Cambodian J. Int'l. Studies **1**, 145-153

An Analysis of Non-Renewable Energy Resources and New Potential Renewable Sources for Environmental Sustainability in Cambodia

Kro Meng

Centre for Research and Creativity, The University of Cambodia, Northbridge Road, Phnom Penh, Cambodia

Abstract

In Cambodia, the supply of fuel, oil and gas are rapidly declining while the energy demands continue to increase more than 20% annually. Currently, approximately 6.9 million people in Cambodia cannot access reliable electricity resources, and the domestic energy sources are inadequate in Cambodia. This study analyzes non-renewable resources in Cambodia and identifies new potential renewable energy sources available to ensure environmental sustainability. Coal and oil comprise the largest non-renewable resources in Cambodia currently, while solar energy, hydropower, biomass, and biofuel all represent potential energy sources for the future.

Keywords: Renewable energy, environmental sustainable development, hydro power, solar, and biomass

I. Introduction

Energy as a source of power is critical for people worldwide. All activities including household activities, industrial operations, transportation, agriculture, education, and communication depend upon energy. The majority of energy generated from fossil fuels such as coal, oil, and natural gas cause serious problems on the environment and human health. Carbon dioxide (CO_2) emissions pollute the atmosphere, and deforestation worsens global warming. These energy sources are non-renewable and will eventually run out in the future (Ismail *et al*., 2015; Ausgrid, 2017).

Worldwide, the supply of fuel oil and gas is rapidly declining while the energy demands in Cambodia continue to increase. Approximately 6.9 million people in Cambodia cannot access reliable electricity. All villages are expected to access to electricity by 2020 but an estimated 820,000 households or at least 4 million people are still not expected to access power until 2030. Energy demand in Cambodia is increasing more than 20% annually. Domestic energy

sources are inadequate in Cambodia. The total electricity power used was around 5201 GWh in 2015, but Cambodia only produced 3,660 GWh for power consumption (WWF, 2016).

Cambodia depends on a mix of both renewable and non-renewable resources in order to meet its increasing energy demands. The aim of the following study is to evaluate the non-renewable resources currently in Cambodia; and identify potential renewable energy sources available for the use and development in Cambodia to ensure environmental sustainability

II. Power Generation by Sources

Cambodia generates power by many different sources.[1] Table 1 highlights hydropower, coal, diesel, and biomass in particular, and shows that the amount of diesel/heavy fuel oil for power generation has decreased since 2012 while hydropower and coal production have started to increase since the same year.

Table 1 Power generation by source **(**2015 Annual Report on the Power Sector of the Kingdom of Cambodia**).**

Year	Sources of Power Generation (GWh)			
	Hydro Power	**Coal**	**Diesel/HFO**	**Biomass**
2003	40.51	-	595.38	-
2004	28.42	-	714.81	-
2005	43.54	-	835.71	0.12
2006	50.61	-	1034.82	1.68
2007	49.71	-	1294.36	5.25
2008	46.28	23.36	1409.94	4.53
2009	47.43	28.03	1152.65	6.49
2010	31.73	32.08	989.73	5.82
2011	51.52	46.50	908.61	11.91
2012	517.37	37.42	856.56	11.75
2013	1015.54	168.75	578.99	6.68
2014	1851.60	863.02	326.97	16.79
2015	2159.64	2127.82	163.66	38.15

[1] The Electricity Authority of Cambodia (EAC) and EDC collect power generation data from all the stakeholders and GDE maintains the data: http://eac.gov.kh/wp-content/uploads/2016/10/Annual-Report-2015-English.pdf

In 2015, the majority of energy was generated from hydropower dams and coal power-plants in Cambodia. About 47% of hydropower was supplied to Cambodian people while 19% was based on coal imports (Fig. 1). Coal resource usage for power generation is increasing every year in Cambodia, and renewable resources are growing in popularity.

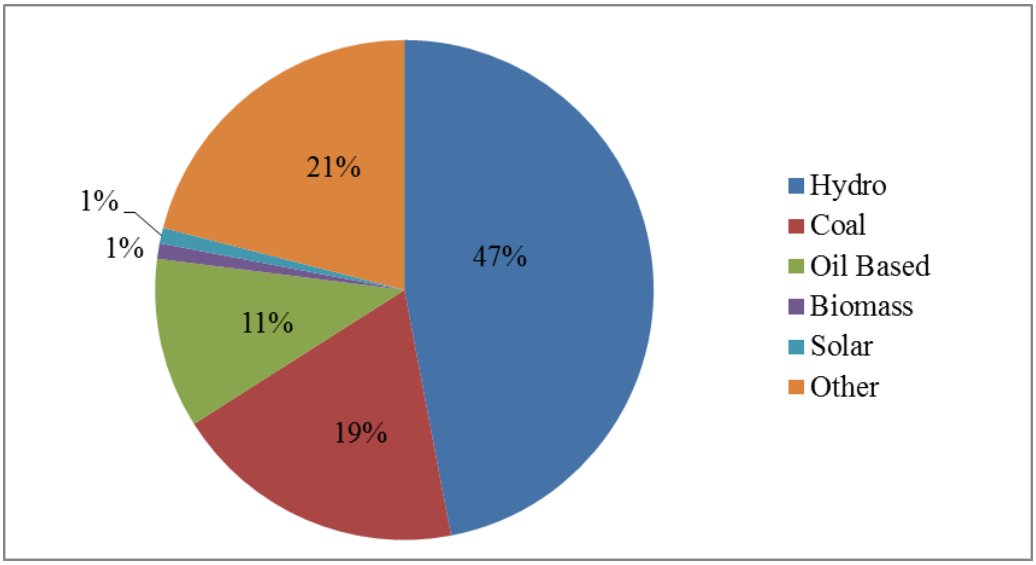

Figure 1 Power Generation (MME, 2016).

III. Imported Non-Renewable Resources

Whilst there is the possibility of gaining access to off- and on-shore reserves of fossil fuels, this potential has yet to be realised.

1. Coal

Coal consumption for power generation increased largely in 2014 and 2015 (see Fig. 2)[2] due to two major issues: the operation of new coal power plants (Sihanoukville 100 MW coal power plant and the first 270 MW coal power plants of the CIIDG Erdos Hongjun Electric Power Co.Ltd.), as well as the operation of a new cement plant in 2015. In fact, most coal consumption is allocated to the cement sector (ERIA, 2016).

The amount of coal consumption in the industrial sector more than doubled between 2010 and 2015 (Fig. 3). Coal combustion emits carbon dioxide into the atmosphere, which impacts climate change and human health. A World Bank report showed that CO_2 emission in

[2] Two types of coal data exist in Cambodia related to coal consumption for power generation and for the industry sector. The data are managed by Electricité du Cambodge (EDC), which collects coal consumption data from the coal power plants (managed by independent power producers or IPPs) and the General Department of Energy (GDE), Ministry of Mines and Energy (MME), which maintains the data.

Cambodia was 5574 kilotons in 2013 (ICMARKETS, 2013). According to the US Energy Information Administration (EIA), one ton of coal generates 2.86 tons of carbon dioxide (CO_2) into the atmosphere. The total of coal generation from both power generation and industry consumption was 1,029.49 kilotons in 2015. Thus, the amount of CO_2 emitted from coal consumption was 2,944.34 kilotons in 2015. Increasing the amount of CO_2 seriously impacts the effects of climate change due to greenhouse gases forbidding the infrared energy from the earth to the atmosphere.

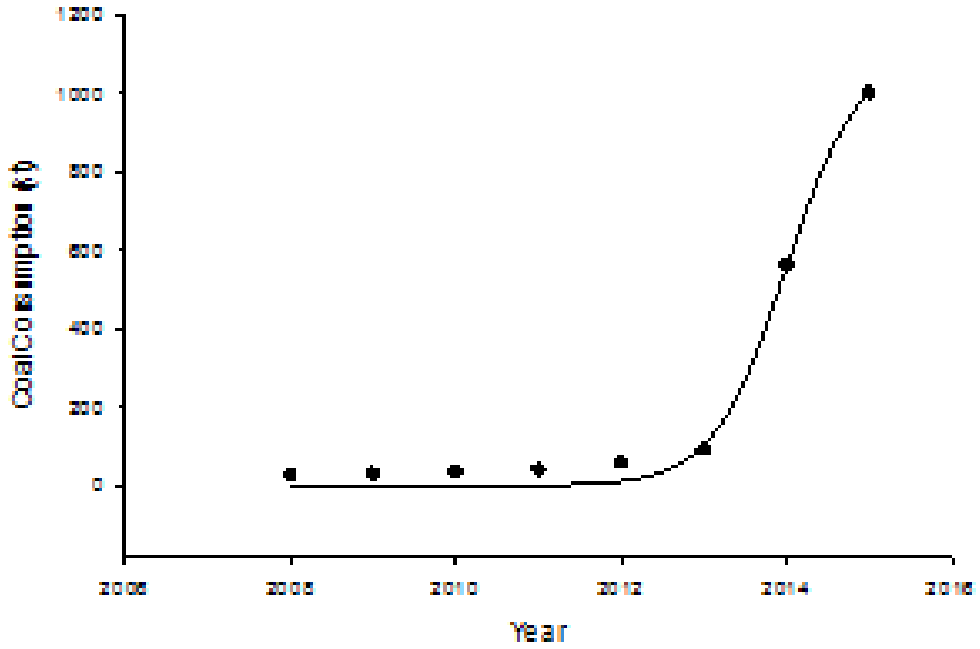

Figure 2 Coal consumption data for power generation in Cambodia

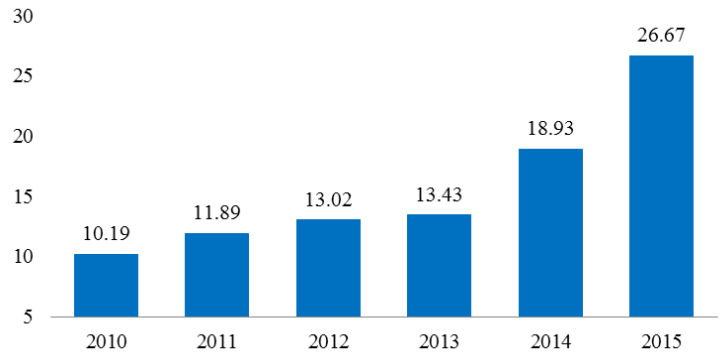

Figure 3 Coal consumption (kilotons) for power generation in the industrial sector.

The increase in power generation due to coal is due to the full operation of the 100 MW coal fired power plant operated by Cambodian Energy Limited in 2008, and a 270 MW coal fired power plant implemented by CIIDG Erdos Hongjun Electric Power Co. Ltd in 2014 (EAC, 2015). Moreover, a coal fire power plant that generates 150 MW is planned to be implemented at Preah Sihanouk province, which is headed by the Malaysian firm Cambodia

Energy Co. Ltd. The plant will be constructed by Toshiba, the first Japanese company to build a coal power plant in Cambodia (Kunmakara, 2017). The plant is expected to generate the electricity by 2019 (Vannak, 2017).

2. Oil

The amount of imported oil products in Cambodia has fallen since 2010, from 170 kilotons then to 43.03 kilotons in 2015. Diesel consumption also dropped from 6.05 kilotons to 1.46 kilotons. A report from the Customs Office shows that the petroleum products imported to Cambodia are Jet A-1: kerosene type jet fuel, motor gasoline, gas/diesel oil, fuel oil, lubricant, and liquid petroleum gas, all of which have been consumed for power generation. Energy sources have shifted from these oil-based products to coal power plants and hydropower (ERIA, 2016).

IV. Potential of Renewable Energy Development in Cambodia

The energy policy for the Cambodian government aims (i) to supply adequate energy at affordable rates, (ii) to ensure the reliability and security of electricity supply to facilitate investments and advance national economic development, (iii) to encourage the socially acceptable development of energy resources and (iv) to promote the efficient use of energy and minimize environmental effects resulting from energy supply and consumption. The renewable energy potential in Cambodia from solar, biomass and biogas, hydropower and wind generation combined together will be an estimated 87% of power generation in 2050 (WWF, 2016).

1. Solar energy

Solar energy resource development depends largely on the degree of solar irradiation and land area surface that is suitable for photovoltaic (PV) development and the efficiency of the solar energy systems. Cambodia has high degree of solar irradiation and large solar resource potential. Cambodia has a land area about 134,500 square kilometers that is suitable for photovoltaic development. Solar energy resource projects conducted by the Potential for Clean Development Mechanism Projects showed that solar energy in terms of electricity generation. The potential is about 7,470 GWh per year and an ADB pilot project in 2012 estimated that there is 10,000 GWh per year for solar energy resource potential in Cambodia (ADB, 2015). The solar photovoltaic power potential is estimated to be approximately 21 GWh per day (Sarraf, M. 2013).

2. Hydropower

Cambodia has many waterways for hydropower development. The technical potential of hydropower resource is estimated to be 8,000 MW by the Greater Mekong Sub-Region, 8,600 MW by Asian Development Bank, 10,000 MW by Ministry of Mine and Energy and 15,000 MW reported by JICA (Sarraf, 2013). Less than 10% of hydropower has been developed and around 50% of hydropower resources are located in the Mekong River, 40% on the Mekong River tributaries and 10% in the coastal area in Cambodia (WWF, 2016). More than 60% of energy in Cambodia currently depends on hydropower, but NGOs have been making an effort to conserve the environment due to the impact large-scale hydropower dams have in destroying biodiversity, natural resources and human health on people who live along the Mekong River. Hydropower plants generated 1,015.54 million kWh in 2013, and that increased to 1,851.60 million kWh the following year. About 42 potential hydropower projects have been developed with a total capacity of 1,825 MW which is generating roughly 9,000 GWh/year of electricity (WWF, 2016).

A hydropower dam, the Lower Seson 2 with the capability of 400MW, is being developed by China Huaneng Group at a total cost US$977 million. The construction is expected to be completed in 2017. In early 2016 the Ministry of Mines and Energy tried to mitigate hydropower problems by offering compensation and resettlement for one thousand families. Many of these families were displaced by the hydropower dam and rejected the proposed compensation property from the government, which was 80 m^2 and 5 hectares of plantation land, regardless of their existing property wealth. In the southeast part of Cambodia, the Stung Areng Valley has been studied for hydropower feasibility. However, the proposal of hydropower in Areng Valley has been strongly opposed by environmentalists and local communities in the area. The proposal has been postponed after it was protested by many groups of people. Prime Minister Hun Sen reported that the Areng Valley hydropower development would not be constructed due to data deficiency from the study. The Areng Valley will be conserved as an eco-tourism area which will preserve the land. A new coal fired power plant will be constructed in Preah Sihanouk province instead (Carlisle, 2017).

However, the scale of hydropower is projected to drop from 60% in 2014, to 47% in 2015, and to 40% in 2030. Large-scale hydropower plants impact local communities and ecology systems particularly in Koh Kong and Stung Treng provinces, as well as the downstream part of the Mekong River, which affects biodiversity resources. Some proposals of hydropower

were rejected and transferred to generate coal power plants due to these potential negative impacts on biodiversity, natural resources, and human environment.

3. Biomass

A few companies such as Angkor Bio Cogen Co. Ltd., Phnom Penh Sugar Co., Ltd, IED Invest (Cambodia) and Cam Chilbo Electric Power Co. Ltd used wood and agricultural products or waste to produce electricity in Cambodia. The electricity generated by biomass increased from 6.68 million kWh in 2013 to 16.79 million kWh in 2014, respectively. An ADB study in 2015 estimated that Cambodian biomass energy generation has the potential to produce 15,025 GWh/year, and biogas potential from livestock manure is 13,590,766 kWh/day (WWF, 2016). Biomass productions such as firewood, charcoal and biogas based on animal manure are consumed in Cambodia, particularly in rural areas. A small amount of firewood is still use in some industries in Cambodia for tasks such as heating boilers (ERIA, 2016). Power generation produced by biomass production has increased as can be seen in Table 2 and Figure 4).

Table 2 Final Consumption of Biomass (General Department of Energy)

Year	Sources (Tonnes)			
	Firewood		Charcoal	Biogas
	Residential	Industrial	Residential	Residential
2007	1,380,816	605,077	260,648	621.57
2008	1,441,482	631,661	272,100	1265.29
2009	1,480,823	648,900	279,526	1413.93
2010	1,501,030	657,755	283,341	2023.60
2011	1,566,978	686,653	295,789	2608.41
2012	1,631,058	714,733	307,885	2270.61
2013	1,700,601	745,207	321,012	602.65
2014	1,780,000	780,000	336,000	881.54
2015	1,806,735	842,347	341,047	881.54

4. Biofuel

Biofuel production in Cambodia was produced by rice husks. About 25% of this waste was used as fuel biomass. Cambodia generates approximately 1.6 million tons of rice husks a year. It was estimated that 1 million tons of rice husks could produce 60 MW of power. In

2014, the Malaysian company PMTI Energy (Cambodia) Co. Ltd. supplied 48,000 MW of energy to EDC produced from rice husks at a price of $0.09 per kW (Muyhong, 2014). Biofuel production has significant potential because 1,000 ha of jatropha, 4,000-10,000 ha of palm oil and 20,000 ha of sugarcane are available in Cambodia.

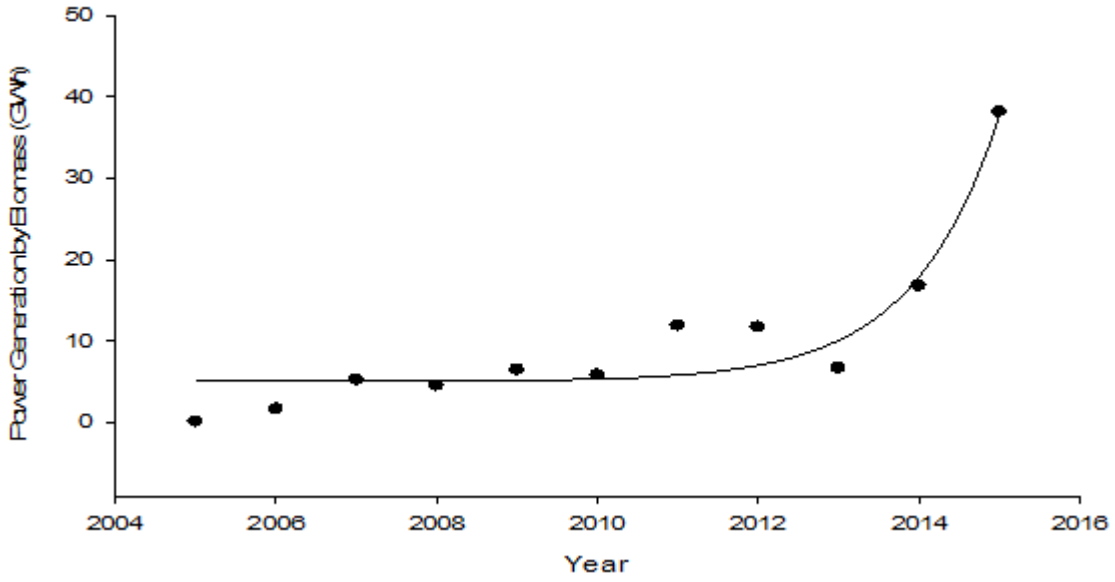

Figure 4 Power Generation by Biomass.

V. Conclusions

Cambodia currently used hydropower resources to produce electricity in the country. The large scale of hydropower dams has negatively affected the environment, ecological systems, biodiversity and natural resources. Moreover, it has affected human health, especially people living along the Mekong River. Cambodia is making an effort to reduce large-scale hydropower dams and instead operate small and medium-scale dams while implementing environmental impact assessments (EIA). Cambodia has reduced the use of fuel oil for power generation and substituted with coal production, which is imported from Malaysia. However, a large amount of coal production used to generate power also negatively affects the environment. Therefore, the Cambodian government and private sector must develop and implement potential renewable energy sources to increase access to power across the nation without serious consequences to the environment.

References

Asian Development Bank (2015) *Renewable Energy Development and Potential in the Greater Mekong Sub-Region*. Philippines.

Ausgrid (2017) *Sources of Electrical Energy*. NSW Department of Education and Communication. http://learnelectricity.ausgrid.com.au/Common/For-Students-in-Years-7-and-8/Sources-of-electrical-energy.aspx

Carlisle, P. (2017) Toshiba to build power plant in Cambodia. http://www.thailand-construction.com/toshiba-to-build-power-plant-in-cambodia/

EAC (2015) *Annual Report on Energy Sector, Phnom Penh*. Electricity Authority of Cambodia.

Economic Research Institute for ASEAN and East Asia (ERIA) and Ministry of Mines and Energy, Cambodia (2016), Cambodia National Energy Statistic 2016.

ICMARKETS (2013) Cambodia-CO_2 emissions (kt). http://www.tradingeconomics.com/cambodia/co2-emissions-kt-wb-data.html

Ismail A.M., Ramirez-Iniguez, R., Asif, M., Munir, A.B., Muhammad-Sukki, F. (2015) Progress of Solar Photovoltaic in ASEAN Countries. *Renewable and Sustainable Energy Review* **48**, 399-412.

Kossove, I. (2016) Renewable Can Replace Fossil Fuels by 2050: WW. *The Phnom Penh Post*, 31 March http://www.phnompenhpost.com/national/renewables-can-replace-fossil-fuels-2050-wwf

Kunmakara, M. (2017) Toshiba to build power plant. *Khmer Times*, 28 February. http://www.khmertimeskh.com/news/35908/toshiba-to-build-power-plant/

Muyhong, C. (2014) Rice Husks to Pump Energy to the Grid. *The Phnom Penh Post*, 10 September. http://www.opendevelopmentcambodia.net/news/rice-husks-to-pump-energy-to-the-grid/

Sarraf, *et al*., (2013) Renewable Energy Policies for Sustainable Development in Cambodia. *Renewable and Sustainable Energy Reviews* **22**, 223-229.

Vannak, C. (2017) Cabinet Approves Power Projects. *Khmer Times*, 20 February. http://www.khmertimeskh.com/news/35605/cabinet-approves-power-projects/

WWF (2016) *Power Sector Vision: Towards 100% Renewable Electricity by 2050*. Great Mekong Region Cambodian Report.