Chapter 13

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Chapter 13

Renewable Energy Policies and the Solar Home System in Cambodia

Han Phoumin[50]

Abstract

Only about one-third of households in Cambodia have access to commercial energy. Full rural electrification remains far from being achieved, and energy services are mainly delivered through fuel-based engines or generators to produce electricity that can then be stored in batteries, while biomass rather than electricity is used to power many small industrial processes. The current electricity cost in Cambodia is very high, ranging from $0.15/kWh in Phnom Penh to $1.00/kWh in rural areas. This high cost of electricity in rural areas provides an opportunity for the Solar Home System (SHS) to be competitive, although the installed system price of SHS remains high despite a decline in global SHS prices. This study aims to (i) review the current renewable energy (RE) policies in Cambodia, and (ii) analyse the cost structure through the levelised cost of electricity (LCOE) of HSH compared with current electricity costs in rural areas. The results indicate that the LCOE of SHS (without any government subsidy) is about 50% cheaper than the current electricity price in rural areas. When factoring in a government subsidy of $100 per SHS unit, the LCOE of SHS drops to about one third of the current electricity price in rural areas. These results imply that promoting SHS would enable rural households to cut spending on electricity, thus increasing deposable incomes and social wellbeing of rural communities. Policy support for SHS is needed from the Royal Government of Cambodia to ensure that the upfront costs remain comparable to other countries. It is therefore important for the state-owned electricity utility, Electricité du Cambodge, and the Rural Electricity Department to look into the whole value chain of SHS from procurement through to installation. In order to achieve savings it may be necessary to make large purchases directly from manufacturers, and increase transparency in the bidding and procurement process, together with the removal of import taxes on Renewable Energy equipment, including SHS. Furthermore, providing training to local technicians and small business entrepreneurs will be necessary to promote the solar energy business in rural Cambodia. This will help to drive down the unit costs of SHS, and promote the widespread use and application of SHS in rural Cambodia.

Keywords: Government policy, Solar Home System, solar PV, rural electrification
JEL Classification: Q42, L11, Q48

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1. Introduction

Cambodia has achieved a stellar performance in terms of economic growth over the past decade, with an average annual gross domestic product (GDP) growth rate of 7.7% from 1994 to 2013, and an all-time high of 13% in 2005. However, growth also fell to a low of 0.1% in 2009 due to the global economic crisis.[51] This robust economic growth increased Cambodia's GDP per capita in purchasing power parity (PPP) terms from an average $1,797 per capita in 1993 to an all-time high of $2,945 in 2013.[52] Cambodia is expected to continue its rapid rate of GDP per capita growth, closing the gap with the Association of Southeast Asian Nations (ASEAN) peers such as Thailand and Viet Nam through the expansion of social, economic, and industrial development. Economic growth will be accompanied by an increase in energy demand across all sectors in Cambodia, but especially in the transportation, industry and services sectors (Kimura, 2014).

Cambodia's total primary energy supply (TPES) in 2011 stood at 5.33 million tonnes of oil equivalent (Mtoe), with oil representing the second-largest share of Cambodia's TPES at 26%, while coal was the third-largest at 0.2%, followed by hydropower at 0.1%. Others, mostly in the form of biomass, accounted for the bulk of about 74% of TPES (Lieng, 2014). Final energy consumption stood at 4.51 Mtoe in 2011. The country is dependent on imports of petroleum products having no crude oil production or oil refining facilities of its own. Cambodia's electricity supply is dominated by oil at 85%, with hydropower, coal, and biomass accounting for the remainder. However, Cambodia is still in the process of exploring for oil and gas, and it is expected that some off-shore oil production could be tapped by 2017 and one refinery may also be built.[53]

In 2013, only 34% of Cambodian households had access to electricity (IEA & ERIA, 2013), which is one of the lowest electrification rates in ASEAN. Rural electrification

[51] GDP annual growth rate in Cambodia is reported by the National Institute of Statistics of Cambodia.
[52] GDP per capita PPP in Cambodia is reported by the World Bank.
[53] The information obtained when the author had a discussion with a senior officer at the Ministry of Mines and Energy during his time providing assistance to the Ministry in the oil consumption demand in Cambodia 2014.

remains far from being achieved, and energy services are mainly delivered through fuel-based engines or generators to produce electricity that can then be stored in batteries, while biomass rather than electricity is used to power many small industrial processes. The current electricity cost is high, ranging from $0.15/kWh in Phnom Penh to $1.00/kWh in rural areas (MIME, 2005). The supply of electricity currently fails to meet basic demand, but is expected to grow from 1,643 megawatts (MW) in 2015 to 2,770 MW in 2020 (EDC, 2015). Although there is still considerable underinvestment in the sector, Electricité du Cambodge (EDC) aims to provide electricity services to all villages by 2020 and to 70% of all the rural households by 2030.

To accelerate rural electrification, off-grid solar systems are viewed by the Royal Government of Cambodia (hereafter, government) as a potential solution in providing rural people with access to electricity. Thus, the government established the Rural Electrification Fund (REF) in 2004 to attract and encourage the private sector to invest in electric power infrastructure so that rural areas can have access to electricity for lighting, commercial use, handicraft production and other purposes for improving standards of living and general wellbeing.

The government aims to promote renewable energy in its energy sector plan, targeting a 15% share of renewable energies (REs) by 2015. However, there has been no policy support to ensure that this target is achieved. No feed-in-tariff (FIT) system exists for REs and upfront costs remain a barrier in promoting REs. Currently, the government is looking into the possibility of the Solar Home System (SHS), but a long-term solar market has yet to be created.

This study aims to (i) review current RE policies in Cambodia, particularly on whether the policy on SHS is in line with policies to promote the energy access in rural areas, and (ii) explore various scenarios in the solar energy market by looking into the cost structure and estimating the levelised cost of electricity (LCOE) through SHS instalment. This will enable the involved authorities to decide whether such a project would be feasible and could be scaled up, given the fact that RE policies such as a FIT support policy are not yet in place.

The study found that Cambodia lacks an appropriate policy to promote renewable energy technology (RET). This means that policy support for RET, such as FIT and green certificates, among others, are absent and the solar energy business is expected to stand on its own feet. However, for SHS, a government subsidy is provided to reduce the upfront costs. Fortunately, the SHS in this study showed economic viability through its competitive LCOE. The results showed that the LCOE of SHS without any government subsidy is about 50% cheaper than the current electricity price in rural areas, but if including the government subsidy of $100 per SHS unit then the LCOE of SHS is about one-third of the current electricity price in rural areas. This study implies that promoting SHS would provide remote areas with energy access, and also enable residents in remote areas to reduce spending on electricity, thereby increasing deposable incomes and social wellbeing in rural communities.

This chapter is structured as follows. Section 2 describes the review of renewable energy policies in Cambodia, while Section 3 provides a review of agents funding and promoting SHS. Section 4 describes the methodology used in analysing the LCOE of SHS in the case of Cambodia. Section 5 analyses the results of the system price and the LCOE, and Sections 6 and 7 offer conclusions and policy recommendations.

2. Review of renewable energy policies in Cambodia

The Royal Government of Cambodia defined its energy sector development policy in October 1994 (Un Ning, 2010). Subsequently, this policy evolved into the Power Sector Strategy 1999–2016, with four objectives as follows: (1) to provide an adequate supply of energy throughout Cambodia at reasonable and affordable prices; (2) to ensure a reliable and secure electricity supply at prices that allow sufficient investment in Cambodia and the development of the national economy; (3) to encourage the exploration, and environmentally and socially acceptable development of energy resources needed as supply to all sectors of the Cambodian economy; and (4) to encourage efficient use of energy and to minimise detrimental environmental impacts resulting from energy supply and use. This strategy has guided the development and

policy framework of all energy sectors in Cambodia, including the Rural Electrification by Renewable Energy Policy, Renewable Electricity Action Plan 2002–12 (REAP), and the Energy Efficiency and Conservation (EE&C) goals.

In early 2001, the Electricity Law was passed with the following aims: (1) to ensure the protection of the rights of consumers to receive a reliable and adequate supply of electricity power services at reasonable cost; (2) to promote private ownership of the facilities for providing electric power services; (3) to establish competition wherever feasible in the sector; (4) to establish the Electricity Authority of Cambodia (EAC) to regulate electricity power services, granting it the right to penalise, if necessary, the suppliers and consumers of electricity in relation to electricity generation and supply facilities; and (5) to create favourable conditions for investment in, and the commercial operation of, the electricity power industry in Cambodia.

The EAC is an autonomous body set up to regulate and monitor the electricity power sector throughout the country. Its duties include issuing licenses, approving and enforcing performance standards for licensees in order to ensure quality supply and better services to the consumers, and determining tariff rates and charges for electricity power services that are fair to both consumers and licensees.

The Electricity Law also seeks to promote private investment and ownership of power facilities, and to encourage competition in the sector. The Electricity Law establishes the EAC as a legal public entity with the power to act as the regulator of power sector business activities, and also defines the roles of the Ministry of Mines and Energy (MME), formerly known as the Ministry of Industry, Mines and Energy (MIME). The MME is responsible for the overall administration of the energy sector. It is responsible for developing policies and strategies, power development plans, electricity trade with neighbouring countries, major investment projects, and the management of rural electrification. Together with the Ministry of Economy and Finance (MEF), the MME is the joint owner of Electricité du Cambodge (EDC).

EDC was established in 1996 as a state-owned company responsible for generating, transmitting and distributing electricity throughout Cambodia. Its main functions are supplying electricity, developing the transmission grid and facilitating the

import and export of electricity to and from neighbouring countries. The independent power providers (IPPs) are private companies that have received a licence from the EAC to generate electricity for public consumption. IPPs generate electricity and sell it on to EDC, which then distributes the electricity through the national grid.

In 2006, the government approved the Rural Electrification by Renewable Energy Policy. Its main objective is to create an enabling framework for renewable energy technologies to increase access to electricity in rural areas. The policy acknowledges the Master Plan Study on Rural Electrification by Renewable Energy in the Kingdom of Cambodia as the guiding document for the implementation of projects and programmes. The Master Plan envisions: (1) achieving full village electrification, including battery lightning, by 2020; and (2) providing 70% of households with electrification through the national grid by 2030. In addition, Cambodia aims to achieve 15% of rural electricity supply from solar energy and small hydro by 2015. The Master Plan also lays out clear targets, investments, and responsibilities, with 1,828,485 households to be connected to the national grid by 2020. An additional 260,000 households in very remote areas – too far from the planned grid extension – will be supplied through isolated mini-grids using diesel-generated power and/or renewable energy (220,000 households) and SHS (40,000 households). The total cost for expanding the rural grid is estimated at $1.37 billion. In the Master Plan, EDC will be responsible for the overall planning, development, investment, and operation of the rural medium-voltage (22 kilovolt [kV]) sub transmission lines and will partner with private rural energy enterprises (REEs) to expand, operate, and maintain low-voltage distribution and service lines (<0.4 kV).

The Energy Efficiency and Conservation (EE&C) goals submitted to the Fifth East Asia Summit Energy Ministers Meeting, held on 20 September 2011 in Brunei Darussalam, state that Cambodia will adopt the Final Energy Demand as its energy efficiency (EE) indicator, and aims at a 10% reduction from the 'business-as-usual' scenario by 2030. The action plans to achieve the EE&C goals cover the use of energy by industry, transportation, and commercial and residential users, such as the introduction of energy efficient equipment and EE labelling, as well as the promotion of EE awareness among the public.

3. Review of agents in funding and promoting solar systems

Currently, about 74% of energy demand is met by traditional biomass (Kimura, 2014). Rural areas are largely disconnected from the electricity grid and there is an urgent need to connect them through an off-grid power system. In this regard, SHS have been promoted since 2004 by the RGC. In Cambodia, there are few active agents involved in the promotion and marketing of SHS. These are listed below.

3.1. The government agent: Department of Rural Electrification Fund

The REF was established in 2004 by the government to accelerate the development of rural electrification. In 2005–2012, the REF utilised funds provided by the World Bank under the Rural Electrification and Transmission Project (RETP) and the government's counterpart fund. The RETP was a $46 million World Bank–funded project involving a $40 million loan from the World Bank and S$6 million provided by an International Development Association and Global Environment Facility Grant to the government (World Bank, 2012). The RETP aims were to (i) improve power sector efficiency and reliability, and reduce electricity supply costs; (ii) improve standards of living and foster economic growth in rural areas by expanding rural electricity supplies; and (iii) strengthen electricity institutions, the regulatory framework and the 'enabling environment' for sector commercialisation and privatisation. SHS is one of the sub-components of the project (roughly $5 million allocated for this sub-component) and involved the installation of SHS in 12,000 household during the project implementation.

The RETP was completed in 2012, at which point the SHS sub-component was assessed in terms of its economic return. The analysis shows that the LCOE from SHS is highly sensitive to under-utilisation. For example, with 4 hours of use per day, the 50 watt peak (Wp) and 30 Wp systems deliver electricity at around $0.75/ kilowatt hour (kWh) and $1.00/kWh, but these costs double if the system is used for only 2 hours per day.

To continue the work after the completion of the RETP, the government integrated the Rural Electrification Fund (REF) into Electricité du Cambodge (EDC) to allow the Department of Rural Electrification to perform its works independently using

Cambodian funding, while also continuing to receive grants and donations from external funding sources to assist in the development of rural electrification in Cambodia. In 2014 alone, EDC provided S$6 million for the operation of the REF and the implementation of three rural electrification development programmes consisting of: (i) the Programme for Power to the Poor (P2P); (ii) the Programme for Solar Home Systems (SHS); and (iii) the Programme for Providing Assistance to Develop Electricity Infrastructure in Rural Areas.

3.1.1. Power to the Poor (P2P) Programme

The purpose of this programme is to facilitate poor households in rural areas to have access to electricity for their homes from the national grid by providing interest free loans to cover: (i) the connection fees of the electricity supplier, (ii) a deposit payment to be deposited with the electricity supplier, (iii) the purchase of materials and labour for the installation of wires from the connection point to its house, and (iv) the purchase of materials and labour for the installation of in-house wiring. In 2014, 2,176 rural households were connected to electricity supply system.

3.1.2. Solar Home System (SHS) Programme

According to the World Bank (2012), the purpose of the SHS Programme is to facilitate remote rural households that may not have access to the electricity network for long periods to access electricity through SHS. SHS was one of the sub-components of the World Bank–funded REF project. However, the project was completed in 2012. In 2014–2015, the REF has resumed its function under the responsibility and oversight of EDC, and has sold and installed 13,240 SHS-50 Wp to rural households in remote areas (EDC, 2015). To facilitate the purchasers, ensure that the SHS installed in rural households operate well, and collect the payback amount in instalments from the purchasers, EDC has contracted BNP Power Green (Cambodia) Co., Ltd to provide transportation, installation, collection of payback in instalments, and maintenance of 4,000 systems.

3.1.3. Programme for Providing Assistance to Improve Existing and Develop Electricity Infrastructure in Rural Areas

The purpose of this programme is to facilitate private electricity suppliers in rural areas to obtain legal licenses to access funding for investing in the expansion of electricity supply infrastructure to fully cover their authorised distribution areas. In 2014, REF executed 72 contracts for providing assistance to improve existing and develop new electricity infrastructure in rural areas by 66 licensees.

3.2. Solar services providers

Based on a literature review, only a few agents exist to provide solar services in Cambodia. Currently, there are about a dozen agents but only a few of these are active, as follows.

Kamworks. This private company is a solar energy company that makes innovative products for off-grid populations in Cambodia and beyond. Kamworks has developed award-winning solar lighting, the Moon Light, as well as several other products. By setting up an assembly plant in Cambodia, Kamworks aims to transfer technology and provide better services to its clients. Kamworks was established in 2006 with an annual budget of $30,000. It has about 25 staff, with 1 to 5 volunteers. In 2006, it received seed funding of $175,000 from the World Bank, and later it won a contract from the World Bank worth of $500,000 to install 12,000 SHS in Cambodia.

Crédit Mutuel Kampuchea (CMK). This is a mutual saving and loans cooperative that provides credit for solar energy but has no specific loan products. However, CMK has a memorandum of understanding with the supplier Kamworks to provide products and services.

Up to now, only a few other organisations such as VisionFund, Yejj Solar (NGO), International Solar Solutions (Enterprise/Supplier), Khmer Solar (Enterprise/Supplier), and Kamworks (Enterprise/Supplier) are involved in funding solar energy, and no other institutions intend to enter the sector (World Vision, UNEP, and Frankfurt School, 2012).

4. Methodology of analysing LCOE from solar PV in Cambodia

A literature review into the financing of solar photovoltaic (PV) in Cambodia offers scant information on how solar PV might play a role in the country's power generation mix. As is often the case elsewhere, in Cambodia the funding of SHS has been on a small scale with only modest subsidies from the government.

World Vision, UNEP, and the Frankfurt School (2012) conducted a detailed feasibility study of 401 clients on access to financing for RE appliances for the rural poor in Cambodia. This study found that despite the lack of awareness of RE in general, almost 70% of those interviewed were willing to take out loans to purchase solar energy systems. This suggests that solar energy could have a potential market in Cambodia. Based on these findings, the study will undertake further analysis of economic feasibility in terms of the LCOE provided by solar PV.

For the system cost of SHS, the study is based on the findings of a World Bank project implementation completion report (World Bank, 2012). The report indicates there are two sizes of SHS rooftop rated capacity, namely 30 Wp and 50 Wp, and the system costs are $260 and $333, respectively. When SHS was first introduced, no subsidies were available, but subsequently a $100 per unit subsidy was made available for the upfront cost of purchasing the SHS. Because of the high cost of electricity in Cambodia, this provided an opportunity for SHS to gain a foothold in the market. Average daily sunlight in Cambodia is about 5 hours. However, this study uses 4 hours per day to avoid overestimating annul electricity production from SHS.

Given that rural areas in Cambodia have limited access to finance this study uses a simple methodology by not considering discounting rates in the analysis of the LCOE. The rationale for using a simplified methodology is that the calculation adopted a 0.5% rate of annual degradation of electricity production while keeping a fixed tariff rate at $1.00/kWh. With this in mind, the LCOE could be derived as follows:

$$LCOE\ without\ subsidy = \frac{\sum_{year=1}^{10}(Overnight\ Capital\ Cost + O\&M\ Cost)}{\sum_{year=1}^{10} Electricity\ production \times Annual\ \deg radation\ rate}$$

$$LCOE\ without\ subsidy = \frac{\sum_{year=1}^{10}(Overnight\ Capital\ Cost + O\&M\ Cost) - Subsidy\ Cost}{\sum_{year=1}^{10} Electricity\ production \times Annual\ \deg radation\ rate}$$

Note that solar PV has no fuel costs. As such, $Electricity\ \Pr oduction = 8760 \times Capacity\ factor$.

The capacity factor is 4 hours per day to reflect average daily sunlight available. The annual degradation rate is set at 0.5%.

5. Results and analyses of the LCOE from solar PV in Cambodia

Using the above methodology, the study used the LCEO results to compare different system sizes, both with and without government subsidies. The results of the LCOE analysis in Table 13.1 show that the LCOE is $0.61/kWh for a system size of 30 Wp without a government subsidy, and $0.38/kWh for a system size of 30 Wp with a government subsidy of $100 per unit to cover upfront costs. These results suggest that SHS is far more competitive than the current local diesel-engine service providers in rural areas that charge an electricity price of up to $1.00/kWh.

Table 13.1: Comparisons of LCOE with and without Government Subsidies (system size of 30 Wp) over a 10-year period

System Inputs	
System Size (kW-DC)	0.03
1st-Year Production (kWh)	44
Annual Degradation	0.50%

Direct Purchase Inputs Without Subsidy	
Cost (US$/W)	8.660
Initial Rebate/Incentive	US$
O&M Cost (US$/kW)	10.00
O&M Escalator (%)	3%

Current electricity tariff	
Tariff (US$/kWh)	1.00000
Tariff Escalator	0.00%

LCOE	
10 Years	US$ 0.6146

System Inputs		
System Size (kW-DC)		0.03
1st-Year Production (kWh)	44	
Annual Degradation		0.50%

Direct Purchase Inputs With Subsidy		
Cost (US$/W)	8.660	
Initial Rebate/Incentive	US$ 0	10
O&M Cost (US$/kW)	10.00	
O&M Escalator (%)		3%

Current electricity tariff		
PPA Rate (US$/kWh)	1.00000	
PPA Escalator		0.00%

LCOE with US$100 Subsidy for Upfront Cost	
10 Years	US$ 0.3811

DC = kW = kilowatt; kWh = kilowatt hour; LCOE = levelised cost of electricity; O&M = operations and maintenance; PPA =purchasing power parity.
Source: Author's calculation.

Table 13:2: Comparisons of LCOE with and without Government Subsidies (system size of 50 Wp) over a 10-year period

System Inputs	
System Size (kW-DC)	0.05
1st-Year Production (kWh)	73
Annual Degradation	0.50%

Direct Purchase Inputs Without Subsidy	
Cost (US$/W)	6.66
Initial Rebate/Incentive	US$ 0
O&M Cost (US$/kW)	12.00
O&M Escalator (%)	3%

Current Electricity Tariff	
Tariff (US$/kWh)	1.00000
Tariff Escalator	0.00%

LCOE	
10 Years	US$ 0.476

System Inputs	
System Size (kW-DC)	0.05
1st-Year Production (kWh)	73
Annual Degradation	0.50%

Direct Purchase Inputs With Subsidy	
Cost (US$/W)	6.66
Initial Rebate/Incentive	US$ 100
O&M Cost (US$/kW)	12.00
O&M Escalator (%)	3%

Current Electricity Tariff	
PPA Rate (US$/kWh)	1.00000
PPA Escalator	0.00%

LCOE with US$100 subsidy for the upfront cost	
10 Years	US$ 0.3360

DC = kW = kilowatt; kWh = kilowatt hour; LCOE = levelised cost of electricity; O&M = operations and maintenance; PPA =purchasing power parity.
Source: Author's calculation.

Likewise, the results in Table 13.2 show that SHS with a system size of 50 Wp is also highly competitive compared with the current diesel-engine electricity service providers in rural areas. With a system size of 50 Wp, the LCOEs are $0.33/kWh and $0.47/kWh with and without a government subsidy, respectively. With still larger system sizes, the LCOE becomes lower still, as seen in Tables 13. 1 and 13.2.

For this study, the calculated installed system price is $8.6/W and $6.6/W for 30 Wp and 50 Wp system sizes, respectively. However, global experience shows that the

installed system price of solar PV (that is, below 10 kW) for residential and commercial use was about $4.7/W in 2013, and expected to decline further to $2–$3/W in 2014 (Feldman et al., 2014). This indicates that the SHS installed system price remains excessively high in Cambodia and needs to fall over time to reflect the global market price of SHS.

In Cambodia, there is no policy support such as feed-in-tariff, net-metering, or green certificates. Thus, global experience offers Cambodia some examples of how solar PV business models can promote the uptake of solar PV and help more villages to become electrified.

6. Conclusions

Energy access remains a fundamental development issue for Cambodia, as electricity costs are high in both urban and rural areas. Because of prolonged underinvestment in the electricity sector, Cambodia's electrification rate as just 34% in 2013. Despite the passage of the Electricity Law more than a decade ago, Cambodia's electricity sector has not developed fast enough to meet demand in either urban or rural areas. The government, in its rural electrification master plan, has realised the adverse consequences of high electricity costs, as well as the importance of accelerating electricity access in rural areas. Based on the master plan, 70% of households will be connected to the national electricity grid by 2030. In the medium term to 2020, the master plan foresees an increase in mini-grids from small hydropower and solar PV systems, including SHS, to provide electricity access in rural areas.

About 12,000 households installed SHS in the period 2005–2012 under the Rural Electrification Fund (REF) established by the government to accelerate the development of rural electrification. However, the REF project was completed in 2012. In 2014–2015, the REF has resumed its work and sold and installed 13,240 SHS-50 Wp to rural households in remote areas. Electricity costs in rural areas charged by current electricity providers using diesel generators can be as high as $1.00/kWh, which provides an opportunity for SHS to enter the market, although the upfront costs of SHS remain high

compared with other countries. The study found that the LCOE of SHS without any government subsidy is about 50% cheaper than the current electricity price in rural areas. With a government subsidy of $100 per SHS unit, the LCOE of SHS falls to about one-third of the current electricity price in rural areas.

The installed system price of SHS is about $8.6/W and $6.6/W for 30 Wp and 50 Wp systems sizes, respectively. This is relatively high cost compared with global experience where installed SHS prices are only $2–$3/W. Given the high cost of electricity in rural areas, SHS remains competitive. These results imply that promoting SHS will provide remote areas with energy access, and also enable residents in remote areas to reduce spending on electricity, thereby increasing deposable incomes and the social wellbeing of rural communities.

7. Policy recommendations

The findings in this study point towards the following recommendations:

7.1 **High cost of installed SHS.** The high installed system price of SHS is one of the obstacles in promoting the uptake of solar PV. It is recommended that the involved authorities such as the Electricity Authority of Cambodia, Electricité du Cambodge, and the Department of Rural Electricity might look at the whole value chain of SHS from procurement through to instalment to ensure that transition costs are minimised in order to reduce the system price. It may be necessary to make large purchases of SHS directly from manufacturers, and create an effective and transparent procurement process in RE equipment, including solar PV and SHS.

7.2 **Mini-grids from solar PV.** The electricity authorities might consider attracting investment in mini-grids supplied by solar PV, as these would provide economies of scale compared with SHS. Mini-grids supplied by solar PV systems offer lower system costs than SHS. However, there is also a need to look at the whole value chain of mini-grids, from procurement through to instalment. The authorities

should also explore the possibility of FIT or net-metering policies if they wish to promote this option.

7.2 **Competitive SHS.** Although the upfront system price remains high, the LECO suggests that SHS remains competitive given high electricity prices in remote areas. Thus, it is crucial to scale up SHS in remote areas. This will require promoting SHS in rural Cambodia through the capacity-building of local technicians and small business entrepreneurs.

References

Feldman, D. et al. (2014), *Photovoltaic System Pricing Trends*. Washington, DC: US Department of Energy.

Electricité du Cambodge (EDC) (2015), *Report on Activities of the Department of Rural Electrification Fund for the Year 2014.* Phnom Penh: Electricity of Cambodia.

International Energy Agency (IEA) and Economic Research Institute for ASEAN and East Asia (ERIA) (2013), *Southeast Asia Energy Outlook.* Paris: OECD/IEA.

Kimura, S. (2014), *Preparation of Energy Outlook and Analysis on Energy Saving Potential in East Asia.* Jakarta: Economic Research Institute for ASEAN and East Asia.

Ministry of Industry, Mines and Energy (MIME) (2005), *The Energy Sector Development Plan, 2005–2024*. Phnom Penh: Ministry of Industry, Mines and Energy.

Un Ning (2010), Country Report on Clean Energy, on the Occasion of Second Asian Inter-Parliamentary Assembly (AIPA) Caucus, 22–25 June 2010, Singapore.

World Bank (2012), 'Implementation Completion and Results Report'. *Report No: ICR2320.* Washington, DC: World Bank.

World Vision, United Nations Environment Programme (UNEP), and Frankfurt School (2012), *Feasibility Study on Access to Financing for RE Appliance for Rural Poor in Cambodia*. Phnom Penh: World Vision, UNEP, and Frankfurt School.

Vuthy, L. (2014), 'Cambodia Country Report', in *Study on Preparation of Energy Outlook and Analysis on Energy Saving Potential in East Asia.* Jakarta: Economic Research Institute for ASEAN and East Asia.