Chapter 7

Renewable Energy Development in Cambodia: Status, Prospects and Policies

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CHAPTER 7

Renewable Energy Development in Cambodia: Status, Prospects and Policies

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The central question of this study is how to accelerate renewable energy (RE) development in Cambodia in a sustainable manner. Based on international experience, setting a national target for RE's share is an essential part in guiding and inducing RE development. The supporting mechanisms of both financial and non-financial policies should be in place to achieve the national target effectively. Currently, the scale of RE deployment in Cambodia remains low, although there has been steady progress. Rather than focusing predominantly on hydropower and coal, the government should increase its efforts on the development of other REs (e.g., biomass and solar), as the vast potential has been under-utilised. The government should systematically expand RE promotion and information to the general public; especially those potential consumers who live in areas where publicly provided electricity is not available. Public financing is needed to aid the private sector to pioneer RE projects, because of the high upfront investment costs and the public bidding process ensures fair competition. Enhancing the data management of the RE industry, adopting a pricing policy, and relevant regulations are also required to build trust in the private sector to invest in RE projects and to integrate renewables based electricity into the national grid.

1. Introduction

Cambodia, officially known as the Kingdom of Cambodia, is located on the mainland of Southeast Asia and is bordered by Lao PDR, Thailand, and Vietnam. With a total population of approximately 15 million, of which approximately 80 per cent live in rural areas, the country is one of the poorest in terms of economic development and electricity accessibility throughout the region.

Cambodia's electricity demand has grown faster than what was projected. The demand has averaged 19.0 per cent per annum (p.a.), which is higher than the previous estimate of 12.1 per cent p.a. (REEEP, 2012). The consumption of electricity per capita has grown roughly seven per cent p.a. over the past five years (Prime Minister, 2013). Nonetheless, this growth rate is not sufficient for such a fast growing economy. Excluding the year 2009, when the economy was affected by the global economic downturn, the average economic growth rate during 2003-12 was 9.0 per cent p.a., according to the data received from the National Institute of Statistics (NIS).

The majority of the people, especially those living in rural and remote areas, still have no access to electricity. By 2011, while almost all the households in Phnom Penh (98.9 per cent) had access to on-grid electricity, only 23.5 per cent of total households in rural areas had access to publicly provided electricity (Prime Minister, 2013).

The diversification of power sources is a critical issue for Cambodia for expanding the rate of electrification and increasing the electricity supply. At present, the supply is constrained in terms of quantity and quality. Power is produced mainly by generators that use costly Heavy Fuel Oil (HFO), diesel, hydropower, and coal, the last two being the minor sources. Instability and inefficiency continue to be concerns for power distribution. These two factors create difficulties for households and businesses in addition to expensive electricity bills.

Cambodia is blessed with an abundance of renewable resources, which have great potential for power production. Situated in the middle of the Greater Mekong Sub-region (GMS), Cambodia contains major rivers and waterways, which are suitable for hydropower development. Given its geographical location, the country is also endowed with wind and solar resources that have not been exploited to generate electricity for industry or household consumption. Moreover, the agricultural sector has annually produced an abundance of residues that are suitable for electricity generation.

The development of Renewable Energy (RE) is a significant solution to accelerate power sector development. The crucial question–how to promote RE development–is vital and needs to be explored. In the context of regionalism, how Cambodia can develop the potential of its renewable resources and contribute to the domestic and regional Energy Market Integration (EMI) is an intriguing question.

Many studies on RE in Cambodia have been conducted, but studies on RE development in the context of regional integration are lacking. This study intends to bridge that gap in the current literature and more importantly; it aims to develop the policy implications for Cambodia's RE development. This study has three main objectives , which include:

- examining the current condition of the RE sector in Cambodia to identify the barriers, challenges, and possibility for RE development;
- examining international experience and using the lessons learnt to develop Cambodia's RE sustainably; and
- deriving policy implications to accelerate RE development in Cambodia and to enhance EMI in the region.

Reviewing the literature on RE development is carried out to create a foundation and to gather the essential data for analysis. Consultation with key informants is conducted to collect primary data, verify secondary data, and to acquire industry insiders' insights. A SWOT (strength, weakness, opportunity, threat) analysis is employed in the study as well.

This study is undertaken with the perspective of accelerating power sector development. RE development is essential for other sectors such as heating, cooking, and transportation. This study, however, focuses primarily on enhancing RE development in order to resolve concerns in the electricity sector.

2. Renewable Energy Development – International Experience

2.1. RE deployment

RE is considered the best alternative for power supply in terms of environmental friendliness and sustainability. RE is essentially produced from such resources as hydropower, wind and solar energy, biomass, biogas, biofuel, solid wastes, and geothermal energy. These resources have their own potential and require different extractive technologies, but they are fundamental in promoting the sustainability of power sector development.

Energy security, environmental concerns, and sustained economic growth are the essential drivers for RE deployment. The International Energy Agency (IEA, 2011a) indicated that RE deployment is driven predominately by energy security, the reduction of CO_2 emissions and environmental impacts, economic development, and innovation and industrial development.

RE development is increasing. Over the last five years, the IEA (2011b) found that the deployment of RE technologies has increased significantly around the world. It is no longer an interest typical of the countries in the Organisation for Economic Co-operation and Development (OECD) but of many other countries as well. China has become a leader in RE deployment.

RE development, however, faces critical barriers. According to the IEA (2011a), obstacles to RE deployment can be classified as techno-economic and non-economic barriers. The non-economic barriers include:

- regulatory and policy uncertainty;
- institutional and administrative issues.;
- the markets;
- finance;
- infrastructure.;
- the lack of knowledgeable and skilled personnel.;
- public acceptance; and
- environmental concerns.

Deployment difficulties are dynamic and vary from country to country. The dynamics relate to the maturity of a particular energy technology, the condition of domestic markets for that technology, and the status of global markets for that technology (Muller, *et al.* 2011).

RE production also requires different kinds of technologies and different levels of technological application, due to the distinctive types of renewable resources and diverse areas. In this regard, RE promotion policy plays an essential role in accelerating renewable technologies (Zhang and Cooke, 2009).

A conducive investment environment plays a crucial role in stimulating RE production. The European Renewable Energy Council (EREC, 2008) found that easing administration and regulation created a favourable environment for businesses and was beneficial to RE advancement.

The government supports RE market businesses through production subsidies that promote electricity generation from renewable resources. These subsidies contribute to the cost of electricity production from renewable resources, through either Production Tax Credit (PTC) or by subsidising the initial capital investment. This has a positive effect on RE production (Doner, 2007).

2.2. RE Policy

Regulators and policy makers have an essential role in promoting and accelerating RE deployment. One of their tasks is to enact policies or regulations that are conducive to RE deployment across the country. The IEA's *Renewable Energy Technology Deployment* (2012) stated that, "policy-makers play a key role in accelerating deployment of RE technologies by influencing near-and long-term planning and investment decisions through government policy."

Favourable policies and a regulatory framework are the underlying basis for diffusing RE deployment effectively. It also creates suitable conditions for the RE market. The IEA (2012a) found that supportive policies and a market framework in OECD countries stimulated a maturing portfolio of RE technologies, which led to an unprecedented expansion of global RE capacity.

Transitioning from a fossil fuel based economy to a renewables based economy requires an inclusive policy that commits the government to certain policy targets and close collaboration with the relevant stakeholders, especially the private sector.

Strong cooperation between policy makers and businesspeople can make the crucial change in the power system both timely and successfully (IEA-RETD, 2012).

Setting the national target for an RE share of total energy consumption is understood as a common policy agenda (EREC, 2008). As of 2009, RE policy targets exist in at least 73 countries worldwide, including all 27 European Union countries, the U.S., Japan, and developing countries such as China and India (Zhang and Cooke, 2009). There are also at least 64 other countries implementing specific support schemes (Pegels, 2009).

Policy action is a necessary instrument for RE deployment, as it is a guide to set the direction and drive the implementation. To accelerate RE deployment successfully, The IEA-Renewable Energy Technology Deployment (2012) proposed six policy acts called ACTION:

- *Alliance building*: Build alliances and reach agreements among policy makers and relevant stakeholders; including industry members, consumers, investors, and others
- *Communicating*: Communicate knowledge about renewable energy resources, technologies and issues to create awareness on all levels, address the concerns of stakeholders, and build up the needed work force
- *Target setting*: Clarify the goals, set ambitious targets on all levels of government, and enact policies to achieve those goals
- *Integrating*: Integrate renewables into policymaking and take advantage of synergies with energy efficiency
- *Optimizing*: Optimize policy frameworks by building on own policies or other proven policy mechanisms and adapting them to specific circumstances
- *Neutralizing*: Neutralize the disadvantages in the marketplace, such as misconceptions of costs and the lack of a level playing field

According to the Renewable Energy Policy Network for the 21st Century (2012), three types of policy devices are available for the government to promote RE development including financial incentives, public financing, and regulatory policies. Financial incentives are comprised of capital subsidies, grants or rebates, tax incentives, and energy production payments. The two financing strategies of public investment are loans or financing and public competitive bidding. Regulatory policies include Feed-in-Tariff (FIT), utility quota obligation, net metering, obligation and mandate, and tradable RE Certificate (REC).

2.3. Incentives for RE Development

Government granted incentives are imperative to promote private sector participation in the RE market because there are high costs and numerous risks associated with initial RE projects. Zhang and Cooke (2009) stressed that successful RE development was derived from the incentives set by central and regional governments. Many such incentives go directly to the developers of renewable energy projects, such as capital investment subsidies, tax incentives, and low-interest loans.

The appropriate arrangement of incentives for developing a functional RE market is an essential prerequisite to foster RE development. The IEA (2012b) emphasized that, “incentives are justified to compensate for market failure.” In its sustainability survey of 2011, which interviewed 551 qualified sustainability experts, GlobeScan (2011) found that four out of five experts thought governments should subsidize solar and energy efficiency initiatives to accomplish low-carbon energy.

Incentives for the government to support businesses are justified because there are exorbitant costs for businesses to initiate RE projects. It should, however, be reduced over time once the market has matured. It is also worth noting that different stimuli are required as there are a wide range of renewables at different stages of technological and market development (IEA, 2012b).

To attract financial investments from the private sector for RE development, the government must formulate policies that are beneficial for businesses by incentives and the market environment. Doner (2007) found that to maintain RE growth, government policies should be designed in a way that investors are given incentives to channel their finances into the development of RE technologies.

2.4. Case studies

2.4.1. China

Over the past three decades, China’s economy has averaged a growth of more than 10.0 per cent annually. During this strong economic performance, China’s energy demand has surged 13.0 per cent p.a., since 2001 and it accounted for 10.0 per cent of the global energy demand. Its share of global energy consumption has continued to rise to over 15.0 per cent, making China the second largest energy consumer in the world (Wang, Yuan, Li & Jiao, 2011).

Renewable energy development is a priority for China to satisfy its ever-expanding energy demands, mitigate CO_2 emission and pollution, and maintain a sustained economic development. Schuman and Lin (2012) pointed out that to further its low-carbon economic development strategy, China needed to enlarge the share of renewable energy in its energy mix. Wang, *et al*. (2011) agreed that expanding the RE share in the energy mix was a way to sustain economic development and reduce the negative effects on the environment and realise the target of reducing GHG emission by 40-45 per cent from 2005.

China aims to achieve a target of 10 per cent of RE of total energy consumption by 2010 and 15 per cent by 2020 (Schuman and Lin, 2012). The mid-term and long-term RE Development Plan 2007-2020 (REDP) also set specific targets of installed capacity for various RE technologies in 2010 and 2020 (Table 1).

Table 1: Installed capacity targets for China's renewable energies

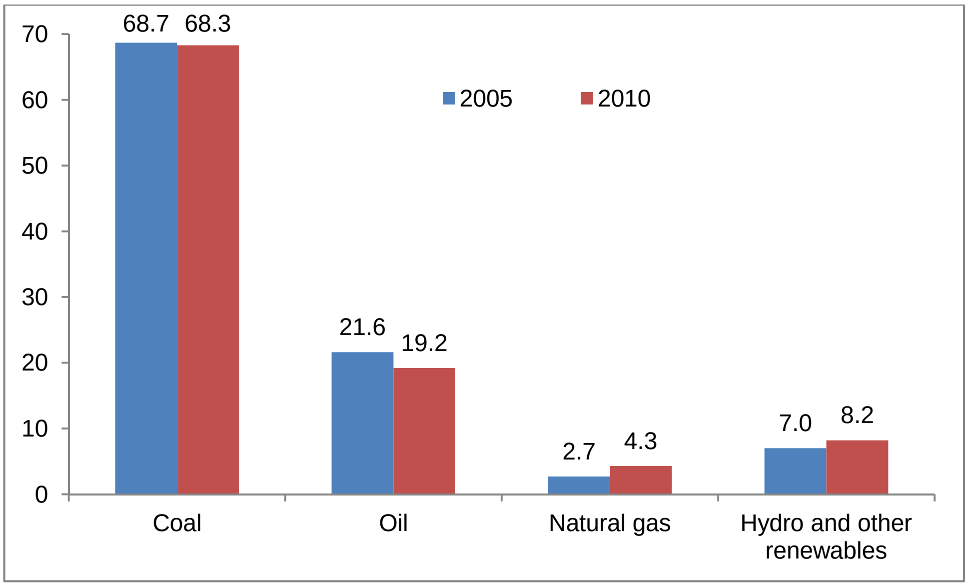
Type	2010	2020
Hydropower	190 GW (50 GW from small hydro)	300 GW (75 GW from small hydro)
Wind power	10 GW	200 GW
Solar PV	0.3 GW	30 GW
Solar water heating (SWH)	150 million m^2	300 million m^2
Biomass power	5.5 GW	30 GW
Bioethanol	3 million tons	10 million tons
Biodiesel	0.2 million tons	2 million tons
Biogas	19 billion m^3	44 billion m^3

Source: Compiled from Fourmeau (2009), APCO (2010), and Schuman and Lin (2012)

The ambitious target of RE's share of total energy consumption was almost met. The RE share in the total energy consumption rose significantly from 7.0 per cent in 2005 to 8.2 per cent in 2010, expanding 1.2 percentage points (Figure 1). The RE industry has developed quickly in recent years as well as the scale of equipment manufacturing for renewable energy. The research and development of industrialisation technology has also experienced a swift expansion (Zhang and Ding, 2012). Given this rapid expansion in RE share of total energy composition since

2006, China is placed among the leading countries in deploying renewable energy (Schuman and Lin, 2012).

Figure 1: China's Energy Consumption in 2010 by Sources (%)



Source: Li (2011).

The Renewable Energy Law (REL) and its associated regulations had a substantial impact on the growth of RE (Schuman and Lin, 2012). China's REL, which came into effect in 2006 and was amended in 2009, is the guiding policy directing RE development. The REL set out specific RE targets; a mandatory connection and purchase policy, on-grid electricity price for renewables, and a cost-sharing mechanism. The defined targets provided the consent to industry (including generators) grid companies, equipment manufacturers, and indicated to government officials at all levels that the central government supported RE development (Schuman and Lin, 2012).

A stimulus program of US $68,724 million was devoted to sustainable energy and released in late 2008 (Fourmeau, 2009). In addition to the feed-in-tariff (FIT) to incentivise investments in REs subsidies (e.g., Golden Sun program and the Building Integrated PV Installation program for solar energy), special funds for project developments are provided for various types of renewable technologies. Given the FIT measure that was announced in late 2009, wind energy has accelerated faster than the government anticipated and has more than doubled each year since 2005 (Schuman and Lin, 2012).

Policy and regulatory framework plays a vital role in promoting the RE industry and in expanding the RE share of total energy consumption. Financial incentives were also crucial to stimulate investments in RE including production, distribution, equipment manufacturing, and technology research and development.

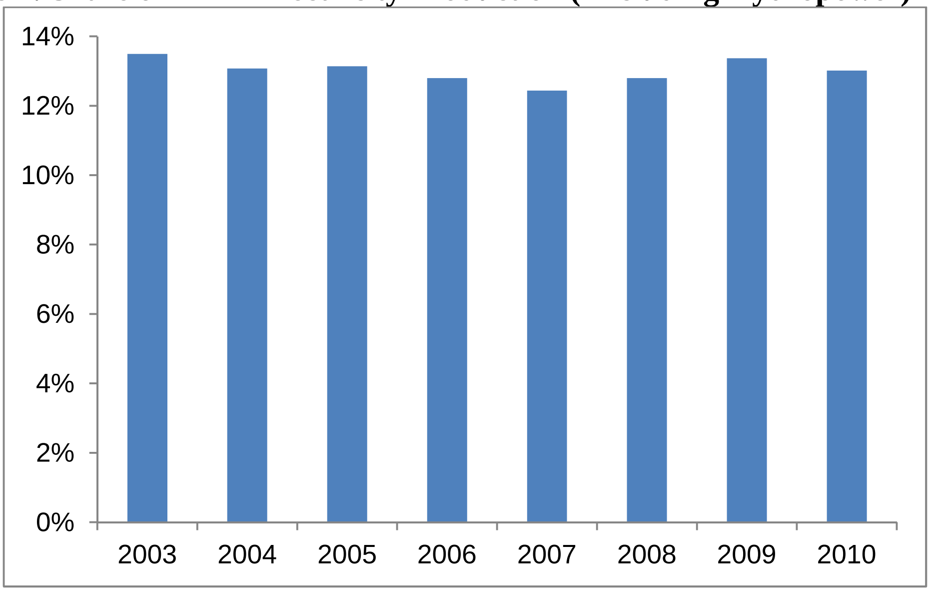
2.4.2. South Africa

South Africa is an emerging economy and a member of the BRICS group (Brazil, Russia, India, China, and South Africa). The economy gained a moderate growth of 2.8 per cent p.a. during 2010-12 after the economy had contracted by 1.5 per cent in 2009 due to the global economic downturn.

With a per capita GDP of US $3,825, electricity consumption per capita was 4,802.5 kWh in 2010 (WDI database, 2013). Although it is a middle-income country, a quarter of the total population remains without access to electricity according to the World Development Indicator (WDI) database.

In response to the global concern of greenhouse gas emission and energy security, the government of South Africa adopted the *White Paper on Renewable Energy* in 2003 to guide its RE development. The target of the policy was to produce 10,000 GWh of electricity from renewables including biomass, wind, solar, and small-scale hydropower by 2013.

Figure 2: Share of RE in Electricity Production (Excluding Hydropower)



Source: World Development Indicator Database (2013)

Winkler (2006) argued that financial support for renewables in the form of subsidies and tax incentives should be considered, but for a limited period.

In 2009, the Renewable Energy Feed-in-Tariff (REFIT) was introduced. With a guarantee of tariff payments for a period of 20 years (Pegels, 2009), the REFIT is, “a mechanism to promote the deployment of renewable energy that places an obligation on specific entities to purchase the output from qualifying renewable energy generators at pre-determined prices.”

Edkins, *et al.* (2010) pointed out that, “the REFIT has resulted in a great interest by independent power producers to develop renewable energy projects.” The impact of the REFIT program is clearly demonstrated by the instalment of more than 1,100 MW of wind energy, which is under firm development, as well as 500–600 MW of Concentrated Solar Power (CSP) and 0.5 MW from solar PV (Edkins, *et al*., 2010).

Within ten years of implementation, the target of 10,000 GWh by 2013 seemed unrealistic. However, since the announcement of the REFIT, it is conceivable that the renewable energy market in South Africa is set to go. Edkins, *et al*. (2010) projected that South Africa could achieve the set target by 2011 if the REFIT had been introduced into practice earlier than its current phase.

The projection showed that 4,700 GWh could have been supplied from biomass, 1,400 GWh from landfill gas, nearly 2,000 GWh from wind, 2,300 GWh from CSP, and about 100 GWh each from solar PV and small hydropower in 2011 (Edkins, *et al*., 2010).

Though the REFIT seems to be a productive mechanism, it has a crucial flaw. The state owned utilities Eskom is the unchallenged purchaser of electricity from all types of RE projects and responsible for distributing it to consumers. RE investments, however, are not secured because Eskom is not oblighed to buy the electricity produced from those projects (Pegels, 2009).

Consequently, the achievements remain far short of the policy target. Accelerating the implementation of the REFIT is a priority and reforming the existing electricity infrastructure as a means to encourage further investments in RE is required.

3. Cambodia's Electricity Sector Overview

As stated in the National Strategic Development Plan Update 2009-2013 (NSDP), the electricity sector is one of the Cambodian government's development priorities. The government aims to accomplish two policy targets: (1) by 2020, all villages in the country should have access to electricity; and (2) by 2030, at least 70 per cent of total households in the country should have access to quality grid electricity. Achieving these two main targets depends on the utilisation of all types of electricity sources and the participation from relevant stakeholders.

Electricity consumption has expanded significantly during the last decade. Per capita consumption of electricity reached 190 kWh in 2011, increasing almost four-fold from 54 kWh in 2005 (MIME, 2012). Practically all people in urban areas can access electricity from different sources, although price and quality remain crucial concerns. However, only a small fraction of the rural population has been electrified.

Electricity coverage remains low despite the progress that has been made. More than half of the total villages in the country have not been connected to transmission lines. Out of 13,935 villages, only 43.6 per cent have transmission lines in their villages (EAC, 2012b). The electrification rate grew to 34.1 per cent in 2011, which is up from 20.3 per cent in 2007 (MIME, 2012). Yet, more than 60 per cent of the entire population is still has no access to electricity.

Table 2: Electricity Sector in Cambodia at a Glance

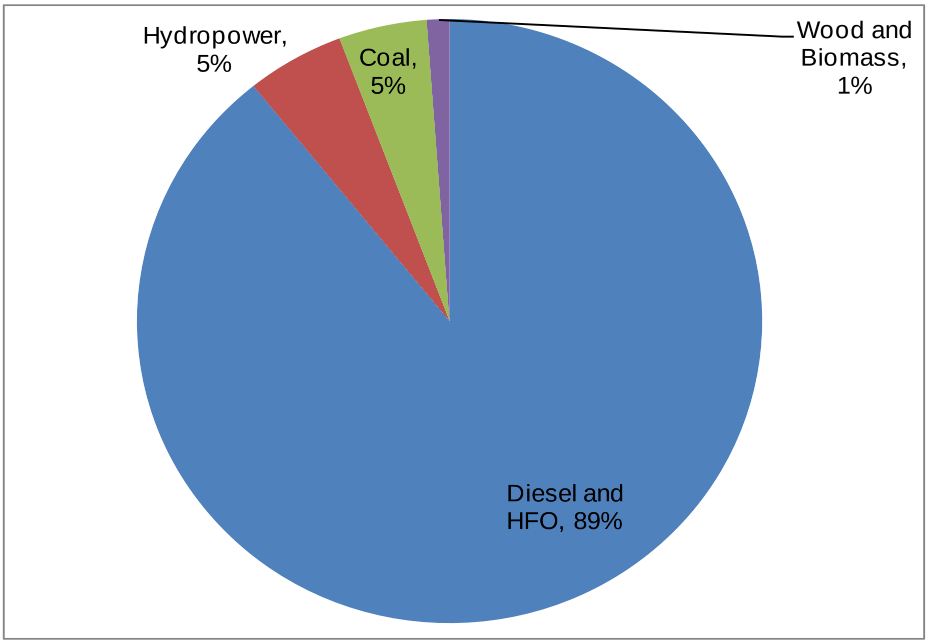
Description	Unit	2010	2011	% Change
Electricity generated	Million kWh	968.364	1,018.540	5.18
Electricity imported from Thailand	Million kWh	385.278	430.790	11.81
Electricity imported from Vietnam	Million kWh	1,155.409	1,392.396	20.51
Electricity imported from Lao PDR	Million kWh	5.749	6.599	14.79
Total electricity import	Million kWh	1,546.436	1,829.786	18.32
Total electricity available	Million kWh	2,514.800	2,848.326	13.26
Generation Capacity	kW	360,078	569,041	58.03
Number of consumers	#	672,709	810,984	20.55
Electricity sold to consumers	Million kWh	2,254.039	2,572.737	14.14
Overall loss	%	10.37	9.68	

Source: EAC (2012a).

Electricity transmission in 2011 was diffused by fragmented grids. A national grid incorporating 68.0 per cent of the total energy input would serve only 48.7 per cent of total consumers. This grid covers only a few areas of the country including Phnom Penh, Kandal, Kampong Speu, Takeo, and Kampong Chnang province. Other grids inputted by local electricity generators and imported from neighbouring countries supplied electricity to other parts of the country.

The installed electricity capacity in 2011 was 569 MW, expanding by more than half of the previous year's capacity due to newly introduced hydropower plants and other power plants. The installed capacity could generate electricity of 1,018.5 GWh. In 2011, electricity was generated from four types of facilities: (1) hydropower plants; (2) diesel power plants; (3) coal-using thermal power plants; and (4) wood/biomass power plants.

Figure 3: Electricity Generation by Types of Sources in 2011



Source: EAC (2012a).

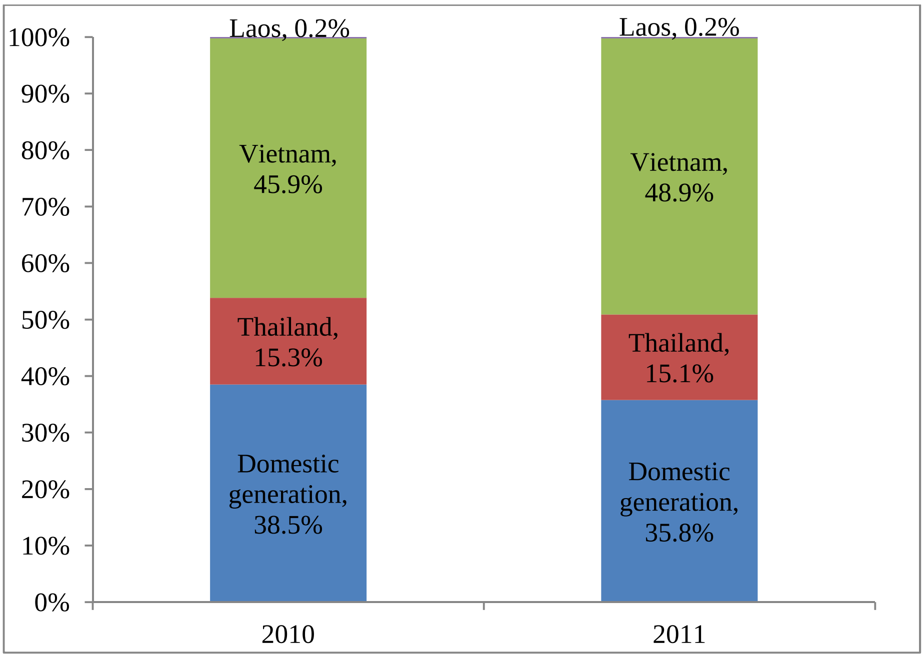
Nevertheless, domestic electricity generation remained substantially below electricity needs. Annual demand within the country grew at an average rate of 19.0 per cent. The demand, however, in Phnom Penh was 25.0 per cent (Jona, 2011). Electricity consumption in 2011 was 2,848.3 GWh, expanding 13.3 per cent from the previous year's 2,514.8 GWh. Given the limited domestic production, electricity is imported from three neighbouring countries, Lao PDR, Thailand, and Vietnam to satisfy the rising demand.

Cambodia is unduly dependent on electricity imports for domestic consumption. Total electricity imports represented more than half of the entire electricity consumption within the country. Based on the data from the Electricity Advisory Committee (EAC), Cambodia is highly reliant on electricity imports from Vietnam and Thailand, which have low electricity consumption in their own territories.

In 2011, Cambodia's total electricity imports expanded by 18.3 per cent, reaching 1,829.8 GWh. This accounted for 64.2 per cent of the total electricity supply within the country. Imports from Vietnam were 1,392.4 GWh and accounted for 76.1 per cent of total imports, while another 430.8 GWh and 6.6 GWh were from Thailand and Lao PDR with 23.5 and 0.4 per cent of the total imports, respectively.

In other words, while the domestic production of electricity was only 35.8 per cent of the total supply in 2011, imports from Vietnam accounted for 48.9 per cent, followed by 15.1 per cent from Thailand, and 0.2 per cent from Lao PDR.

Figure 4: Electricity Supply in the Country in 2010-2011



Source: EAC (2012a).

Cambodia's electricity tariffs are the highest in the region and in the world. The tariffs for industrial consumers range from US ¢11.71-14.63 per kWh and is the most expensive in ASEAN. The high rates of electricity tariffs make Cambodia less competitive in global and regional trade and investments.

The high tariff is because Cambodia's domestic electricity generation is highly dependent on oil and Cambodia is a net oil importer. Diesel and Heavy Fuel Oil (HFO) remain the main source for power generation, though power sources are quite mixed. Diesel and HFO comprise 89.0 per cent of the total power sources used to produce electricity in 2011 (EAC, 2012a).

Electricity tariffs vary considerably across the country due to the diverse sources of electricity supply. While only a small number of rural households are accessible to electricity, they pay higher tariffs than their urban counterparts. For the EdC grid, which is generally available in urban areas, consumers pay US ¢9-25 per kWh, while consumers in rural areas pay US ¢40-80 per kWh (Lieng, 2010). The differences in tariffs between the urban and rural areas are due to several factors; including different capacities of electricity suppliers, economy of scale, load factor, fuel transportation cost, cost of capital and financing, power supply losses, and high risk premium for rural consumers (Poch and Tuy, 2012).

4. Why Renewable Energy for Cambodia

The lack of electricity is unmistakable and almost two thirds of the total population is without access to electricity. Even the capital Phnom Penh suffers from electricity shortages due to higher than forecasted demand and the slow progress of investment in electricity generation. Electricity outages are quite frequent because the electricity needs to be cut off for a period in some areas to supply other areas. Phnom Penh's electricity demand in 2012 was 456 MW, while the supply could serve only 412 M, resulting in a deficiency of 44 MW.

Beside expensive tariff rates, electricity provision is not reliable. Diesel and HFO, the only main source of power generation, are imported from foreign countries. This makes electricity tariffs very high and exceedingly volatile, as they fluctuate with the price of imported oils. Due to the unstable supply from diesel and HFO based power plants, old facilities and voltage fluctuations the reliability of electricity supply remains a daunting challenge for the country.

Despite the fact that Cambodia is a low-income country, getting electricity is costly and only a fifth of the total population living in rural areas has electrical access. In addition, rural households spend on average 10.0 per cent of their income on fuel and electricity and have to spend roughly 3-4 hours per day on energy related activities such as collecting fuel wood, boiling water, and cooking (World Bank, 2009).

Electricity security is significantly at risk. Electricity supplies across the country rely predominately on imports from neighbouring countries. Moreover, domestic production, which is generated almost exclusively from diesel and HFO, is exposed to oil price shocks. Therefore, the country's economic activities are particularly vulnerable. More importantly, this situation has a considerable effect on political and social stability. Protests relating to electricity disconnection and tariff increases have been significant.

It is evident that Cambodia's power sector is narrowly based and the diversification of power sources is essential. Various renewable resources can play a key role in tackling the rising electricity demand and extend electricity coverage across the whole country. Furthermore, if they are able to push down the electricity tariffs, more households and businesses would have access to low-cost electricity.

The reduction of fossil fuel imports is critical, at least in the mid-term as long as domestic oil production has yet to materialise. This would lessen the country's vulnerability to oil price crises and maintain a macro-economic stability and sustained growth. Cambodia experienced an extremely high inflation rate of 25 per cent in 2008 due to the global oil price crisis. Moreover, reducing the use of fossil fuel is beneficial for mitigating pollution and the negative environmental impacts.

Climate change is a grave concern for the country's power sector development. The growing consumption of fossil fuels and the higher demand for sufficient energy supplies are a major cause of climate change (Abbaspour and Ghazi, 2013). To address such energy challenges as climate change, the growing demand for energy, and energy security renewable energy requires effective technologies (Zhang and Cooke, 2009). Renewable energy has the potential to mitigate the negative impacts of climate change and CO_2 emissions. It can also lead to a reduction in global warming (Toch, 2012).

Restructuring the power sector is indispensable if a greener growth is to be realised. The Cambodia Green Growth Roadmap and The National Policy and Strategic Plan for Green Growth 2013-2030 were enacted in 2010 and 2013. In order to achieve the envisaged green growth objectives, focusing on the utilisation of renewable resources for electricity generation is required. Furthermore, renewable resource development will help create green investments, jobs, and technologies that are correlated with green growth and environmental sustainability.

5. Analysis on Renewable Energy Development

5.1. Overview

Although Cambodia is endowed with huge potential, the RE share of total electricity production is at present minimal. According to the data compiled by the Electricity Authority of Cambodia (2012a), even including both large and small-scale hydropower and biomass the RE share could reach only 6.0 per cent of the total electricity generation in 2011. If large-scale hydropower (larger than 10 MW) was excluded, the RE share would fall to around 1.0 per cent.

Based on the Rural Electrification Master Plan (REMP), the government is intending to expand the electrification of rural areas through RE in addition to other options. There is, however, no specific target of how much renewable energy will share in the total energy mix by a particular deadline. This unspecified plan might be attributed to a greater focus on hydropower and coal power development.

The deployment of RE technologies remains at a low level and various RE projects are still in the pilot or demonstration stage (Toch, 2012). The people's acceptance of RE technologies is quite slow due to limited knowledge and inadequate information dissemination.

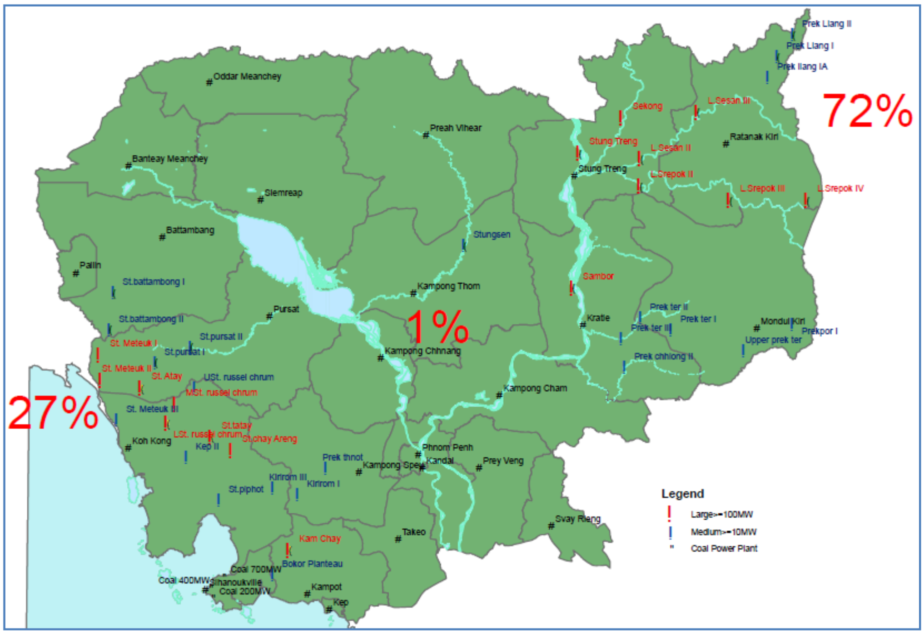
5.2. Renewable Energy Potential and Development

Cambodia has a variety of viable RE resources including hydropower, biomass, biogas, biofuel, solar and wind energy, to address the rising energy demand in the country. The Japan Development Institute (JDI, 2007) projected that if 10.0 per cent of alternative sources replaced imported fossil fuels in power generation, Cambodia would be able to save up to US $30 million by 2020. Nonetheless, these resources are presently underutilised, though hydropower has been progressively utilised.

1) Hydropower

The potential of hydropower is estimated at 8,600-15,000 MW of installed capacity, of which 90.0 per cent is located in the Mekong River basin and its tributaries. The remaining 10.0 per cent is in the southwestern coastal areas (CRCD, 2006b). However, according to the government (Figure 5), prospective hydropower is roughly 10,000 MW, of which 72.0 per cent is located in the northeastern region of the country, 27.0 per cent in the southwestern region, and another one per cent in other regions (Eav, 2011).

Figure 5: Hydropower Development Sites



Source: Eav (2011).

As of now, approximately 220 MW capacities have been installed, while 1,104 MW are under construction according to the data compiled by The Ministry of Industry, Mine and Energy (MIME) and EdC. Therefore, about 10.3 per cent of the total 10,000 MW has been exploited and many other projects are under feasibility studies. Most hydropower projects have been carried out under the Build Operate Transfer (BOT) modelled by Chinese companies.

Electricity demand by 2020 is estimated to grow to around 4,000 MW (Jona, 2011). Seventeen (17) hydropower projects have been proposed for development and they might meet at least half of the total estimated demand. The total capacity of the proposed projects is 4,048 MW, but this capacity is unlikely to deliver its maximum potential.

Hydropower plants' electricity supply is significantly vulnerable to seasonal variations in hydrology, weather pattern, and climate phenomena (e.g., droughts). Cambodia has two seasons, rainy and dry. The former is generally able to provide enough water to run hydropower plants. During the dry season, however, the country is very likely to run short of water for hydropower plants' operations.

The development of large-scale hydropower is indeed risky, not only for the electricity supply itself but also for socio-economic development and environmental sustainability. The alteration of the water flow is anticipated and fisheries production is expected to decline. As a result, the livelihoods of people will be affected. The extinction of species is anticipated due to accumulative impacts of proposed large-scale hydroelectric dams, particularly on the mainstream of the Mekong River (Worrell and Seangly, 2013).

According to the EdC in March 2013, the Kamchay hydroelectric dam, the country's largest hydropower station, was reportedly operating at 10.0 per cent of its total 190 MW capacity due to a water shortage. Because the station served almost half of the electricity supply to Phnom Penh via the national grid, electricity shortages and outages were a recurring problem. This has prompted the EdC to urge big businesses to use their own generators, which are very costly in terms of production and maintenance, to ease the electricity demand from the grid.

2) Biomass

Traditional biomass is composed of wood and charcoal and accounts for about 80.0 per cent of the total energy consumption in the country. It is primarily used for cooking in rural areas and by a small segment of households in urban areas. This has put considerable pressure on forests in Cambodia. Though the dependence on firewood has declined from 90.4 per cent in 1998 to 79.5 per cent in 2010, it remains far behind the national target of 52.0 per cent by 2015 (UNCSD, 2012). Encouraging people to use alternative energy sources (e.g., electricity and liquefied petroleum gas) for cooking is particularly challenging given the fact that almost one-third of the total population remains in poverty and live in rural and remote areas. Other energy sources are expensive and the electrification rate remains extremely low. Wood is also used in biomass combusting gasifiers for electricity generation, but it is not encouraged because it is not a renewable energy.

Rubber trees are also a wood based biomass that can be used for electricity generation. Proper planning is required to use this type of biomass material for power generation sustainably. Jona (2011) revealed that more than 25,000 tons of old rubber trees are available every year and rubber production is on the rise. As of 2011, the total number of rubber plantation regions reached 213,104 ha in which 45,163 ha, or 21.2 per cent, have been tapped (MAFF, 2012). The Ministry of Agriculture, Forestry and Fisheries (MAFF) expects that rubber plantation regions will increase to 300,433 ha in 2020 (MAFF, 2011).

An abundant amount of agricultural residue and the rapid growth of the agro-industry has resulted in growing biomass resources (modern biomass) available for power generation. As an agrarian economy, Cambodia grows many crops–the most important being rice–which produces a considerable amount of biomass materials. Other types of agricultural residues such as corncobs, peanut and coconut shells, and other kinds of plant husks are potentially usable for biomass combusting electricity production.

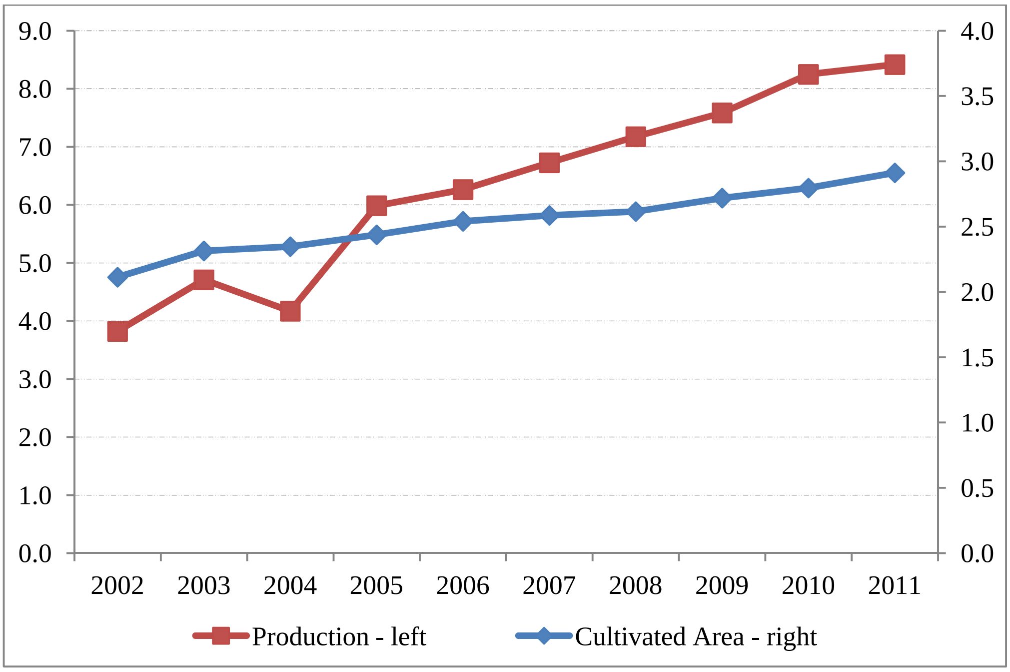
With 8.4 million tons of rice produced in 2011 (Figure 6), roughly 1.8 million tons of rice husks, or about 22 per cent of total rice milled in the country is available for power generation. Approximately 2 kilograms (kgs) of rice husks can generate nearly a kilowatt-hour. The total estimate of rice husks can generate around 924 million kWh of electricity, which is 32.4 per cent of the total electricity supply in 2011.

Although roughly two million tons of rice is exported from the country every year there remains more than one million tons of rice husk usable for electricity generation. Currently, the country exports about 0.2 million tons of milled rice. The government plans to expand milled rice exports to one million tons by 2015; this would require at least 1.6 million tons of rice surpluses after domestic consumption. Consequently, rice husk available for power generation will have to be expanded.

Given the significant potential of reduced production costs and increased savings, biomass combusting gasifiers have powered many industries; including rice milling factories, brick kilns, ice-making enterprises, garment factories, rural electricity enterprises (REEs), and electricity retailers in rural areas. Many rice-milling factories located in Battambang, Kampong Cham, Kampong Thom, Kampong Speu, Kandal, and Takeo province, have started using gasifiers to produce electricity for their own consumption and selling the surplus to households in their communities. The exact number of gasifiers being operated in the country is not available at present. By June 2009, with six suppliers of gasifiers, 126 gasifiers had been installed.

No formal arrangement has been agreed upon as to how the electricity surpluses from these producers are to be sold to the state owned utilities or other electricity wholesale distributors. Producers sell their surpluses through their own small grids or households contribute to the grid extension for electricity connection.

Figure 6: Rice Production (million tons) and Cultivated Area (million ha)



Source: Ministry of agriculture, forestry and fisheries (MAFF).

3) Biofuel

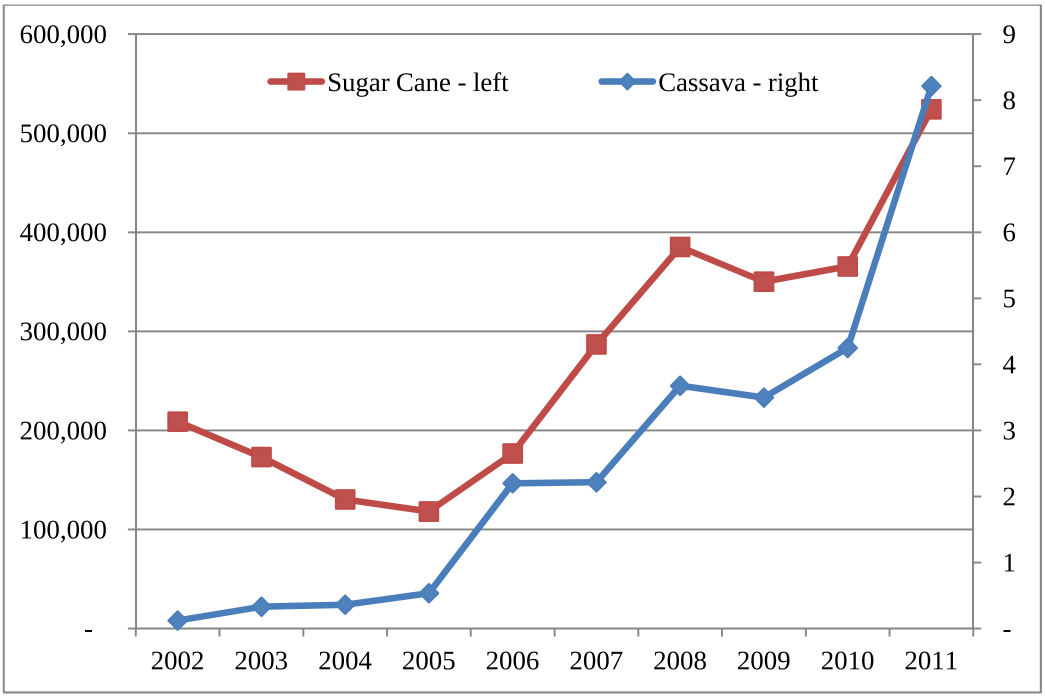
Cambodia has great potential for biofuels to replace fossil fuels and as long as the country prioritises the use of biofuels to meet internal demand over export, economic sectors would be less vulnerable to fluctuations in oil prices (ADB, 2012). A range of agricultural materials such as cassava and sugar cane provide substantial potential for biofuel production.

The JDI (2007) recommended that given its good soil and weather, Cambodia should plant cassava, as it holds considerable potential for biofuel extraction. Total cassava cultivated areas and production has increased rapidly over the last decade. These cultivated areas increased twenty-fold, from 19,563 ha in 2002 to 387,952 ha in 2011 and production expanded to 8.2 million tons, up from 0.1 million tons in 2002.

Cambodia's first ethanol shipment was sent to the European market in late 2008 by a Korean company, the first company to produce ethanol from cassava. Cambodia could export 9,600 tons of ethanol to Europe in 2009 (May, 2009). Ethanol production in Cambodia is primarily for export, because domestic consumption is not considered. Recently, production was not stable because the price of cassava fluctuates significantly, causing difficulties for a company's operation. Ineffective management of the company is largely responsible for this issue. At present, few companies are setting up their ethanol producing operations in the country.

Sugar cane production has also increased rapidly. While sugar cane can be processed into products such as sugar and ethanol, its bagasse is extremely useful for electricity generation. Cultivated areas expanded to 24,103 ha in 2011 and production was 524,126 tons. The total amount of bagasse was approximately 157,238 tons with 30 per cent from sugar cane processing, which can generate roughly 70,757 MW of electricity and was nearly 2.5 per cent of the total electricity supply in 2011. Sugar cane production is dispersed across the country but there is a concentration of production (e.g., sugar cane plantations via land concessions). More importantly, rural areas are more likely to get electrical access because they are located near the sugar plantations. Two plantations have already used sugar cane bagasse to generate electricity for their factories' operations and supply surpluses, although a small amount of power, to local communities. However, there is no policy in place on how the electricity surpluses are to be sold and fed into the national grid.

Figure 7: Sugar Cane (tons) and Cassava (million tons)



Source: Ministry of agriculture, forestry and fisheries (MAFF).

Biofuel production can also be extracted from around 1,000 ha of jatropha and 4,000-10,000 ha of palm oil (So, 2011). These two crops have significant potential for electricity generation using biodiesel in the country. As the price of fuel is on the rise and the current tariff of electricity is expensive, interest in cultivating biofuel or biodiesel to generate electricity is increasing. This is possible over the next 5-10 years, when an adequate electricity supply and a sharp drop of the tariff are not anticipated. A feasibility study was conducted to establish a power plant using biodiesel from jatropha seeds to supply electricity to Cambodia's Phnom Penh Special Economic Zone. How these resources can be extracted for biofuel production and thus electricity generation is not indicative.

4) Biogas

A number of projects have been effective with small-scaled biogas, though they are still in the pilot and demonstration stage. The conversion of waste material (e.g., animal and human waste) into high quality gas for cooking and electricity for lighting can deliver remarkable socio-economic, heath, and environmental benefits for poor and rural households.

A joint development program between Cambodia’s Ministry of Agriculture, Forestry and Fisheries (MAFF) and the Netherlands Development Organization (SNV), with the financial support of the Dutch Ministry of Foreign Affairs National Bio-digester Program (NBP), is aimed at establishing a market oriented biogas sector in Cambodia. More than 15,000 bio-digester plants have been installed since 2005 and an additional 23,000 units are anticipated by 2016.

The NBP provides a fixed subsidy of US $150 per unit for all plant sizes. Moreover, farmers who have the technical potential and credit worthiness can get a loan of up to US $1,000 from participating microfinance institutions. This program has exhibited a significant effectiveness that is due to several key factors. Farmers are convinced that their animal waste can be converted into gas for cooking and electricity for lighting and subsidies share a significant portion of the farmers’ financial burdens. The subsidies range from 37.5 per cent of the investment cost of small sized bio-digester ($4m^3$) to 16.7 per cent for the largest ones ($15m^3$). The quality of biodigester construction, training for farmer usage, and after-sale services also play a crucial role.

Though the government plans to disperse electricity transmission lines across the country by 2020, but not all villages will be able to connect to the grids due to economic inefficiency. Given the current pace of electricity generation and transmission development, biogas is expected to satisfy the growing demand for scarce products such as electricity and gas in poor and rural areas, where grid connection remains out of reach.

Adopting biogas over the grid is dependent on the cost of running biogas and the tariff of grid electricity, which is not expected to be reduced. A bio-digester has a lifespan of 10 years, which gives a household the ability to save up to US $1,400 and around 2,600 hours in collecting firewood (GreenSeat, 2013). Although a specific policy for the biogas sector has not been spelled out, the government plays a crucial role for alternative energies, including biogas in expanding electrification and reducing the forest dependency ratio.

5) Solar energy

Average sunshine duration in Cambodia is 6-9 hours per day and solar radiation is estimated at 5 kWh/ m^2 per day. This creates a huge potential for Solar Home Systems (SHS), solar Photovoltaic (PV), and Concentrated Solar Power (CSP). The total technical potential of solar power is 65 GWh per year (CRCD, 2004) but only about 2 MW of solar power has been installed so far (Toch, 2012).

The country's solar power is driven mainly by donor projects extending from pilot stages. With the assistance of the World Bank, the Bulk Purchase, and the SHS Installation project implemented by the government's REF, the goal is to install 30W and 50W SHS for 12,000 households in rural areas where mini or the national grid is not anticipated for the next 5-10 years. This subsidized project allows beneficiary households to repay the cost of system installation to the REF in instalments of up to four years. As of March 2012, the project has installed 11,975 units throughout eight provinces. Alongside this project, other solar powered solutions projects have been carried out by other donors; such as the Japan International Cooperation Agency (JICO), the Korean International Cooperation Agency (KOICA), the United Nations Industrial Development Organization (UNIDO), the Agence Française de Développement (AFD), and other NGOs.

A solar energy market is emerging. About 20 companies have been importing and selling solar products (e.g., solar panel, lantern, and lamp) in the country. Though these companies are typically targeting households living in areas where grid connection is not available, only a number of companies are active in rural areas.

The solar energy systems face a crucial challenge for acceptance by rural households. The upfront costs of solar powered solutions are significantly expensive and rural households are low-income or poor. Rural and poor people possess a limited knowledge while solar technologies are rather complicated and public financial support is not available to promote this fledgling sector. Poorly designed systems or poor quality solar products damage the reputation of solar technologies and the market.

The solar systems are not financially competitive with battery charging, which costs a household about US $2 per month for lighting. Though the import tax on solar components has been reduced from 30.0 per cent to 7.0 per cent since 2009, solar technologies remain costly for rural households. A SHS of 40Wp costs US $298 and can only generate 45 kWh per year and the 80Wp unit costing US $450 produces just 130 kWh per year (Picosol, 2011).

With a lifespan of approximately 20-25 years, the cost of electricity generated from the 40Wp SHS for lighting is roughly US $1 per month or US $0.26-0.33 per kWh excluding other maintenance costs. Moreover, the lifespan of a battery used with a solar system is about 3-4 years, so maintenance cost increases.

The uptake of solar power will expand as long as the cost of solar technologies decline to a level that is competitive with the current cost of the electricity tariff or battery charging in rural areas.

6) Wind energy

Wind speeds of at least 5 meters per second are available for electricity generation in the southern parts of the Tonle Sap River and coastal regions such as Preah Sihanouk, Kampot, Kep, and Koh Kong province. The Cambodian Research Centre for Development (CRCD, 2004) pointed out that wind energy could deliver a total electrical capacity of 3,665 GWh per year.

The development of this renewable resource is in the early stages. A few projects have been piloted in the northeastern and southwestern provinces. The first wind turbine, costing roughly US 1.74 million, is located in Preah Sihanouk province. It is co-funded by Cambodia's Sihanoukville port authority (48%), Belgium (28%), the EU (24%), and was inaugurated in January 2010. The pilot project was to demonstrate that wind power could be an effective energy source in Cambodia as well as in the region. The generated electricity is to supply the Sihanoukville port.

Since the resources remain untapped, investments in this sector are scarce. The private sector has not indicated that there is opportunity for investments. This can be attributed to a range of factors. First, the upfront investment is extremely costly. Second, policy direction and incentive schemes for development of the sector are not in place. Third, while electricity demand in Phnom Penh and other provincial towns is substantial, the areas to generate electricity from wind power are in the southern coastal areas and the national grid is not available yet.

Table 3: Summary of Potential Energy Generation and Saving

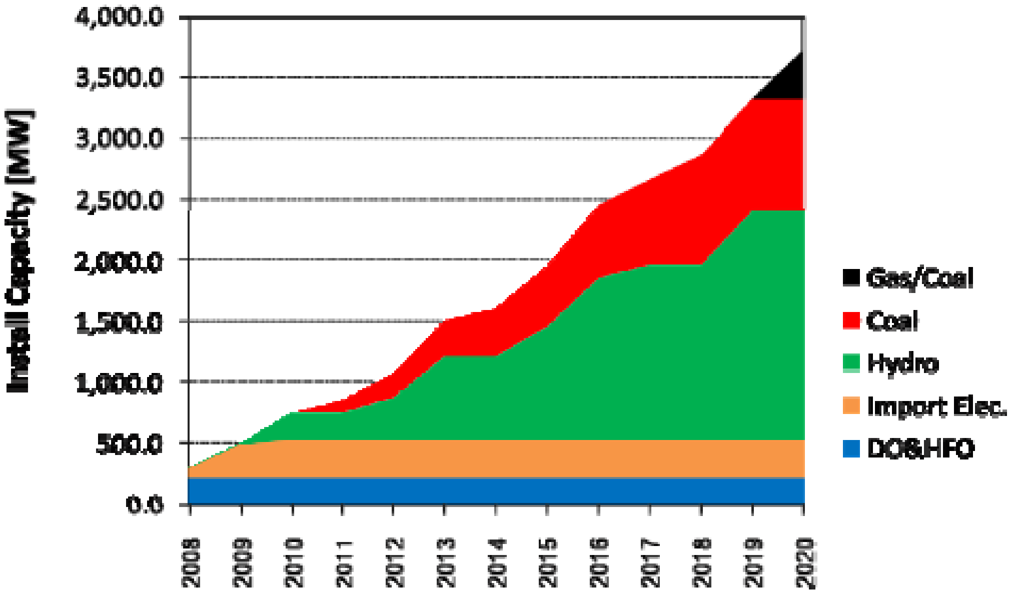
Energy Sources	Technical Potential (GWh/year)	Currently Installed Projects (GWh/year)	Theoretical Remaining Potential (GWh/year)	Potential Annual GHG Abatement (kton CO_2 equiv.)
Solar	65	1	64	44
Wind	3,665	-	3,665	2,556
Industrial energy efficiency	547	-	547	381
Residential energy efficiency	6,591	29	6,562	4,576
Total	**10,868**	**30**	**10,838**	**46,931**

Source: CRCD (2004).

5.3. Power Development Plan and RE Analysis

According to government projections, electricity demand in the country will reach almost 4,000 MW by 2020 (Figure 8). The Power Development Plan 2008-2020 indicated that hydropower would account for more than half of the total installed capacity by 2020, followed by coal, gas, imports, diesel and HFO. Electricity imports will be kept at roughly 250 MW per year and applies to electricity generated from diesel and HFO.

Figure 8: Power Development Plan 2008-2020



Source: Jona (2011).

If electricity demand increases to around 4,000 MW by 2020 as projected, the Power Generation Plan (PGP) over the period of 2011-20 is very likely to meet the estimated demand. Total installed capacity of the planned 29 projects in the Power Generation Plan 2011-2020 is estimated at 5,137 MW. As long as the planned projects are commissioned by 2020, combined with the existing capacity of 585 MW, the total electricity supply will reach 5,722 MW. The PGP is essentially focused on large-scale hydropower to meet the electricity demand by 2020. Out of the total 5,137 MW estimated capacity, hydropower will account for 4,261 MW (82.9 per cent), followed by coal (15.6 per cent), imports (1.4 per cent), and diesel (0.1 per cent).

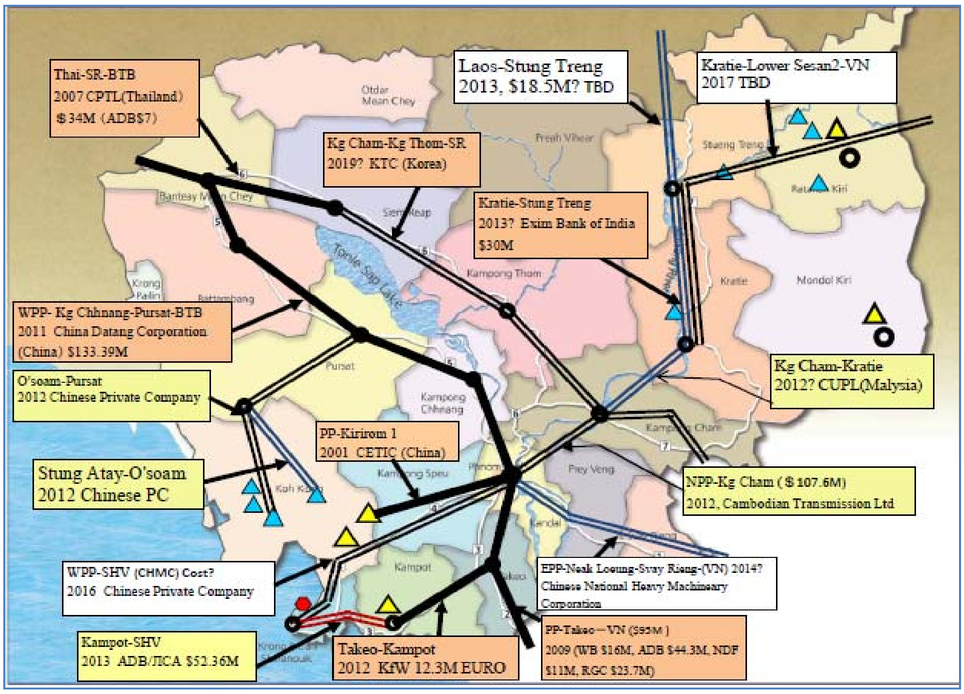
However, there remain risks. First, the feasibility of planned hydroelectric dams remains in doubts as hydropower projects on the Mekong River are subject to agreement by the other three Mekong River countries, Lao PDR, Thailand, and Vietnam. Second, due to the number of large hydroelectric stations on the upper Mekong River, the planned projects in Cambodia are not likely to produce at maximum capacity. Third, as explained in the hydropower section, the relentless concentration on hydropower is undeniably precarious for the country, especially in the current context of climate change. More importantly, when hydropower is the primary focus, the government abandons opportunities to develop alternative resources to achieve electricity development goals in a sustainable and equitable manner.

Cambodia can rely on power imports from neighbouring countries, but it should not depend completely on imports to power its fast growing economy while it holds considerable potential of energy resources. It can, however, import electricity to supply areas where domestic supply is inefficient (e.g., areas along its borders). Dependence on power imports is highly insecure for the country. On 22 May 2013, a wide spread power outage affected Phnom Penh for a few hours due to an electricity interruption in Vietnam (Chan and Henderson, 2013). Rather than being a power importer, Cambodia should utilise its potential energy resources to become not only power self-sufficient but also a power exporter in the region.

There is a role for RE to expand power generation and consumption. It can support power development given the deficiencies of large-scale hydropower projects. The government also needs to achieve the regional target of RE share by 15.0 per cent of total energy consumption by 2015.

Figure 9 illustrates the transmission development plan to create a national grid by 2020. The dark lines are current transmission lines and additional lines are in the planning stage. According to this scheme, some parts of the country are still left without connection to the national grid.

Figure 9: Transmission Development Plan 2020



Source: Hirata (2012).

By 2020, the total number of transmission lines will increase to approximately 2,106 kilometres (Jona, 2011). The transmission development plan consists of 17 projects for transmission lines to be built. This will expand the grid to cover the main parts of the country, particularly in areas of high population density, which are in the areas along the Mekong and Tonle Sap Rivers. Electricity distribution, however, to areas of low density remains a critical challenge because of the economy of scale and efficiency issues. For these reasons, electricity generated from renewable resources is the solution.

5.4. Barriers

The slow progress of RE development can be explained by the lack of accurate data. Another factor is that the accuracy and reliability of the data on RE resources is questionable due to the lack of scientific studies, systematic storage, and the update of data. The distrust of government among private businesses, related to potentially sensitive business data that could be used to extract higher taxes and fees or assist competitors, results in incomplete RE data (Williamson, 2006). Though some data are accessible, they need to be verified and updated in order to reflect the changes that occurred from the time the studies were conducted to the current situation so that real conditions are reflected.

Institutional capacity is undoubtedly a crucial barrier. The concept of RE has yet to be widespread among government agencies and relevant stakeholders. Well-trained professionals in RE technologies and development skills are not readily available in government agencies or the private sector. According to Toch (2012), the government has little experience in the development of RE resources. Moreover, relevant government agencies are deficient in resources and the technical capacity to collect data (Williamson, 2006).

Policy makers are not encouraged to implement renewable energy policies since there is an expectation that current electricity problems will be resolved by imports from neighbouring countries and by investments in large-scale hydropower and coal power plants. Oil and gas deposit are also anticipated to provide cheaper fossil fuels for electricity production in the country. This is termed the "high hope" barrier (Williamson, 2006).

An important barrier is technology stigma (Williamson, 2006). RE technologies are costly so as they are not prevalent in the country, while there are cheaper sources of energy available.

The lack of financial support is a barrier to RE development and public financing is not available. The government's national budget, which about half is financed by foreign aid and loans, doesn't allocate a particular amount for the promotion of RE production and deployment. Consequently, on-going RE projects are primarily financed by donors.

The lack of maintenance and management skills in RE equipment (e.g., solar PV products) is decisive barriers. The population in rural areas does not have a sufficient knowledge to maintain or repair RE products. Therefore they are reluctant to adopt the use of these products, which are now available through imports.

5.5. Policy and Regulatory Climate

The *Renewable Energy Action Plan* (REAP) and the *Rural Electrification Master Plan* (REMP) are the main policy papers that have been introduced since 2003 to promote RE development and utilization. The REMP emphasises the use of renewable energy to increase the supply of modern electricity services to the rural population.

To implement the Rural Electrification Policy, the government has established a Rural Electrification Funds (REF), which is an institution to promote the equity of access to electricity supplies. It also encourages the private sector to invest in a rural electricity supply in a sustainable manner and to encourage the use of renewable energy.

Since it was created in 2004, the REF has played a role in carrying out pilot renewable energy projects that are jointly supported by the government and development partners. Minimal progress has been made as this institution is short of human and technical resources and financial support from the government. Implementing projects to expand electrification and use renewable energy is mainly dependent on the funding from development partners.

Tax incentives are provided to encourage the private sector to engage in RE development. Since 2009, import taxes on solar PV components, biomass, and solar water heating components have been reduced from 30 per cent to seven per cent and from 15 per cent to zero per cent, respectively (Bun, 2012).

Referring to the power sector development plan, if both large and small-scale hydropower is considered renewable energy, the RE will account for more than half of the total energy production by 2020. The adopted policies, however, do not set out a specific target within a particular timeframe for the other types of renewable resources, such as biomass and solar power in the total energy mix.

Given the fact that large-scale power projects, hydroelectric and coal fired plants, are the main focuses until 2020, the government's incentive schemes are disproportionately directed towards these two types of power projects. The government provides guaranteed payments to hydroelectric and coal fired plant developers for generated electricity during the concession periods. As of early 2013, the government has provided guaranteed payments to 13 power projects in the country (Naren and Chen, 2013).

Incentive schemes are not available for other types of RE such as biomass and solar power. The solar power market has been predominantly driven by the electricity needs of people who are unable to access on-grid electricity. Increased solar PV installation is also stimulated by the two programs implemented by the REF and the MIME, which are funded by the World Bank and AFD, respectively.

6. Key Findings

RE deployment is on the rise. Energy security, environmental concerns, and sustained economic growth are the driving forces. Enabling the regulatory and business environment is fundamentally important to promote RE development. Supporting mechanisms via financial and non-financial policies are always a part of the national target setting, which is a common policy tool.

The experience of China and South Africa shows that a national target is beneficial in spearheading RE development. At the same time, other supporting policies are required to achieve the target by the prescribed deadline.

The scale of RE deployment in Cambodia remains low. To expand the electricity supply, substantial investments in hydropower are anticipated over the next decade and coal is another priority. The electricity generated from biomass combusting gasifiers is gradually growing among Small and Medium Enterprises (SMEs), especially in rural areas.

While the limited biofuel production has been primarily for export, biogas based electricity has been adopted for cooking and lighting by a small percentage of households in areas where publicly provided electricity is not available. The solar energy market has been emerging because a small portion of the total households in the country has access to electricity. Wind energy is in its early stages.

Though the demand for energy in the future is expected to be fulfilled by hydropower and coal power by 2020, there remains a role for RE. RE helps diversify power sources, reinforces hydropower, increases the power supply, hastens the electrification rate, and lessens power import dependency.

Feeding the power surplus from RE using producers (e.g., biomass) into the national grid is not available and the regulatory framework for the sale of electricity surpluses to communities or national grid is not defined.

RE development is obstructed by many barriers, such as the lack of accurate data, institutional capacity, government commitment and financial supports, and the people's awareness and acceptance.

The national target is not defined and the supporting policies are extremely limited. Though there is an emerging market, the lack of public effort and financing has resulted in slow progress for RE deployment.

7. Conclusion

The national target for RE's share of total energy consumption, or energy mix, is the primary instrument in guiding RE development. It is employed worldwide not only in advanced countries, but also developing countries such as China and South Africa. RE development requires the government's political will and actions in establishing a favourable business environment, effective institutions, and providing financial support.

RE is typically utilised for the electricity supply in Cambodia's rural areas, where power grids are not available, so electricity access cannot be expanded. A considerable amount of RE potential remains untapped, so there are ample opportunities for advancing RE development in response to the growing electricity needs and ultimately to achieve continued economic development and environmental sustainability.

Hydropower, together with coal power, will be major power sources in satisfying the power needs of Cambodia by 2020. The role of RE, however, will be significant because of the deficiencies of the major power sources, the increasing availability of RE resources such as biomass and biofuel, and the growing demand for power. Moreover, nearly two-thirds of the total population remains non-electrified.

Although there are many decisive barriers, the RE market is slowly emerging. An appetite for power, where the electricity grid is not available, prompts an increasing demand for RE technologies (e.g., solar PV, bio-digesters, and gasifiers). People's awareness, however, and the acceptance of RE technologies is a formidable barrier. Another critical barrier is the lack of government commitment and support.

The policy and regulatory framework is inadequate to promote RE development. The national target for RE's share in the energy mix is not specified by a particular timeline and the supporting mechanism is not enough to energise the RE market.

Integrating the power surpluses generated from renewable based producers is a decisive challenge. Pricing policies and regulations need to be adopted to promote RE development, to expand electricity access, and to reduce tariff rates.

8. Policy Implications

Implications for Cambodia:

Setting the national target for RE's share in the total energy mix is vital to spearhead government resources and efforts to mobilise the private sector's participation in RE development.

Financial incentives (e.g., subsidies and tax incentives) are essential to attract investments and encourage consumer usage. At the same time, public financing is needed to assist the private sector to pioneer RE projects, because of the high upfront investment costs and to ensure fair competition. Incentives, however, should be balanced and reduced over time as market conditions change.

FIT is proven to be a useful application in various countries including China and South Africa. It should be defined to promote renewable based electricity generation and to integrate that electricity into the national grid.

The business environment needs to be improved in order to attract investments in the RE industry. Enhancing the data management of the RE industry, adopting pricing policy, and relevant regulations are required to build the trust of the private sector so it will invest in RE projects.

The government, or the REF, should systematically increase RE promotion and information dissemination to the general public, especially those potential consumers who live in areas where the power grids are not available.

Rather than focusing exclusively on hydropower, the government should increase its efforts on the development of other REs, as the vast potential has been under-utilised.

The government should provide financial incentives to promote electricity production using biomass, such as rice husk and other plants husks. A policy to integrate the electricity surpluses generated from biomass into the national grid should be enacted.

Public financing and tax incentives should be channelled into the biofuel industry to promote production for either export or domestic consumption. A policy on how to use ethanol with diesel should be introduced to increase electricity generation from this renewable resource.

The government should augment its effort to increase public awareness and acceptance of biogas in daily cooking and lighting, particularly in the areas where the national grid has not reached.

The government needs to create a mechanism to control the trade and distribution of solar products in Cambodia to prevent the inflow of poor quality products that can ruin the reputation of solar energy technologies and thus the solar market.

The government should engage the private sector to participate in wind energy production through public financing, financial incentives, and regulatory policies, such as FIT.

Implications for EMI in East Asian Summit (EAS) countries:

To accelerate the role of RE in EMI, setting the target for the RE share in the energy mix in EAS countries is fundamental. Each country needs to commit to a specific target of RE share in the energy mix by a particular timeframe.

For the purpose of bridging the developmental gap, countries in the region should set up a mechanism for the technical transfer, cooperation, and the best practices for sharing to promote RE deployment in the region.

Capacity building should be at the centre of cooperation in the region. Less developed member countries are desirous of knowledge and the know-how to use RE technologies that are available in the market.

Given the fact that financing is the most crucial challenge, financial cooperation is a policy priority to help poorer member countries to embark upon RE development. This can be carried out through multilateral financing mechanisms.

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