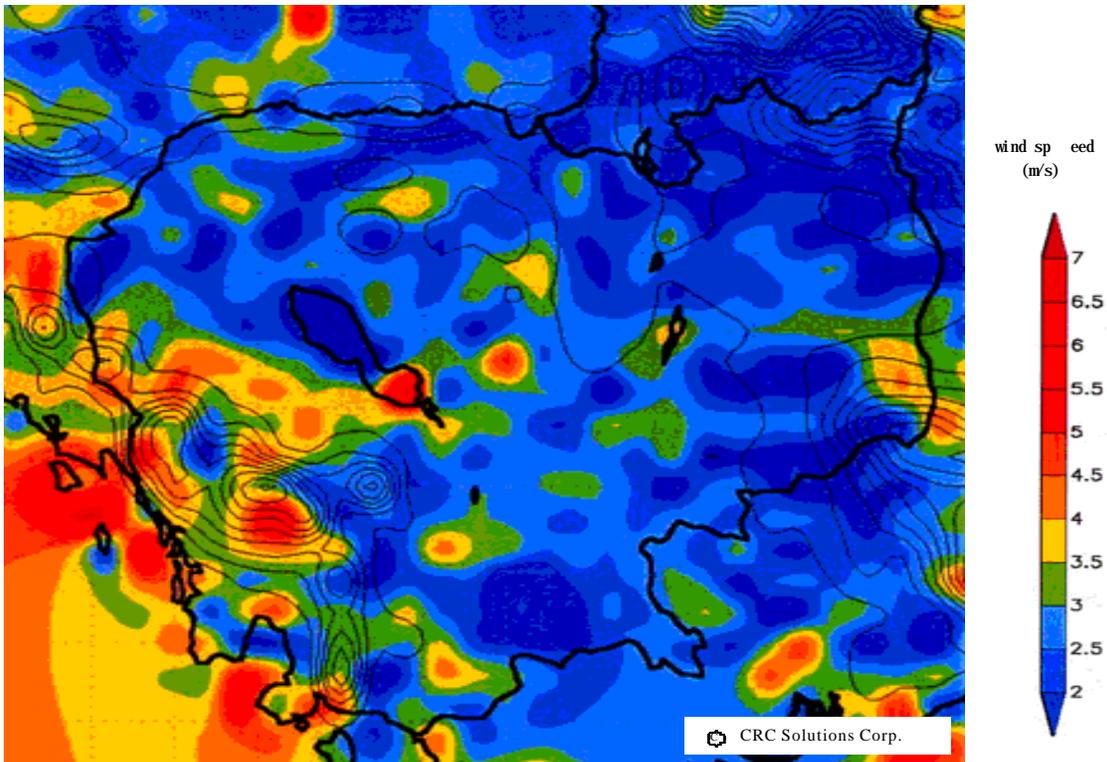
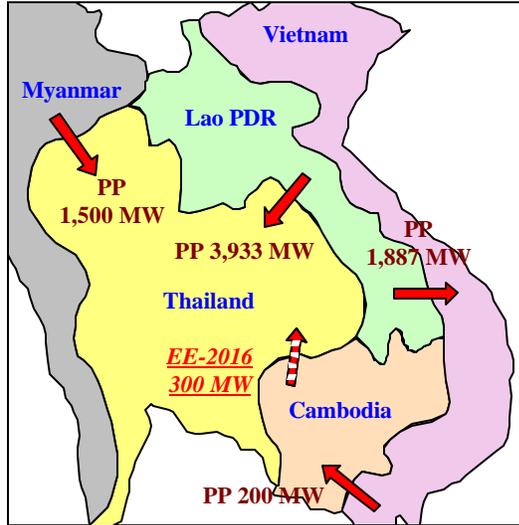
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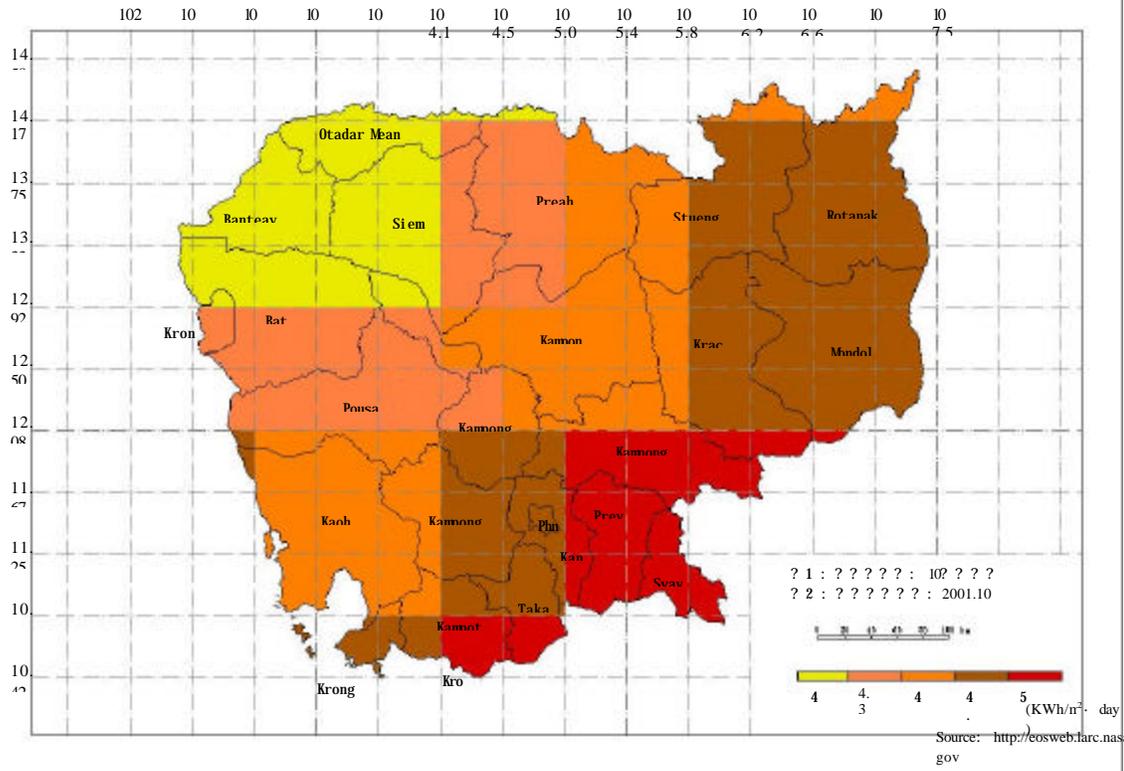


## INTERCONNECTION PROGRAM

### Selected Plans

- **Power Purchase:**
  - Myanmar-Thailand 1,500 MW
  - Laos-Thailand 3,933 MW
  - Laos-Vietnam 1,887 MW
  - Vietnam-Cambodia 200 MW
- **Energy Exchange:**
  - Cambodia-Thailand 300 MW





### SUPPLY AND DEMAND BALANCE

