Country Paper: Cambodia

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The Role of Renewable Energy for Rural Electrification in Kingdom of Cambodia

1. ABSTRACT

The Royal Government of Cambodia has set ultimate goals for the rural electrification sector as 1) poverty alleviation, 2) improvement of living standards, and 3) development assistance for the rural economy. As the first step to achieving these goals, MIME has set targets for rural electrification as follows:

1) To achieve 100% level of village electrification by the year 2020 including battery lighting; and

2) To achieve a 70% level of household electrification by the year 2030 with grid quality electricity.

In the electricity sector of Cambodia, the Electricity Law enacted in 2001 has clearly defined, under the private sector participation and beneficiaries-pay principle, the roles of concerned parties: 1) MIME as policy maker, 2) EAC as regulatory and supervisory agency, and 3) REEs (Rural Electricity Enterprises) to provide electricity supply services. EdC, who constructs and operates the National Grid, is also regarded as one of the REEs. The other private REEs (including Community Electricity Cambodia, CEC) have opportunities to distribute electricity, receiving power from the grid inside the PAGE, as well as to electrify communities in the off-grid areas. In other words, all those living in rural communities should not simply wait for the grid arrival to be implemented by EdC but have equal opportunities to electrify their own communities by self-help. Such electrification policy cannot be found in the neighbouring countries. The study team is of the opinion that such a policy will achieve a significant improvement in the level of rural electrification, if the policy is implemented appropriately.

The following are the basic policies of the MP for planning rural electrification:

Adoption of Three Levels of Electrification

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Taking into account the high penetration level of battery lighting and the fact that nearly 20% of the people of Cambodia are living in those areas that have very low probability of grid extension by the year 2020, the three level of electrification has been adopted as shown in the table 1 below.

Table 1: Three Levels of Electrification

Region			Electrification Plan				
			Level	Consumption Standards		Type	Energy Sources
				Watt	kWh/month		
Nationwide	Inside PAGE	On-grid	3	<400	50	Grid	National grid
	Outside PAGE	Off-grid	2	100 (30-200 subject to village economic levels)	10	Decentralized mini-grid	Micro hydro, 24 hours operation possible
							Biomass gasification power, hourly supply depending on demand
							Diesel power, hourly supply depending on demand
			1	10 (40 for households with TV)	3	BCS, SHS for public facilities	Existing diesel power, Solar power

Figure 1 illustrates applications of the three levels of electrification to non-electrified areas depending on the household income level as of 2005. Figure 1 also represents the area outside the PAGE, which covers the main parts of the off-grid areas. The current status of the community electrification is shown on the left side, type of electrification in 2020 in the center triangle, and its electrification level on the right. For those villages in the bottom layer, battery lighting with a solar BCS at Level 1 will be promoted. The BCS will be a principal driving vehicle for achieving the 100% level of village electrification.

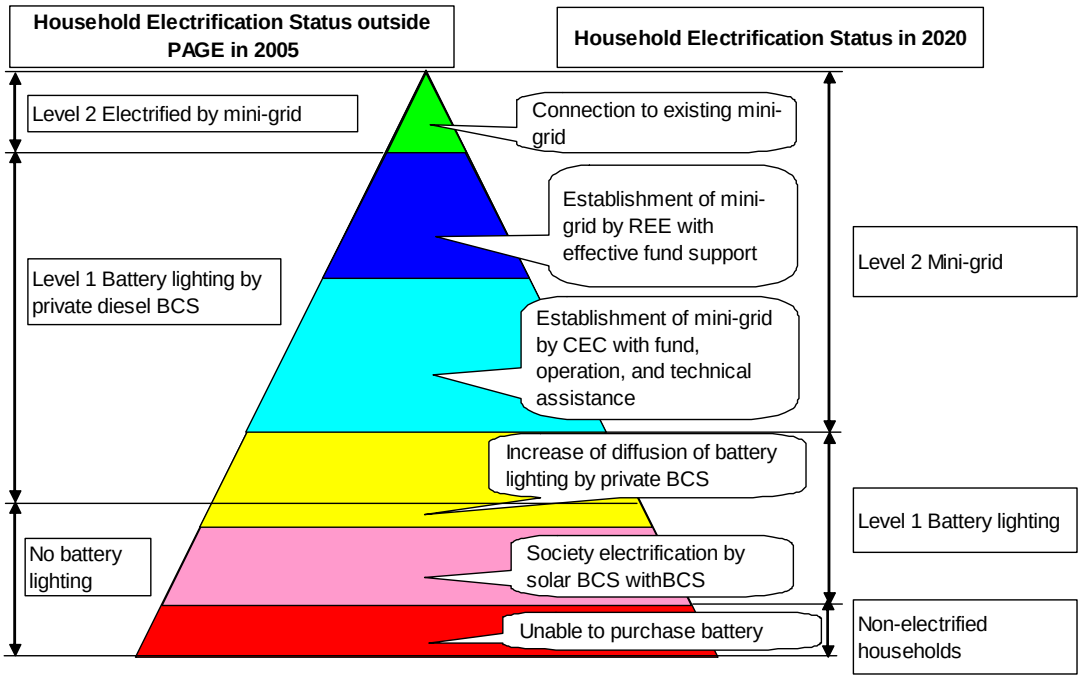


Figure 1: Present and Planned Level and Types of Electrification outside Maximum Use of Renewable Energy

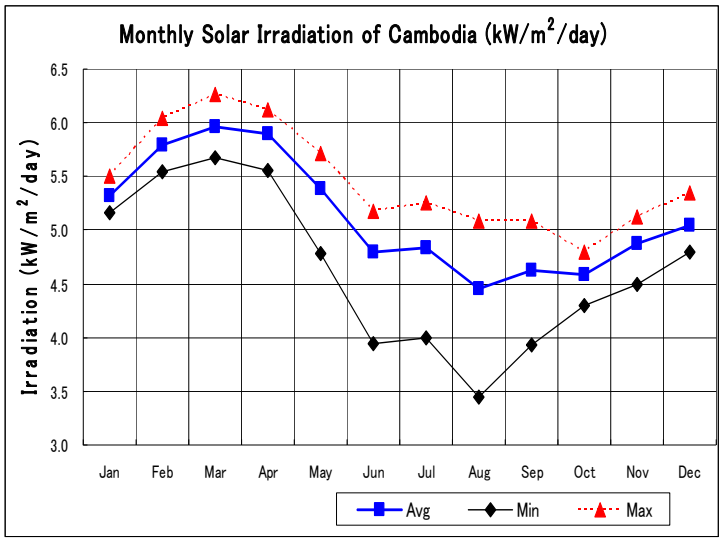
In accordance with the basic approach of the MP, the renewable energy potential, biomass gasification power which is a new technology to Cambodia, power sources of mini-grids, and power sources for BCSs are explained below in brief:

a) Renewable Energy Potential

The potential of renewable energy in the off-grid areas and its characteristics are presented in Table 2 and Figure 2 shows the monthly variation of solar irradiation obtained from satellite data.

Table 2: Renewable Energy Potential as Power Sources for Rural Electrification

No.	Energy Source (Type)	Characteristics of Potential
1.	**Micro-hydro power** (mini-grid)	Micro-hydro power (MHP) potential is limited to mountainous or hilly areas mainly in the eastern and south-western part of the country. In the plain areas, which cover more than half of the country, there is hardly any potential for MHP.
2.	**Biomass** (mini-grid)	Blessed with abundant solar irradiation, precipitation, and land resources, biomass resources are abundant all over the country, and there is biomass farming potential as well (even grassland and shrub land alone are more than sufficient to grow the required fuel trees).
3.	**Solar** (BCS, SHS)	Abundant all over the country (annual average monthly minimum is 4.7 kWh/m^2/day)
4.	**Wind** (BCS, SHS)	Scarce. Average wind speed at 20 m above ground level is as low as 2.6 m/s. Wind power may be used for BCS in local wind corridors.



Source: Processed by JICA study team from NASA satellite data

Figure 2: Monthly Variation of Solar Irradiation in Cambodia

b) Biomass Gasification Power

The biomass gasification power has the following advantages in application to decentralized mini-grids for rural electrification:

1. It can be applied to most of the villages in Cambodia since these have grass land and shrub land in sufficient areas to grow fuel trees without affecting agricultural production;
2. Fuel trees can be grown locally within the community and, therefore, the supply can be stable and sustainable if combined with an energy reserve of trees to cope with droughts, fire in plantations, flooding, and so forth;
3. Some fast growing tree species can be harvested from one year after planting and every 4-6 months thereafter like mulberry trees for silk production;
4. Unit fuel cost is $0.03/kWh, being much lower than diesel fuel cost at $0.23 /kWh;
5. The money paid for fuel trees will remain inside the community and can be reused for other economic activities;
6. Poor households, if given priority in farming fuel trees, can also join CEC and receive electricity by paying tariff out of the tree sales;
7. Some types of gasifier require less maintenance work than diesel engines;
8. Generating capacity can be extended when demand has grown beyond the planned level.

Biomass gasification power does not have a long history of applications over 100 years like micro-hydro. However, some types of small scale gasifier (down draft type with closed top and side air nozzles using charcoal) had over one million applications to vehicles during World War II. Such small scale gasifiers up to 100 kW are suitable for rural electrification. In India, People's Republic of China, and Myanmar, biomass gasification power is applied as a source of power for rural electrification, irrigation pumps, and rice mills.

In Cambodia, one small scale gasifier was introduced in 2004 for research purposes. Another was installed in January 2005 for electrification of Anlong Ta Mei village in Battambang Province and has been operated since then (refer to photographs of Figure 3, 4).

Source: Courtesy of CEC Anlong Ta Mei and SMEC, photographs by the JICA study team

Figure 3: Existing Rural Electrification by Biomass Power

Source: CEC Anlong Ta Mei, photograph by JICA study team

Figure 4: Fuel Wood Prepared for Gasifier

c) Power Sources of Mini-grids

As shown in Table 3 BGP satisfies the required conditions as an energy source for mini-grids except for the arrangement of initial capital costs. In addition, if the plant factor (usage ratio) of power generation equipment is higher than 12%, the unit cost of electricity will be lower than that from a diesel generator. The study team considers it is appropriate to apply three types of renewable energy (micro-hydro, biomass gasification power and diesel power) as sources for decentralized mini-grids in Cambodia.

d) Power Sources for BCS

Candidate power sources for BCS in the plain regions are biomass and solar in terms of renewable energy potential. As BCSs are for rural villages where there is little penetration of battery lighting, the key factor is easiness of operation and maintenance. Solar power does not require any generator (panel) operation, and is almost maintenance free. On the other hand, biomass power generation is difficult to apply to remote small villages in view of the required output for a BCS at 1 to 4 kW being too small to apply a biomass gasifier. Operation and maintenance of the machine is also required. In specific wind corridors, wind power can also be a power source candidate for a BCS. In the case of applying wind power for a BCS, observation of wind conditions throughout the year is required, and special attention should be paid to the maintenance system for mechanical parts.

Diesel power generation, though it is not renewable energy, can be employed also for the small scale demand of a BCS. A diesel generator can be purchased in local markets and sales routes for fuel have been established, except for very remote areas. Because of its high technical reliability and low prices, all the existing BCS operators are using diesel generators. However, in small scale rural villages, there are several issues such as recruitment of operation and maintenance staff, transportation of fuel over roads that are in a bad condition, in the rainy season in particular, risks of fuel price fluctuation, and low profitability inherent in small scale BCS business. In this connection, the study team is of the opinion that diesel BCS operation should be left in the hands of markets, waiting for participation from the private sector where profitable.

Framework of Rural Electrification Program

Targeting about 14,000 villages in the whole of Cambodia, a rural electrification plan has been formulated using a GIS database. The plan consists of grid extension by EdC, decentralized mini-grids powered by micro-hydro, biomass, and diesel, and solar home systems (SHS) and solar battery charging systems (BCSs). The plan is shown in the location map at the beginning of this report and is featured in Table 3.

Table 3: Framework of Rural Electrification Program

Name of Representative Regions	Energy Sources	Number of Villages	Number of Households	Target Number of Households for Electrification by the Year 2020
Electrified area (2004) **A**	Grid/Diesel	**2,588**	**623,523**	**350,000**
Newly electrifying areas				
Grid extension **B**	Grid	5,885	1,007,291	600,000
Off-grid Area (2020)				
Northeast, Southwest and mountainous areas	Micro-hydro, hybrid	137	18,541	9,000 (50% of left)
Tonle Sap coastal region, etc.	Biomass gasification	3,071	501,636	168,000 (33% of left)
	Diesel	392	69,390	23,000 (33% of left)
Sub-total of mini-grids C		**3,600**	**589,567**	**200,000**
Northeast or North provinces	Solar BCS SHS **D**	1,720	237,570	60,000 12,000
Sub-total of newly electrifying areas E = B+C+D		**11,205**	**1,834,428**	**872,000**
Total A+E		13,914	2,457,951	1,222,000

Note: Inside bold lines is for the off-grid area. In this MP, as potential for local wind corridors cannot be obtained, such potential is not included in this electrification plan.

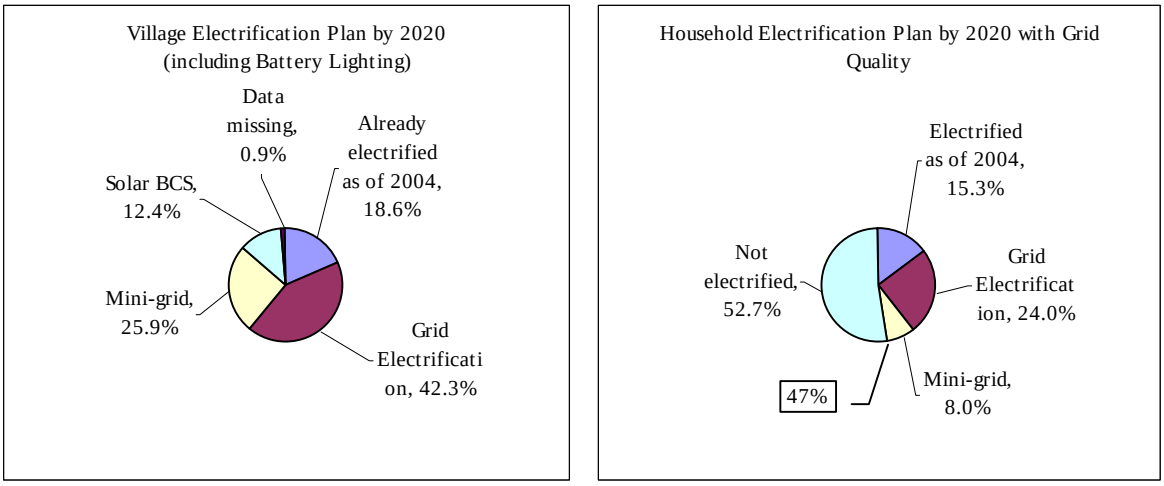


Figure 7: Constitutions of Village and Household Electrification Plans by 2020

2. THE ENERGY POLICY:

- To provide an adequate supply of energy throughout Cambodia at reasonable and affordable price.
- To ensure a reliable and secured electricity supply at reasonable prices, which facilitates the investments in Cambodia and developments of the national economy?
- To encourage exploration and environmentally and socially acceptable development of energy resources needed for supply to all sectors of Cambodia economy.
- To encourage the efficient use of energy and to minimize the detrimental environmental effects resulted from energy supply and consumption.

3. DOMESTIC INVESTMENT AND FOREIGN DIRECT INVESTMENT (FDI) IN LOW CARBON AND POLLUTION PREVENTION TECHNOLOGIES

a) Cambodian Fuel Wood Saving Program: Geres has implemented Cambodia Stoves by replacing the traditional (inefficient) Lao stove with a version delivering measurable gains in efficiency. The GHS emission reductions reported from the project during the period May 10, 2003- January 9, 2007 amounting to 182 402 tones of CO2 equivalent.

The breakdown of GHG emission reduction (VCUs) for the respective period is as follows:

a) 10 June 2003-9 Dec.2003 (2822t CO2e)
b) 10 Dec. 2003-9 Dec.2004 (21`833 t CO2e)
c) 10 Dec. 2004-9 Dec.2005 (50 980 tCO2e)
d) 10 Dec.2005-9 Dec. 2006 (95 880 tCO2e)

e) 10 Dec. 2006-9 Jan.2007 (10887tCO2e)
Source: http: www.dnu.com

b) CDM small scale projects in Cambodia

*** Energy Project**

- Renewable Energy Generation: Solar, Wind, Hydro, Biomass feed to grid or onsite Mechanical or Electricity.
- Energy Efficiency: Improve production, transmission, distribution efficiency. Improve user efficiency-Industrial Site, buildings, agriculture activities.

*** Methane & Waste Projects**

- Capture methane: Capture methane from landfill gas, wastewater treatment
- Methane Avoidance: Prevent biomass decay

*** Forestry Project**

- A forestation or Reforestation
- Fuel Switching: Bio-fuels for transport to natural gas

For Foreign Direct Investment (FDI), CETICI Company invests KIRIRUM-III Hydropower with installed capacity 18 MW to be constructed soon. **Sino Hydro Company** has invested Komchay Hydropower with installed capacity 193.2 MW and it is under construction.

Summary of Results

Green Gas Emission from Energy Sector in 2009 (Gg)

Energy Fuel Combustion Greenhouse Gas Source Categories	CO2 Emissions (Gg)	CO2 Emissions (%)
Energy industries	546	27
Manufacturing industries and construction	78	4
Transport	774	38
Commercial/ Institution	62	3
Residential	189	9
Agriculture / Forestry / Fishery	212	10
Other	188	9
Total	2,050	100

Source: Ministry of Industry, Mines and Energy

4. THE IMPACT OF CURRENT FINANCIAL CRISIS AND GLOBAL ECONOMIC DOWNTURN ON COUNTRY'S ENVIRONMENT AND POOR INCOME GROUPS

Cambodia is a small country with only 14 million people and a very thin capital base. 35 % are below poverty level, the vast majority is employed in the family business generating only the bare minimum income, and the garment and tourism sectors pay only minimum wage, like $75 a month.

The impact, of course, garment exports and tourism, foreign money inflow, whether as FDI or Loans, will slow down.

5. CONSIDERATIONS FOR RENEWABLE ENERGY, ENERGY EFFICIENCY SOLUTION AND ENVIRONMENTAL PROTECTION IN THE NEW FISCAL STIMULUS PLANS

The awareness and capacity building is the first consideration to achieve renewable energy, energy efficiency solution and environmental protection for our development in the new fiscal stimulus plans.

The supply side of our renewable energy: Hydro, Biomass, solar, wind (we try to avoid using fossil fuel).

The demand side: Energy efficiency (the energy saving in factories, buildings etc.) we need Financial & Technical assistance)

6. CONCLUSION

The Potential of Renewable Energy Sources and Energy Efficiency are the key role to support and sustain clean energy development for Low Carbon Green Growth (GHG emission reduction) and environmental protection against the climate change that the world is facing global warming today.

The Regional Workshop on Opportunity and Priorities for Low Carbon Green Growth in Asia is very important for participants from the Asian countries to have their opportunity to make discussion on low carbon green growth and improve capacity to identify relevant policies, programs and project for putting them in practice.