Scaling up access to renewable energy financing in Cambodia

Case Study Analysis for Small and Medium Agri-Food Businesses

Nexus for development

KONRAD ADENAUER STIFTUNG

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This project was made possible through the support of Konrad-Adenauer-Stiftung and is based on research conducted by Nexus with the objective of disseminating knowledge and lessons learned associated with financing renewable energy systems for SMAs and farmers.

We hope that this report will inspire other businesses to invest in their own decentralized renewable energy systems and that it will generate interest in innovative financial tools to support the acceleration of energy transition.

ACKNOWLEDGMENT

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ABBREVIATIONS

ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
CCCA	The Cambodian Climate Change Alliance
CIRD	The Cambodian Institution and Rural Development
CERF	Clean Energy Revolving Fund
FIs	Financial Institutions
FOA	Food and Agriculture Organization of United Nations
KPPA	Kamp Pepper Promotion Association
IFAD	The International Fund for Agriculture Development
MAFF	Ministry of Agriculture, Forestry and Fisheries
MEF	Ministry of Economy and Finance
MOC	Ministry of Commerce
NEA	National Employment Agency
NIS	National Institution of Statics
NBP	National Biodigester Programme
PGI	Protected Geographical Identification
RE	Renewable Energy
RDB	Rural Development Bank
SMAs	Small and Medium Agri-Food Businesses
WWF	World Wildlife Fund

EXECUTIVE SUMMARY

The agriculture sector plays a key contributory role to Cambodia's economic development. However, Cambodian farmers have difficulty competing with neighboring countries such as Thailand and Vietnam given their high dependency on grid electricity, which is expensive and unreliable. About 6.9 million people, or 43.1% of the country's population, have no access to dependable electricity in Cambodia. This issue is more prevalent in rural areas where the farmers operate and results in many farmers turning to alternative sources with a predominant reliance on back-up diesel generators, which leaves farmers vulnerable to diesel price fluctuations and also contributes to greenhouse gas emissions. Fossil fuel energy sources in the agricultural sector are expensive, inaccessible, and unreliable. These difficulties hinder agricultural productivity, which has major impacts on the country's prospects for sustainable economic growth and development.

There are increasing opportunities for Cambodian people in rural and remote areas to gain access to electricity through the installation and use of renewable energy (RE) technologies. Access to affordable, reliable, and RE is "a vital input for a productive agriculture value chain", and thus RE technologies such as solar systems and biogas digesters have already gained some traction and have been adopted by Cambodian farmers. Despite the potential for widespread use of RE technologies in Cambodia, the adoption rate remains low. Key barriers to broad adoption are lack of awareness and experience, lack of trust in the technology, and high upfront costs, but the most crucial inhibitor is a lack of access to appropriate financing alternatives.

Although Cambodia has one of the most vibrant microfinancing sectors in the world, RE loan products are not considered as a potential market by local financial institutions (FIs). The FIs are hesitant to engage in RE investments as they believe market opportunities are limited and investments are risky and unprofitable. In addition, the FIs do not have a good understanding of renewable energy technologies offered in the market, the requirements of an energy assessment to support due diligence and risk management, or the possible return prospects for such investments.

The purpose of this research is to provide an evidence-based assessment of RE opportunities in the context of small and medium agri-food businesses and farmers in Cambodia in order to offer recommendations to FIs on the key entry points into the RE market and financing opportunities with suggestions on appropriate business models to match these entry points.

Based on our focused survey results, energy costs represent between 6% to more than 50% of the operational costs for farmers in Cambodia, depending upon the size of farm and type of crops or livestock. Given the significant proportion of energy costs to operational finances, all respondents surveyed acknowledged and expressed their willingness to adopt RE technologies. Our survey further found that respondents were most interested in bank loans and other debt products where interest rates are below 12% per annum. If the FIs wish to expand their services beyond business lending, the study results suggest that RE financing for SMAs and farmers emerges as a potential new market segment. By entering this new market, the FIs can play a key role in increasing access to RE technologies in the agri-food sector in Cambodia.

About 80% of respondents claimed that they had taken loans from a FI to support financing requirements for the operation of their farms. Therefore, offering loans for RE technology purchases to existing clients and farmers represents a primary entry point that is a cost-effective option for FIs as there may be less time required for due diligence and loan assessments. In addition, this represents an opportunity to deepen their relationship with existing clients and to cross-sell other banking products. Furthermore, the survey indicates that approximately 62% of respondents are willing to consider the pledge collateral if banks offered RE loan products.

It is acknowledged that initially FIs may face some challenges due to a lack of expertise in technical aspects of RE products. The major knowledge gaps include: (1) a lack of expertise in helping farmers to assess product quotes and the quality of the respective RE products, (2) limited to no existing expertise in offering technical support to clients for product maintenance, and (3) a lack of knowledge to ensure that RE technologies are installed properly and will lead to the realization of any estimated cost savings. However, to design RE loan products the FIs can develop partnerships with technology providers, which would support the transfer of knowledge and necessary expertise. It is recommended that FIs also engage with other stakeholders such as NGOs and governmental agencies who are already working in the RE sector to support the successful design and delivery of their RE loan products.

Photo credits: Jeremy Meek

INTRODUCTION

Renewable Energy in the Agri-Food Sector

Cambodia has experienced rapid development in the last two decades with agriculture as a key driver to this economic development contributing about 20% of GDP in 2017[1]. Agriculture as a sector continues to be the dominant employer in Cambodia for the rural population although the share of employment decreased from 57.7% to 36.4% between 2007 and 2016[2].

Despite the size and strength of the sector there are still many challenges. The sector is highly dependent on monsoon rainfall, which in recent years has become increasingly unpredictable. This irregular rainfall usually associated with climate change has adversely affected crop production[3]. In addition, Cambodian farmers have difficulty competing with neighboring countries such as Thailand and Vietnam given their high reliance on grid electricity that is expensive and unreliable. About 6.9 million people or 43% of the country's population have no access to dependable electricity in Cambodia[4]. This issue is more prevalent in rural areas where the farmers operate and results in many farmers turning to alternative sources with a predominant reliance on back-up diesel generators, which leaves farmers vulnerable to diesel price fluctuations and also contributes to greenhouse gas emissions.

One of the primary opportunities for Cambodia to reduce its high dependency on fossil fuels is within the agricultural sector. Fossil fuel energy sources in the agricultural sector and more specifically for rural areas are expensive, inaccessible, and unreliable. These difficulties hinder agricultural productivity, which has negative impacts on sustainable economic growth and development.

There are increasing opportunities for Cambodian people in rural and remote areas to gain access to electricity through the installation and use of renewable energy (RE) technologies. Access to affordable, reliable, and renewable energy is "a vital input for a productive agriculture value chain"[5]. Solar power in particular shows exceptional potential as the Asian Development Bank (ADB) suggests. Due to Cambodia's high suitability to solar power, energy from solar panels is a viable and sustainable source of power that could lead to energy independence[6]. This potential for energy transition is further supported by the fact that the price of solar panels started to decrease dramatically, making solar technologies an economically viable energy alternative for agricultural purposes. In remote areas where diesel fuel is expensive or where reliable access to the electricity grid is lacking, solar water pump systems can provide a relatively flexible and climate friendly alternative energy source[7].

Biogas technology is another RE option, which shows potential in Cambodia, and has started to become more popular in the agricultural sector. The use of medium and large biogas installations has surged in Cambodia in recent years, driven by a number of international programs; particularly in the commercial pig farms. By adopting biogas digester technology, pig farms can convert pig manure to energy that can be used in the farms. Biogas systems have both environmental and economic benefits because they help reduce unpleasant odor and methane emissions, in addition to reducing the energy cost of the farm owners[8].

Based on the experiences of Nexus's Clean Energy Revolving Fund (CERF)[9] the observed trend evidences a very low adoption rate of RE in Cambodia despite the potential. Some key barriers to RE adoption in rural areas include:

- a lack of awareness and experience of RE technologies amongst farmers,
- a lack of trust in the technology,
- high upfront costs for farmers, and
- a lack of access to appropriate financing options.

RE finance products should be established and encouraged by local financial institutions (FIs) to enable the switch to RE resources. Although Cambodia has one of the most vibrant microfinancing sectors in the world, RE loan products are not considered as a potential market by local FIs. The FIs are hesitant to engage in RE investments as they believe market opportunities are limited, and investments are deemed too risky and unprofitable. In addition, in some instances the FIs might not have a good understanding of renewable energy technologies on the market, the requirements for an energy assessment, or an understanding of the possible return prospects on such investments.

The FIs are hesitant to engage in RE investments as they believe market opportuni are limited and investments are risky and unprofitable. In addition, the FIs do not have a good understanding of renewable energy technologies on the market, the requirements of an energy assessment, and the possible return on such investment.

[1] Ministry of Economy and Finance, 2017
[2] National Employment Agency, 2018
[3] Bansok et al, 2011.
[4] WWF, 2016.
[5] SEVEA, 2017
[6] ABD, 2015
[7] Hans. H & Lucie. P 2018
[8] National Biodigester Programme (NBP) through collaboration with some international donors, and United Nations Industrial Organization (UNIDO) are supporting large and medium pig farmers to adopt the biogas digester system.
[9] The Clean Energy Revolving Fund (CERF) offers affordable loans to farmers and small agricultural processing businesses, for the purchase of clean energy technologies. CERF is managed by Nexus for Development and supported by REEEP with funding from the Austrian Government and Blue Moon Fund.

Photo credits: Jeremy Meek

STUDY OVERVIEW

Objectives and Scope

The purpose of this research is to provide an evidence-based assessment of RE adoption by small and medium agri-food businesses and farms in Cambodia in order to offer recommendations for FIs on the key entry points into RE financing and appropriate business models to match these entry points. The research has three objectives:

(1) to provide an overview of different agri-food sectors that are suitable to renewable energy technologies including pepper, livestock, longan, vegetable, mango and orange,

(2) to produce five attractive and practical case studies of Small and Medium Agri-Food Businesses (SMAs), and

(3) to provide financial cases or financial data, which would be valuable for any financial institutions (FIs) seeking to understand the investment opportunity and to leverage insights on the willingness and ability of the SMAs and farmers to pledge collateral, the range of interest rates borrowers may find acceptable and are able to service, suitable repayment structures, other measures of financial capacity, and interest of SMAs and farmers in transitioning to renewable energy technologies.

Methodology

The research is based on qualitative and quantitative data. The methodology for the case studies is a combination of desk-based reviews and primary research. Secondary data is also included to provide an overview of different agri-food sectors. The collection of primary data was produced through interviews with representatives of cooperatives, and farm owners or farmers. The research focuses on highlighting five case studies from different farms in different agri-food subsectors conducted through in-depth interviews with a sample of farmers. A small survey was also conducted to understand farmers' perceptions of RE technologies, source of energy consumption, to facilitate the collection of cash flow and financial information, and developing an understanding of farmers' perspectives on RE financing products. A total of 16 farmers from Battambang, Pailin, Pursat, Mondulkiri, Kampot and Kampong Spue provinces were interviewed through face-to-face meetings and follow-up phone interviews. Small landholder farmers were excluded from the scope of this study, and only SMAs and larger farming businesses were targeted for the interviews.

According to the study on "Preparedness of Cambodia Small Landholder Farmers toward ASEAN Economic Community (AEC) Integration", small landholder farmers refers to those who have limited access to agricultural techniques, irrigation, investment capital, and marketing their products . Both SMAs and larger farming businesses are normally small family run businesses. SMAs are categorized into two groups - farms that employ fewer than 10 employees are classified as small, while enterprises with 10 or more employees are classified as medium size. SMAs often lack the knowledge and skills to successfully commercialize their agricultural output. In addition, access to finance for SMAs and large farmers remains constrained .

With an understanding of the agri-food sector more broadly and through our deep local network, Nexus also interviewed NGO stakeholders including the Cambodian Institution and Rural Development (CIRD), USAID-funded Cambodian Harvest II project, and representatives of associations and cooperatives including:

- Pailin Longan Product Agricultural Cooperative
- Treak Pepper Cooperative,
- the Cambodia Pepper and Spice Federation,
- Kampot Pepper Promotion Association,
- Cambodian Pig Raising Association, and
- Angkrong Orange cooperative in Pursat.

Further research was carried out through engagements and workshop convenings that were attended by the Nexus researcher. A workshop on "Labeling Pursat Orange as Protected Geographical Identification", which was organized by CIRD, and a dissemination workshop on the "Medium Scale Biodigester Innovation for Smart Environment Project" organized by National Biodigester Programme (NBP) were attended and provided more background on farmers' interests in RE technologies and market intelligence on the orange and pig farming sub-sector.

As a fund manager of CERF, we have gleaned new knowledge about the viability of lending to SMAs and farm owners, and integrated these learnings into this study by using two case studies (a pig farm in Kampong Speu and pepper farm in Mondulkiri) that are based on existing investments in Cambodia from our CERF portfolio.

In the following case studies, the term "simple payback period" is used to estimate the length of time that it will take a farmer to recover the costs associated with the purchase of the technology based solely on the cost savings recognized from transitioning away from diesel engines or other fossil fuel powered energy sources and shifting to a renewable energy source. The calculation assumes that no financing was utilized for the purchase. In other words, the simple payback period is the point in time when the farmer achieves "breakeven". For example, if a longan farmer switches from using a diesel pump to using a solar water pump system at an investment cost of $35,000 and the new system saves the farmer $15,000 a year – achieved by foregoing costs associated with the diesel pump (i.e. fuel, maintenance), the solar system payback period is 2.3 years ($35,000/$15,000=2.3).

[10] Seng et al, 2016
[11] The World Bank, 2019

01 Case Study

PEPPER FARM AND SOLAR WATER PUMP

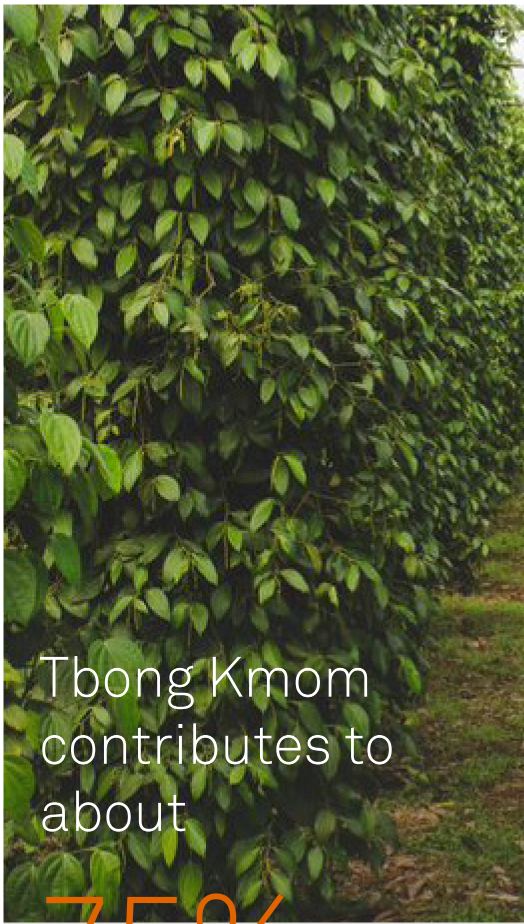
Overview

Table 1: Summary of solar water pump project with pepper farm

Farm owner	Mr. Be Youmeng
Farm type	Pepper farm
Technology	Solar water pump
Capacity of technology	2.48kW
Simple payback period	3.5 years
Cost savings per year	$3,193
Amount of diesel fuel avoided	4,562 liters per year

Pepper is a strategic high value crop in local and international markets. However, a critical factor affecting the production and cultivation of pepper is water irrigation. In Cambodia, two main seasons can be distinguished, the rainy season from May to October and the dry season from November to May. During the dry season or during periods of irregular rainfall patterns, farmers require adequate water irrigation to supplement the limited rainfall. According to Kampot Pepper Promotion Association, a pepper vine needs about 15 liters of water every three days during the dry season.

In order to set-up supplemental irrigation systems, farmers need initial capital to dig wells and ponds, to set up drip irrigation systems, and for the purchase of diesel pumps. Solar water pumps are a viable alternative to replace diesel pumps and can be adopted by the pepper sector. In the case of Mr. Youmeng's pepper farm, he can reduce diesel costs by 50% through investment in a solar water pump.



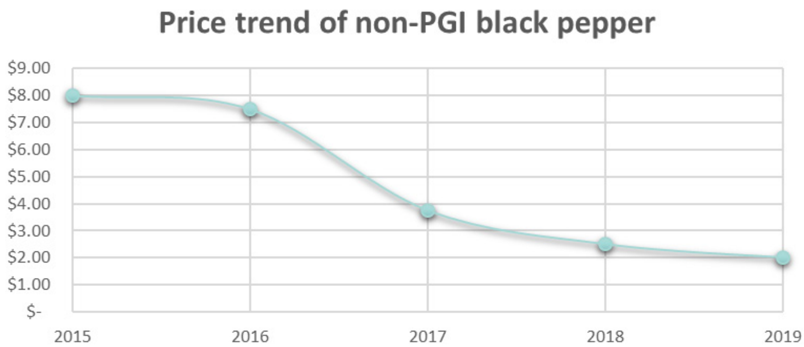
75% of total production

Market – Pepper

Although it is still a small industry compared to other Cambodian agricultural commodities, pepper has become a "Top Ten Product' in five provinces in Cambodia, including Kampot, Kep, Tbong Khmum, Kratie and Sihanoukville[12]. The Cambodian pepper production has expanded since 2013 when Cambodian farmers started to convert much of their land to cultivate pepper. As prices started to increase, additional investments into pepper cultivation soared[13]. According to the Department of Industrial Crops, Ministry of Agriculture, Forestry and Fisheries (MAFF), the pepper output in Cambodia has increased six-fold since 2012 from nearly 5,000 tons in 2012 to 30,000 tons by the end of the 2018. In parallel, the cultivation area has increased from about 1,500 hectares to nearly 8,000 hectares from 2012 to 2018[14], and pepper is now grown in 22 provinces throughout the country. The main plantation area is in Tbong Kmom province and the majority of this is from Memot district. Tbong Kmom is located along the country's eastern border next to the Vietnam border, and contributes about 75% to the country's total production[15].

[12] Youssey, 2018.
[13] Kunal & Anish 2017
[14] Cambodian Pepper Statistics in 2018, Department of Industrial Crops, Ministry of Agriculture, Forestry and Fisheries
[15] https://www.khmertimeskh.com/news/39526/pepper-production-in-cambodia-to-increase/

Figure 1: Price trend on non-PGI black pepper



Source: Interviews with pepper farmers

Unfortunately, there is no data or statistics available about the number of pepper farmers throughout the country. According to the study on Memot Pepper Market System Analysis published in 2015, there are about 5,430 pepper farmers in the Tbong Khmum province[16]. According to Kampot Pepper Promotion Association (KPPA), there are 387 farmers who have become members of KPPA, who in aggregate represent land dedicated to pepper cultivation of over 200 hectares[17].

The main market for Cambodian pepper relies on informal export to neighboring countries, namely Vietnam and Thailand. The market for Non-Protected Geographical Identification (PGI) pepper is struggling as the prices of pepper have fallen. According to the surveyed pepper farmers, in 2019 the prices have dropped to between 7,500 riels ($1.88) and 9,000 riels ($2.25) per kilogram, which are the lowest range of the prices experienced. The decline has been ongoing since 2017 when a kilogram of pepper sold within a range of 15,000 riels ($ 3.75) and 20,000 riels ($5)[18].

However, the Kampot pepper which won the European Union's Protected Geographical Identification (PGI) continues to maintain the high prices. The price of Kampot pepper is approximately $15 per kilogram for black pepper, $25 per kilogram for red pepper and $28 per kilogram for white pepper[19]. The Ministry of Commerce and Ministry of Agriculture, Forestry and Fisheries has jointly formed a new federation called "The Cambodia Pepper and Spice Federation" in November 2018 to enhance the market and solve challenges in the sector, as the cash crop is currently facing depressed prices. The federation will work to promote the value of Cambodian pepper and look for new markets, especially for non-PGI pepper[20].

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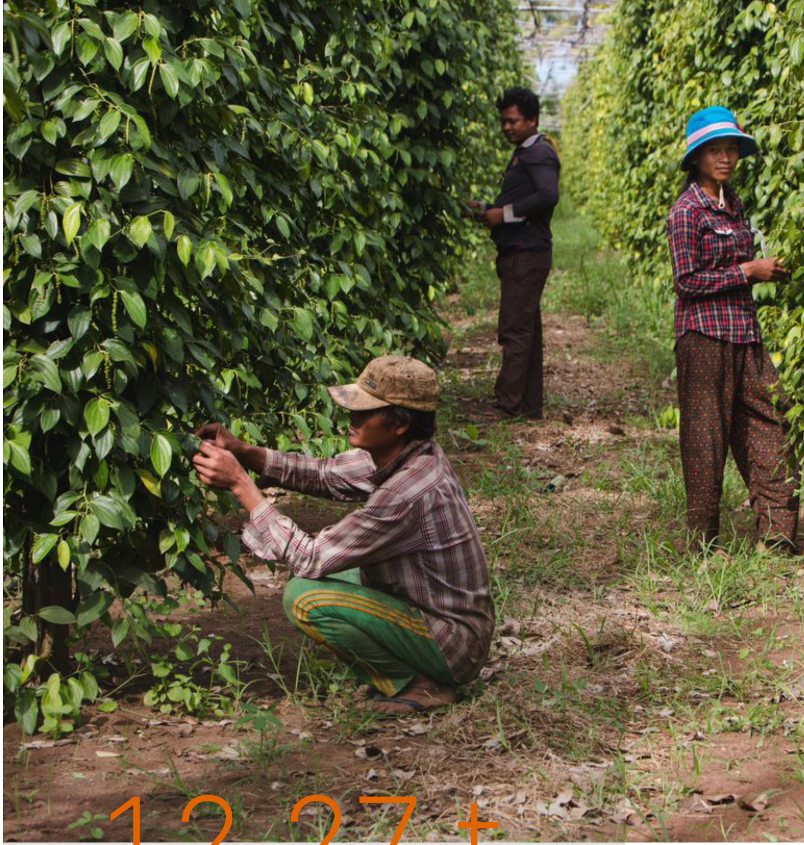
[16] CIRD, 2015.
[17] Interviewed with the president of Kampot Pepper Promotion Association
[18] Interviewed with pepper farmers in Mondulkiri and Tbong Khmum
[19] https://www.phnompenhpost.com/business/price-woes-kingdoms-non-gi-pepper-farmers
[20] https://www.phnompenhpost.com/business/new-pepper-federation-set-promote-sectorhnom Penh Post

Farmer's Profile

Mr. Be Youmeng is the owner of a pepper farm on about 12 hectares of land. His farm is located in Busra commune, Pichreada district of Mondulkiri province. Mondulkiri province is located in a plateau area where the red soil is very fertile for growing agricultural crops. Presently about two and a half hectares of land are used to grow pepper. The pepper usually grows along vertical poles. The first round of planting included planting approximately 2,000 pepper poles, which are now seven years old on about one hectare of land. About 3,000 pepper poles were planted in the second round in October 2016 on one and a half hectares of land.

As described in table 2, the pepper production at Mr. Youmeng's farm has increased over the years. Mr. Youmeng relies largely on Vietnamese brokers to purchase his crop and sell it to the international market and buyers, but he is experiencing the effects of falling prices. The prices have dropped from \$8 per kilogram in 2015 to \$2.50 per kilogram in 2018. Presently, the price of pepper is about \$2 per kilogram, which is very low relative to historical prices. At this price, Mr. Youmeng would still be able to generate gains if one pole of pepper can produce about 3 kilograms.



12.27 t

of avoided CO_2e emission per year

Table 2: Pepper production and prices

	2015	2016	2017	2018
Pepper production	3,500kgs	7,000kgs	10,000kgs	15,000kg
Prices	\$8/kg	\$7.50/kg	\$3.75/kg	\$2.50/kg
Revenue	\$28,000	\$52,500	\$37,500	\$37,500

Energy Consumption at the Farm

Like every pepper farm, proper water management is very important for Mr. Youmeng's farm. In the rainy season, he does not worry about water as Mondulkiri province is located in the plateau area, and the rainfall is high compared to lowland areas. However, irrigation is necessary during dry season when pepper requires water every two or three days depending upon the weather conditions. Mr. Youmeng reported that he requires water to irrigate the farm for about five to six months during the dry season. Mr. Youmeng's plantations are irrigated through a dripping system by pumping the water from nearby ponds.

The farm utilizes two diesel engines to pump water for irrigation. One engine pump is used to pump the water from wells into the ponds (capacity of engines: 40 Horsepower). Mr. Youmeng needs to use the generator every day in order to have sufficient water, which uses about 12 liters of diesel per day to pump the water into the pond. Another engine (24 Horsepower) is used to pump the water from the ponds to supply the drip irrigation system, it is mainly used in the dry season and during unanticipated dry spells. Mr. Youmeng confirmed he spends a significant amount to purchase diesel during the dry season and claimed that the farm consumes about 120 liters of diesel every three days to water the pepper in the dry season. He is now paying about \$0.70 per liter.

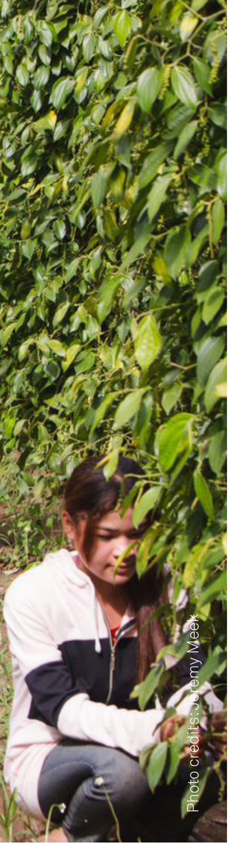


Table 3: Energy consumption at pepper farm

Diesel engine 1	40 Horsepower (pumping water from well into pond)
Diesel engine 2	24 Horsepower (pumping water from pond to support drip irrigation system)
Diesel (liter)	About 1,200 liters per month[21]
Diesel price	2,800 riels ($0.70) per liter
Diesel cost (2 engine pumps)	$5,880 per year

Investing in Solar Water Pump

In order to reduce the expenses related to purchasing diesel, Mr. Youmeng has invested in solar water pumps. The solar water pump is only used to pump water from the well to the pond. The capacity of solar water pump system is about 2.48kW, which facilitates approximately 30 cubic meters of water to be pumped per day.

Table 4: Solar water pump

Technology	Solar water pump
Capacity of system	2.48kW
Cost of system	$11,268
Payback period	3.5 years
Amount of diesel fuel avoided	4,562 liters per year
Energy saving	$ 3,193 per year
Emission reduction potential per annum	12.27 tonnes of CO_2e reduced per year
kWh of clean energy produced	Approx. 3,530 kWh per year

The simple payback period for the 2.48kW solar pump system is about 3.5 years which is considered by the pepper farmers surveyed for this report as a reasonable duration, based on their respective incomes and financial capacity. If the solar pump is used to replace one diesel engine pump, this results in the avoidance of about 4,562 liters of diesel being used per year, and equivalent savings of $3,193 annually. Mr. Youmeng used the financing from Nexus's Clean Energy Revolving Fund (CERF) to purchase this clean energy technology. He currently repays his loan through the cost savings generated from reduced diesel consumption. A further co-benefit to this energy transition is its contribution to emission reductions which Nexus has estimated as 12.27 tonnes of CO2e per year.

By investing in a solar water pump, Mr. Youmeng is able to reduce operational costs by 12% and diesel costs by more than 50%.

Table 5: Annual operational cost of pepper farm

Items	Cost ($) - Pre-investment	Cost ($) – Post-investment
Fertilizers	6,000	6,000
Workers	8,400	8,400
Diesel (2 engine pumps)	5,880	2,940
Maintenance cost, engine oil, etc.	240	240
Total operational cost per year	$26,582	$23,642

[21] The farmer uses the diesel pumps for about 7 months per year

02 Case Study
DEMONSTRATING POSITIVE BENEFITS FOR A PIG FARMER WHO INVESTED IN HYBRID SOLAR SYSTEM

Overview

Table 6: Summary of hybrid solar project with pig farm

Farm owner	Mr. Oeurn Chanrath
Farm type	Pig farm
Technology	Hybrid solar system
Capacity of technology	12kW
Simple payback period	3.5 years
Cost savings per year	$5,400
Amount of diesel fuel avoided	7,200 liters per year

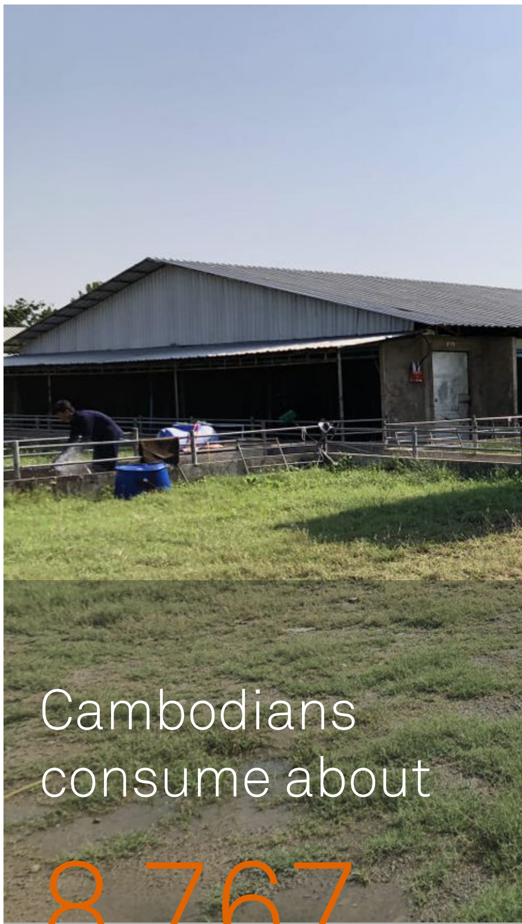
Pig farms require significant amounts of energy to operate specifically when using the enclosed swine stable system for pumping water to clean pigs and stables, lighting (required both day and nighttime) and for running an evaporative cooling system. This case study demonstrates the positive impact or benefits for a pig farmer (Mr. Oeurn Chanrath), who invested in a hybrid solar system for his farm. The technology has helped him reduce a significant amount of costs associated with diesel fuel consumption.

Market – Livestock (Pig)

Cambodia's expanding population, urbanization, economic growth and the changing consumption patterns of the population have created opportunities for the growth of the livestock sub-sector in the country. With an estimated annual human population growth rate of 1.8 %, the projected meat demand in Cambodia from 2014 to 2024 is anticipated to increase from 274,479 to 328,085 tons per year[22].

The demand for pork is much higher than the amount produced in the country, and thus Cambodia has relied on importing pigs from neighboring countries like Vietnam and Thailand. The projected annual demand for pigs in Cambodia is 3.25 million heads compared to the country's previous annual domestic production of 2.7 million heads in 2014. According to Cambodia Livestock Raisers Association, between about 2,000 and 3,000 pigs per day are imported from Vietnam and Thailand to meet local demand[23]. Despite this demand, the Cambodian government claims most of imported pigs are illegal, which drives down the price of local livestock[24]. MAFF data indicates that Cambodians consume about 8,767 pigs per day[25].

CP Cambodia is one company that operates to meet the pork demand in the country. CP Cambodia was established in Cambodia in 1994, as subsidiary of CP Company (based in Thailand), one of the biggest regional agri-businesses. CP Cambodia develops modern farming management systems and engages in contract farming of various types with farmers throughout



Cambodians consume about 8,767 pigs per day

[22] General Directorate of Animal Health and Production: Overview of the livestock industry in Cambodia, http://gdahp-maff.org/blog/overview-of-the-livestock-industry/
[23] Interviewed with Mr. Srun Peou, Director of Cambodian Livestock Raisers Association.
[24] https://www.khmertimeskh.com/news/38411/private-sector-to-monitor-pig-imports/
[25] https://www.phnompenhpost.com/business/farmers-remain-sceptical-even-local-prices-pigs-double

Mr. Oeurn Chanrath with the installed solar system at his farm in Phnom Srouch district of Kampong Speu province.

the country. They have worked with hundreds of swine farms in various regions across Cambodia. CP company signs contracts with producers to rear pigs, poultry (broilers and layers) and fish. The group has about 70% of the market share of livestock in Cambodia where CP controls the supply chain[26].

Contract farming is mainly formed with medium-scale business farmers who have capital to build warehouses. It is challenging for pig farmers who are starting a small enterprise because it is difficult to acquire more than 200 piglets due to limited capital, unless they make a contract with CP to buy piglets[27]. In the pig sector alone, there are more than 400 pig farms and more than 1,000 pig warehouses under CP's contract farming arrangement[28].

Farmer's Profile

Mr. Oeurn Chanrath is the owner of a pig farm in Dambok Rong commune, Phnom Srouch district of Kampong Speu province, about 85 km to the west of Phnom Penh. Mr. Chanrath is a contract farmer of CP Cambodia Co., Ltd. and has worked with CP Cambodia since 2012. Under his contract farming arrangement with CP, Mr. Chanrath must invest the capital to build warehouses and purchase equipment based on CP's specifications. In return CP provides sows, feed, medicines and technical assistance. Training and knowledge on swine farm management is also provided by CP Cambodia as part of the contractual arrangement. The farm only raises piglets, which are collected every three weeks by CP.

[26] CI SAC, 2011
[27] SAC, 2011
[28] Interviewed with CP representative

Energy Consumption at the Farm

Energy consumption of pig farming operations involve appropriate lighting for pigs (both piglets and sows) and an evaporation cooling system. The evaporation cooling system is designed for enclosed pig stables or warehouses to provide pigs with stable temperatures for suitable living conditions (between 25ºC and 28ºC). The evaporation cooling system requires water to keep temperatures low during the daytime and thus water consumption is high, especially in the dry season. As the farm has four warehouses, with each housing about 900 sows and having capacity to produce 1,000 piglets per every three weeks, electricity consumption is significant.

The pig farm is in an off-grid area, hence the farm relies on electricity generated by three diesel generators (Capacity: 75kva). The farm spends about 120 liters of diesel per day, which costs them $30,000 per year for diesel consumption only, which is considered expensive for businesses of this type and size. Furthermore, this does not take into account the expenses that are related to maintenance service or costs for the three diesel generators.

14.72 t

of avoided CO_2e emission per year

Table 7: Energy consumption at the pig farm

3 diesel engines	Each has capacity of 75 KVA
Diesel (liter)	120 liters per day
Diesel price	3,000 riels ($0.75) per liter
Diesel cost	$32,400 per year

Investing in Hybrid Solar System

Mr. Chanrath has been searching for options to reduce the cost of energy or electricity consumption for his farm. Mr. Chanrath did not seek a loan from local banks to purchase the solar system because he learnt that the banks have never provided financing for such purchases. Instead, Mr. Chanrath sought other financing options and learned about Clean Energy Revolving Fund (CERF) through the technology provider, IMB. In April 2018, he applied for financing from Nexus's CERF to purchase a hybrid solar system (capacity: 12kW). Nexus offered a repayment structure that is tied with energy savings generated from the technology investment and that is aligned with revenue streams from the pig farm. Mr. Chanrath's contract with CP Cambodia, to purchase piglets every three weeks, provides Mr. Chanrath with regular cash flows to meet the loan obligation.

Investing in a hybrid solar system is a wise decision for Mr. Chanrath because the electricity demand to operate the pig farm is driven by high consumption during daylight hours. The system is designed without using battery storage, which is similar to the on-grid solar system, and therefore it is less costly compared to off-grid solar system with batteries. The system Mr. Chanrath ordered is designed to synchronize or feed directly into the diesel generator. The hybrid solar system facilitates reduced fuel consumption by the generators as the solar energy produced offsets the fossil fuel needed. A controller is installed that manages the solar power output to ensure the system functions at an optimal level according to the operation of the diesel generator.


Photo credits: Sarou Long

Mr. Chanrath has shown his satisfaction with the installed solar system. He still depends upon the generator, but the hybrid solar system makes his costs related to diesel have been reduced. Through a short training from the technology provider, he also received a basic understanding of set-up and functions of the system and acquired skills related to ongoing maintenance and daily operation. He has shared his satisfaction on the investment in solar technology to several CP pig farmers who have similar operational challenges (i.e. they are off-grid farms) and who are now interested in exploring options to reduce their energy costs.

Table 8: Hybrid solar system

Technology	Hybrid solar system
Capacity of system	12kW
Cost of system	$18,738.60
Payback period	3.5 years
Amount of diesel fuel avoided	7,200 liters per year
Energy saving	$5,400 per year
Emission reduction potential per annum	14.72 tonnes of CO2e reduced per year
kWh of clean energy produced	Approx. 17,919.35 kWh per year

The simple payback period for a 12kW hybrid solar system is about 3.5 years, which would be considered a feasible loan tenor for a pig farmer. Before the investment, Mr. Chanrath spent about $32,400 per year to run the diesel generators. After integrating the system into his operations, he is able to avoid the purchase of 7,200 liters per year, which equates to savings of $5,400 annually. He is using part of these savings to meet his loan obligations, but given that there are residual savings Mr. Chanrath is able to invest this amount back into his staff.

By using a renewable energy system, the pig farm also contributes to GHG emission reductions of 14.72 tonnes of CO2 per year. This energy source not only can offer energy security and independence for the farm, but serves as an energy solution that is non-polluting, clean and reliable.

Table 9: Operational cost per year before and after solar installation

Items	Before ($) – Pre-investment	After ($) – Post-investment
Diesel expense	32,400	27,000
Maintenance and oil	1,800	1,800
Workers	30,000	30,000
Food for workers	6,600	6,600
Others (replacing some spare parts /feeding facilities in the stables)	1,800	1,800
Total operational cost per year	$72,600	$67,200

It can be seen from table 9 that operational costs per year before and after solar installation are different. Mr. Chanrath is able to reduce operational costs by 7.43% through investment in a hybrid solar system. Before investing in solar energy, the diesel expense was about $32,400 per year, but Mr. Chanrath now spends less money on diesel, about $27,000 annually, representing savings of 16%.

03 Case Study
CONVERTING WASTE-TO-ENERGY – BIOGAS DIGESTER SYSTEMS FOR PIG FARM

Overview

Table 10: Summary of biogas project with pig farm

Farm owner	Mr. Chang Touch
Farm type	Pig farm
Technology	Biogas digester system
Size of the lagoon	Approx. 5,625m3
Gas storage	Approx. 3,800m3
Simple payback period	About 3.2 years
Payback period (with financing)	About 4.2 years
Cost saving per year	$17,600 per year
Energy saving	106,600 kWh per year

Some pig farmers are now adopting biogas digester technology, which allows them to convert the pig manure into clean energy. This technology is feasible for larger-scale pig farms because the upfront cost to purchase and assemble is quite high. Mr. Chang Touch, the owner of a pig farm in Kampong Speu province, has expressed his satisfaction with the installed biogas system, because he is also able to reduce his operational cost by more than 60%. The biogas technology investment does not only help him to improve waste management practices, but also reduces methane gas released from the farm.

Market – Livestock (Pig)

Cambodia's expanding population, urbanization, economic growth and the changing consumption patterns of the population have created opportunities for the growth of the livestock sub-sector in the country. With an estimated annual human population growth rate of 1.8 %, the projected meat demand in Cambodia from 2014 to 2024 is anticipated to increase from 274,479 to 328,085 tons per year[29].

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[29] General Directorate of Animal Health and Production: Overview of the livestock industry in Cambodia, http://gdahp-maff.org/blog/overview-of-the-livestock-industry/

[30] Interviewed with Mr. Srun Peou, Director of Cambodian Livestock Raisers Association.

[31] https://www.khmertimeskh.com/news/38411/private-sector-to-monitor-pig-imports/

[32] https://www.phnompenhpost.com/business/farmers-remain-sceptical-even-local-prices-pigs-double

Mr. Chang Touch, the pig farm's owner

CP Cambodia is one company that operates to meet the pork demand in the country. CP Cambodia was established in Cambodia in 1994, as subsidiary of CP Company (based in Thailand), one of the biggest regional agri-businesses. CP Cambodia develops modern farming management systems and engages in contract farming of various types with farmers throughout the country. They have worked with hundreds of swine farms in various regions across Cambodia. CP company signs contracts with producers to rear pigs, poultry (broilers and layers) and fish. The group has about 70% of the market share of livestock in Cambodia where CP controls the supply chain[33].

Contract farming is mainly formed with medium-scale business farmers who have capital to build warehouses. It is challenging for pig farmers who are starting a small enterprise because it is difficult to acquire more than 200 piglets due to limited capital, unless they make a contract with CP to buy piglets[34]. In the pig sector alone, there are more than 400 pig farms and more than 1,000 pig warehouses under CP's contract farming arrangement[35].

Farmer's Profile

Mr. Chang Touch is a contract farmer for CP Cambodia and he has worked with CP for seven years. His farm is located in Tang Kroch commune, Samrong Tong district, Kampong Speu province. Like other CP contract farmers, he has spent a lot of capital at the outset of the contract signing for the construction of warehouses or stables and to set up the necessary facilities. The main expense for pig farm owners is related to the facility, and electricity in the process of producing pigs. CP provides feed, medicines, technical assistance and additional training on how to raise pigs based on the CP's technical requirements and standards. As a pig fattening farm, Mr. Touch has five stables, which can raise up to 3,000 pigs per cycle. The pigs are collected twice per year by CP.

[33] CI SAC, 2011
[34] SAC, 2011
[35] Interviewed with CP representative

Energy consumption at the farm

At the beginning, Mr. Touch established the pig farm by utilizing the CP unenclosed warehouse system. It was an open-air system, which required less energy for operating the farm. However, it is difficult to prevent diseases under such a system and may result in lower quality pig production. Two years ago, he employed a best practice technology from CP Cambodia, called "enclosed stables system". This technology or system is more effective in preventing the spread of disease. Adopting this technology requires the setup of evaporative cooling systems to cool the temperature within the stables to ensure suitable conditions for pigs.

By employing the use of an enclosed swine stables system, this results in increased energy consumption by the farm operation. The energy is used for pumping water to clean pigs and stables, lighting (needed both day and night), and for running the evaporative cooling system. Although the farm is connected to grid electricity, but Mr. Touch pays approximately 60 million Riels (about $15,000) per pig cycle (i.e. two cycles per annum; pig meat production takes about 5 to 6 months).

60%

of operational costs reduced

Investment in biogas digester system

Mr. Touch was introduced to the biogas technology through the National Biodigester Program (NBP). NBP has implemented a project called "Medium Scale Biodigester Innovation for Smart Environment", which was funded by the European Union through the Cambodian Climate Change Alliance (CCCA). As he is keen to look for options to reduce his monthly electricity bill, he decided to install a biogas digester system in 2018 that converted pig manure into biogas. The energy generated can be used for lighting, pumping, running the cooling system, and cooking. The total investment cost for the biogas system is $56,500. The biogas digester technology was installed by a local supplier, VW.GAS CO., LTD. Table 11 provides cost details for the system.

Tables 12 and 13 provide a comparison of the expenditure on electricity per cycle before installing biogas digester system from August 2017 to January 2018 and after the installation of the biogas system from August 2018 to January 2019.

Table 11: The cost of biogas digester system

	Items	Amount ($)
1	Lagoon – the plastic to cover the gas	11,800
2	Piping	2,000
3	Biogas genset 1	24,500
4	Biogas genset 2	15,000
5	Water trap system – biogas purification system	2,000
6	Gas containers	1,200
		$56,500

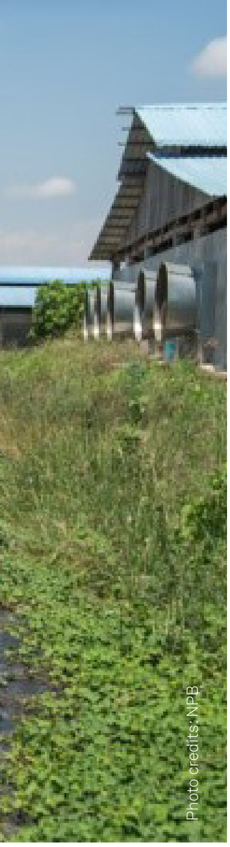


Photo credits: NPB

Before adopting new technology, Mr. Touch paid about $15,000 per pig production cycle for electricity bill. It takes five to six months per production cycle. After installation of the biogas digester system, he has spent around $4,000 per production. Therefore, in comparison of electricity cost with the same duration (five-six months), he can save about $10,000. With the investment in this technology, he is able to reduce electricity costs by more than 70% per cycle. From an environmental benefits perspective, the system helps improve pig waste management by reducing unpleasant odors surrounding communities and reduces the level of methane gas emitted. Investing in biodigester systems works well for larger pig farms (like Mr. Chang Touch's farm) where larger quantities of pig manure are generated and available to be converted into biogas. As the upfront investment cost for this type of technology is quite high, the farmer needs to have enough scale to justify the investment.

Table 12: Electricity cost before investment in bio-gas system

Date	Electricity used (kWh)	Rate per kWh	Total cost (Riels)	Total cost ($)
28-Aug-17	7,671	750	5,753,250	1,438
28-Sep-17	14,042	750	10,531,500	2,633
30-Oct-17	15,395	750	11,546,250	2,887
28-Nov-17	16,626	750	12,469,500	3,117
28-Dec-17	16,587	750	12,440,250	3,110
16-Jan-18	10,505	750	7,878,750	1,970
Total	80,826	750	60,619,500	$15,155

Table 13: Electricity cost after investment in bio-gas system

Date	Electricity used (kWh)	Rate per kWh	Total cost (Riels)	Total cost ($)
28-Aug-18	5,425	750	4,068,750	1,017
28-Sep-18	5,811	750	4,358,250	1,090
29-Oct-18	3,178	750	2,383,500	596
28-Nov-18	2,196	750	1,647,000	412
28-Dec-18	3,393	750	2,544,750	636
9-Jan-19	878	750	658,500	165
Total	21,816	750	16,362,000	$3,916

Table 14: Operational costs per pig collection (5-6 months) before and after installation of biogas digester

Items	Before ($)	After ($)
Electricity bill	15,000	5,000
Maintenance and oil exchange	0	1,200
Workers and food	9,450	9,450
Total operational cost per year	24,450	15,650
Net saving	-	$8,800

After evaluating energy consumption and other expenses for Mr. Chang Touch's pig farm, the analysis illustrates that he is able to reduce his operational costs by more than 60% through an investment in biogas digester technology. The simple payback period for the biogas investment is about 3.2 years. In order to make this technology investment, Mr. Touch took a loan from a local bank at an interest rate of 12%, and it takes him to repay the bank within approximately 4.2 years through the realized energy cost savings. This specific case will be further analyzed in the Renewable Energy Loan Products section.

04 Case Study
SOLAR WATER PUMPS FOR THE CAMBODIAN LONGAN FARMS: HOW IT WORKS AND BENEFITS

Overview

Table 15: Summary of proposed solar water pump project with longan

Farm owner	Mr. Un Theng
Farm type	Longan farm
Technology	Proposed solar water pump
Capacity of technology	Proposed 15 kW
Simple payback period	About 2.4 years
Payback period (with financing)	About 3 years
Cost savings per year	$15,120
Amount of diesel fuel avoided	21,600 liters of diesel per year

In Cambodia, longans are mostly grown in the northwest part of the country. In order to produce large quantities of quality fruit, longan trees need ample amounts of water as insufficient water supply can lead to unsuccessful flowering. Proper installation of an irrigation system is the key to high productivity and quality standard of longan fruits. While most farmers depend upon rainwater during the rainy season, during the dry season and any dry spell periods, longan farmers need to be prepared with the necessary supplementary tools of irrigation systems such as digging wells and ponds, as well as purchasing diesel pumps. Longan fruit are grown all-year round.

According to the Pailin Longan Product Agricultural Cooperative, the majority of longan farmers use diesel engine pumps as the main source of energy to support irrigation system. As most of the farms do not have access to the electricity grid, solar water pumps represent a viable alternative for the longan sub-sector. Although one disadvantage of the system is the potential for reduced pumping capacity in the rainy season due to limited sunlight, the balance to this is that during the rainy season the farms do not need as much supplemental water supply. In the dry season, fruit farms require more water supply, hence the solar system works best in this situation; it can work at full capacity to produce higher water volumes given the optimal sunlight conditions. If solar water pump systems are adopted by the longan sub-sector, it could help farmers improve their yields and reduce vulnerability to the changing rainfall patterns.

Diesel water pumps are generally considered a low-cost investment when compared to employing solar technologies, but farmers that have long-term operational dependencies on diesel are exposed to fluctuating fuel prices. Although a solar water pump has high upfront costs, this is balanced by the fact that the system has lower ongoing operation and maintenance costs. From field experience, solar water pumps can run for at least three years without any intervention as they are reliable and low maintenance. The next case study provides a comparison of diesel pumps to solar water pumps in the longan farming sub-sector.

Photo credits: Jeremy Meek

Photo credits: Jeremy Meek

Market - Longan

Longan is one of a top three fruits grown in Cambodia. According to data from 2010, about 2,376 hectares were covered by longan plantations[36], and this gradually increased to 2,437.3 hectares by 2013[37]. In 2017, longan farms occupied about 8,816 hectares across the country yielding nearly 20,000 tons a year. Longan fruits are grown in 10 provinces, with the majority of the plantations in the provinces of Battambang, Pailin and Banteay Meanchey, accounting for nearly 80% of the total land area. Most longan fruits produced in the country are consumed domestically, with the exception of Pailin and Battambang, both of which share a border with Thailand, and export their fruit production[38].

In Pailin province, longan is the third most important crop after cassava and maize as it is a key contributor to the local economy. In 2012, the total planted area was 425 hectares with a production of about 1,000 tons. There are approximately 165 households growing longan trees, 60% of which are large privately owned farms of up to 10 hectares each, while the remaining 40% of farms lie between one to one and a half hectares and are operated by small landholder farmers[39]. According to the Pailin Longan Product Agricultural Cooperative, more people in Pailin are now growing longan fruits, and thus plantation areas have expanded recently with production output increasing respectively. Currently there are about 230 farmers who are members of Pailin longan cooperative. The main function of the cooperative is to help members to negotiate better prices with the traders and to exchange information regarding price development. In the past several years, the cooperative has signed purchase agreements with traders who transport the longan to Thailand and China. This agreement is very beneficial for members as they have market security. As longan is a high value agricultural crop, the neighboring province of Pailin and Battambang have recognized the economic benefits of longan farming and also converted additional land area into longan farms[40].

Most farmers in Battambang and Pailin have chosen to grow a specific type of longan fruits, known as “Tagan”. Tagan are favored by consumers as they have a meatier fruit flesh and have a distinctive sweet taste. Longan farmers have been able to achieve considerably higher profit compared to other crops, and they can sell their longan fruit for between $1 to $1.50 per kilogram to dealers or other intermediaries who transport the crop to Thailand. In addition to this export market, Cambodia’s longan farmers are most interested in addressing the high demand period between February to March, which

[36] Thorng et al (2013)
[37] Census of Agriculture of the Kingdom of Cambodia 2013
[38] http://www.khmertimeskh.com/5089584/push-increase-longan-exports/
[39] Thorng et al (2013)
[40] Interviewed with deputy president of Pailin Longan Cooperative

$15,120

saved per year

ties in with Chinese New Year and Khmer New Year. This coincides with the dry season though, and as a result farmers need a reliable source of water supply. With the flowering to fruit development cycle of approximately six months, and as this period overlaps with the dry season solar water pumps become a good alternative to ensure the water supply is secured whilst keeping energy costs at moderate levels.

In Kandal province the focus for farmers is on another specific type of longan fruits, and there are about 136 hectares of land dedicated to longan plantations. Koh Krobey is a well-known longan fruit variety within Kandal which has optimal conditions to produce good quality fruit, which is of high demand by the domestic market. The Koh Krobey longan is priced between $2.50 and $5 per kilogram[41].

Farmer’s Profile

Mr. Un Theng is a longan farmer in Pailin province, he also serves as a vice president of the Pailin Longan Product Agricultural Cooperative. He has grown longan since 2008 with 15 hectares of land. There are about 2,250 longan trees, which can produce fruits between the months of January and April. In 2018, about 40 tons of longan fruits were collected. Mr. Theng uses a chemical treatment to help his trees induce flowers off-season, as this is when the market has a high demand. He prefers to harvest longan fruits during Chinese New Year so that he can sell at higher prices and usually sells his longan fruits through Chinese traders, who then transport the fresh longans to Thailand and onward to China. He can sell his production for prices between $1 and $1.25 per kilogram, however he has noted that price volatility has been an issue more recently.

Energy Consumption at the Farm

Similar to other longan farms, water management plays a crucial role to ensure longan trees bear sufficient fruit to meet farmers production targets. Mr. Theng set up a supplemental irrigation system to manage water supply better, and he has put a lot of investment into digging two ponds and a sprinkler irrigation system as well as to purchase diesel pumps. Two ponds serve as reservoirs, but the water supply from this source is not secure in the dry season. Therefore, he plans to dig another pond in the short to medium term to additional water reserve.

Table 16: Energy consumption with the long farm

3 diesel engine pumps	Each has capacity: 35 HP
Liters	120-130 liters per day
Price of diesel	2,800 – 3,200 riels ($0.7 to $0.80) per liter
Diesel cost	$15,000 to $17,000 per year

[41] https://www.khmertimeskh.com/76592/koh-krobeys-premium-longans/

Mr. Theng is currently using three diesel engines to pump water (capacity of each generator is 35 Horsepower). In the rainy season, he depends largely on rainwater, and thus he does not spend as much money on pumping. However, the farm spends a significant amount to purchase diesel fuel to pump the water during the dry season as he uses between 120 and 130 liters of diesel per day, which costs around $90 to $100 per day. Mr. Theng pays diesel prices between

Investing in Solar Water Pumps

Mr. Theng realizes that he spends significant money on diesel pumps, and thus he is also looking for an option to reduce energy costs. He is interested in a solar water pump system, which he learned of from an advert on the Facebook page of a local solar company and was interested in replacing his diesel pumps. One concern that Mr. Theng has though is that the solar pump system might not provide the necessary pressure or have the same level of capacity as a diesel engine pump. According to solar suppliers, solar water pumps can be designed with strong capacity or pressure to support drip irrigation, and sprinkler systems, but it requires greater capital investment. This is an example of where having appropriate financing alternatives is important for farmers like Mr. Theng.

Table 17: Engine diesel pump vs solar water pump

	Diesel pumps	Solar pump
Capital cost	$3,600	$35,000 (15HP-motor, solar power: 11.25kw)
Life span	5 years	20 years
Diesel cost per year	$15,120	$0
Costs after 5 years	$79,200	$35,000 + less maintenance

Table 17 illustrates a comparative scenario for Mr. Theng of choosing to invest in a solar water pump system by replacing three diesel pumps. The cost over a five year period of using the three diesel pumps is $79,200. Given Mr. Theng's concerns noted earlier he is likely to purchase a solar water pump system, which has the same pumping capacity to replace his three diesel engine pumps, which requires an investment of about $35,000. Mr. Theng benefits from the longer life span of the solar technology which is approximately 20 years and requires less maintenance. By transitioning away from the diesel pumps, he saves about $15,120 per year as he can forego purchasing diesel fuel. The simple payback period for this investment is about 2.3 years. If Mr. Theng takes a loan of $35,000 with an interest rate of 12%, he can use this energy savings to repay the bank within approximately three years. This specific case will be further analyzed in the Renewable Energy Loan Products section.

Table 18: Operational cost per year for Mr. Un Theng's longan farm

Items	Amount ($)
Fuel & maintenance	17,080
Fertilizers	10,000
Workers	8,400
Total operational cost per year	35,480

Table 18 indicates yearly operational cost for Mr. Theng's longan farm. The cost related to fuel and maintenance represents about 48% of the operational costs. If an investment is made into solar water pump systems, this would eliminate the expenses related to fuel and engine maintenance.

05 Case Study
SOLAR WATER PUMPS WITH AN ELEVATED TANK FOR CAMBODIAN VEGETABLE FARMS: HOW IT WORKS & BENEFITS

Overview

Table 19: Summary of proposed solar water pump project with vegetable

Farm owner	Mr. Chor Pagncharong	
Farm type	Vegetable farm	
	First Option	Second Option
Technology	Proposed solar water pump plus water storage tanks	Proposed solar water pump
Capacity of technology	Proposed 4.6 kW	Proposed 6kW
Simple payback period	4.8 years	5.4 years
Cost savings per year	$3,240 per year	$3,240 per year
Amount of diesel fuel avoided	4,050 liters of diesel per year	4,050 liters of diesel per year

With access to stable water supply, farmers can grow more vegetables which supports the potential for maximizing cash crop productions. Given that vegetables need adequate water in the morning and the late afternoon, solar water pumps are suitable for the Cambodian vegetable sub-sector. Access to the required water volumes can be achieved by pumping water into elevated water storage tanks, which then releases water leveraging pressure from gravity, but there is an additional capital investment for the tanks. Another alternative that can be designed is to integrate the tanks to the drip or sprinkler systems directly, but there are similar investment cost implications. This case study provides a comparison of diesel pumps to solar water pumps for vegetable farms.

Market – Vegetables

Vegetable production in Cambodia remains a challenging market as it requires large plots of land to be a commercially viable business. In Cambodia most vegetable production occurs at the subsistence farming level, which is unable to achieve commercial production scale. In addition, vegetable production is highly seasonal with variability in supply throughout the year. This is exacerbated by the fact that local producers are challenged by competition from the imported vegetables market[42]; approximately 60% of vegetable products are imported from neighboring countries. Research conducted by the Center for Policy Studies program shows that 200 to 400 tons of vegetable are imported daily from neighboring countries. This represents an import market of between $150 million and $250 million per annum, predominantly from Vietnam, Thailand and China[43].

There are several challenges for the vegetable sub-sector in Cambodia, namely (1) low average yields, (2) poor competitiveness within the region, (3) high postharvest losses, (4) product that does not conform to quality and safety demands of consumers, and (5) there are challenges encountered with satisfying market demand during the wet season[44].

However, there is a potential to move Cambodian vegetable production from subsistence to a commercialized sector with more emphasis on diversification, processing, productivity-enhancement, and capacity development. The rise of Cambodia's middle class and with the country's booming service and tourism industries has resulted in an increased demand for "safe to eat" local vegetables. This provides small landholder farmers and processors an opportunity to increase their income and food security[45]. This trend

[42] Francesco & Sovith, 2016
[43] https://www.khmertimeskh.com/8320/imports-push-veggie-farmers-to-the-wall/
[44] ACIAR, 2017
[45] http://www.snv.org/project/cambodia-horticulture-advancing-income-and-nutrition-chain-ii

Photo credits: Sarou Long

Mr. Pagncharong's vegetable farm, Battambang province

Vegetable products in Cambodia

60% imported

also leads to the emergence of vegetable farmer groups and associations to support the demand. Despite this, some problems do exist related to access to irrigation and water availability. Investments in irrigation systems require access to credit and financing alternatives, but the loan arrangements offered by local financial institutions feature high interest rates and unfavorable conditions[46].

Farmer's Profile

Mr. Chor Pagncharong is the owner of a vegetable farm in Samlot district of Battambang province. Although he has a large piece of land, about 40 hectares, he only uses 5 hectares of land to grow vegetables. He started growing vegetables in 2017 and has chosen to grow only khatna, cabbages, and pak choi. He continues to expand production by adding other vegetables such as long eggplant, round eggplant, long bean, and tomato.

Mr. Pagncharong sees more demand for local vegetables because people are worried that imported vegetables contain unsafe levels of chemicals. Cambodian buyers prefer to purchase local vegetables rather than the imported ones, and thus he aims to increase production to meet the local demand. In the meantime, he needs to adopt good agricultural practices to guarantee and comply with standards on food safety. Mr. Pagncharong has strategically decided to grow vegetables that are not imported from neighboring countries in large quantities, as this reduces any threat of competitor markets specifically from Vietnam and Thailand.

The market that Mr. Pagncharong sells to is mainly the domestic markets through intermediaries, and for vegetables transported to Battambang and Kampong Cham province. He intends to establish relationships with other traders in order to diversify his risk. This also helps to ensure that he can sell his vegetable production at varying prices, and in certain instances at better prices. He is now trying to connect with traders in Phnom Penh.

[46] Francesco & Sovith, 2016

Energy Consumption at the Farm

The farm relies on two diesel engines with respective capacities of 22 horsepower and 16 horsepower. The diesel engine pumps are mainly used in the dry season and during dry spells in the rainy season. Mr. Pagncharong claims that the farm uses about 15 liters of diesel per day and that he is paying between 2,800 riels ($0.70) and 3,200 riels ($0.80) per liter.

4,050

liters of diesel fuel avoided per year

Table 20: Energy consumption with the vegetable farm

Diesel engine pump	22 Horsepower
Diesel engine pump	16 Horsepower
Liters	15 liters per day
Price of diesel	2,800 – 3,200 riels ($0.70 to $0.80) per liter
Diesel cost	$2,835 to $3,240 per year

Investing in solar water pump

In order to maximize the growing season for year-round cultivation and to reduce costs associated with diesel pumps, Mr. Pagncharong wants to invest in solar water pumps and to set-up a sprinkler irrigation. With water supply assurance, he can grow more vegetables and thus could achieve maximum cash crop productions. Mr. Pagncharong has approached a local solar provider to purchase solar water pumping system but given the relatively high upfront costs associated with the purchase he does not have the financial capacity. In Mr. Pagncharong's situation, where he has already pledged the farm's land title as collateral for an existing loan from a local financial institution to start the vegetable farm, new financing from an FI is not an option.

There are two options available to support the water requirements of Mr. Pagncharong's vegetable farm. The first option is that the required water volumes can be achieved by pumping water into an elevated water storage tank which allows for water flow released through gravity, but the tank also adds to the farmer's capital investment. This alternative would also allow the farmer to continuously pump water into the tanks whenever there is sunlight, which provides greater assurance that adequate reserves are maintained. For the second option, which is likely to require an even greater amount of capital investment, the solar water pump could be designed to provide equally as strong capacity and pressure to support sprinkler irrigation systems.

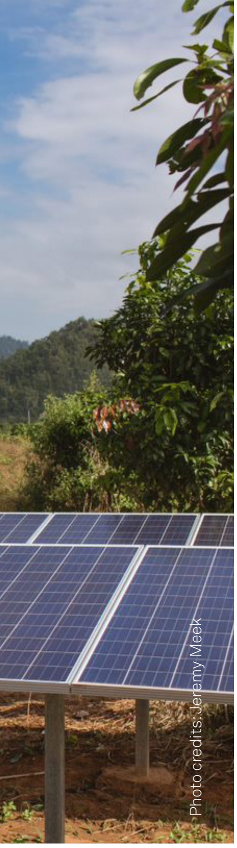


Table 21 illustrates a comparison of Mr. Pagncharong's alternatives from a pure cost perspective. If Mr. Pagnchrong continues to use diesel pumps over the engine's five year lifespan this will cost him approximately $17,700, which is more than the cost of either solar pump option. In option 1, if Mr. Pagncharong decides to purchase a solar water pump system, he will need to invest about $10,500 plus an additional cost of $5,000 on the water storage tanks (i.e. this option assumes a 20 cubic meter elevated water storage unit). Thus, the total investment for option 1 is $15,500, and the simple payback period is about 4.8 years. The estimated annual cost savings of $3,240 is related to reduced diesel fuel consumption. Option 2 would allow Mr. Pagncharng to forego the scenario of having a water storage tank, as the system has more capacity and pressure to support a direct connection to the sprinkler irrigation systems. The simple payback period for the second option is about 5.4 years. However, if he takes a loan from a local bank at any interest rates, it will takes him to repay the bank longer period through using energy cost saving.

Table 21: Diesel engine pump compared to solar water pump alternatives

Items	Diesel pumps	Solar pump (3HP-motor, and Solar power: 4.62kw) – Option 1	Solar pump (5HP-monitor, and solar power: 6kw) – Option 2
Capital cost	$1,500	$10,500	$17,500
Life span	5 years	20 years	20 years
Diesel cost per year	$16,200	$0	$0
Costs after 5 years	$17,700	$10,500+ some maintenance	$17,500+ some maintenance
Water storage tanks		$5,000 (20m3 of elevated water storage capacity)	Not required for this technology option

Table 22: Operational costs per year for Mr. Pagnchrong's vegetable farm

Items	Amount ($)
Fuel & maintenance	3,240
Fertilizers	3,600
Workers	19,500
Seeds	450
Preparing land and materials	1,687.50
Total operational cost per year	$ 28,478

For Mr. Pagnchrong's vegetable farm, costs associated with fuel and maintenance represent about 10% of the operational cost.

Photo credits: Jeremy Meek

RENEWABLE ENERGY LOAN PRODUCTS

Why Loans for RE Investments?

While electricity access has improved in Cambodia in recent years, there are still many farms operating in off-grid areas, and thus many farmers are forced to rely on back-up diesel generators. The prices of diesel are expensive for off-grid farms and the farmers pay between $0.70 and $0.80 per liter. Even in circumstances where farmers have access to grid electricity, the prices are still relatively high and not reliable in some regions of the country. For instance, most of CP Cambodia's contract farmers are able to access the grid, however, those adopting modern pig farm management "enclosed stable systems", consume large amounts of electricity to run the evaporative cooling system which ultimately raises operational expenses for these farmers. As a result of this, an observed trend in the market is that more pig farms are interested in biogas digester technology, which allows them to convert pig manure into energy.

Based on the focused assessment carried out for this study, which was conducted by Nexus with pepper, fruits, vegetable and livestock farms in Battambang, Pailin, Mondulkiri, Tbong Khmum, Kampong Speu, Kampot and Pursat, our findings illustrate that farmers and farm owners are looking for different options to decrease energy costs. Further to this, all surveyed respondents are interested to invest in renewable energy technologies, even though it was self-acknowledged that they have limited information or are less familiar with new technologies.

Energy costs of the surveyed parties in our study represent between 6% to more than 50% of the operational cost depending upon the size of farm and type of crops and livestock. This supports the high interest and expressed need from farmers and SMAs to explore RE investment. However, the high upfront cost, lack of awareness of the technology, and lack of access to appropriate finance remain key inhibitors for the transition to RE technologies, leaving farmers with little option than to rely on diesel generators and engines.

What are the Benefits to Financial Institutions Offering RE Loan Products?

New Market Segment

From our study, there is potential for FIs to finance a variety of farm owners who are interested in RE investments such as solar and biogas technologies. The costs of some RE technologies for SMAs could align well with the average loan sizes provided by commercial banks. In addition, it has been observed that some MFIs may be willing to provide larger loan sizes. For example, an investment in a solar powered irrigation system ranges from $5,000 to $100,000 for SMAs and larger farms If FIs wish to broaden their services and develop products to include a more diverse range that meets the needs of their clients, RE financing could emerge as a new market segment. It is estimated that there are more than 7,000 SMAs and larger farmers in the pepper, pig, and longan sub-sectors alone and these are suitable enterprise sizes that are not only interested in adopting renewable energy technologies, but more importantly have the financial capacity to potentially service the debt required for the technology purchase.

Better Engagement with Existing Clients

About 80% of respondents claimed that they took loans from FIs to either set-up their farms or to support the operation of their farms. In these cases, offering RE loans to existing clients and farmers may be a cost-effective option as the FIs may be able to leverage existing KYC documentation and credit history data to assess the loan application, which would require less time and costs for conducting due diligence. In addition, it provides FIs with an opportunity to engage more deeply with existing customers and could ensue greater customer loyalty. FIs also already have wide networks with established branches in multiple provinces which will allow for a portfolio of this type to quickly scale in a cost-effective manner.

Secured Loans

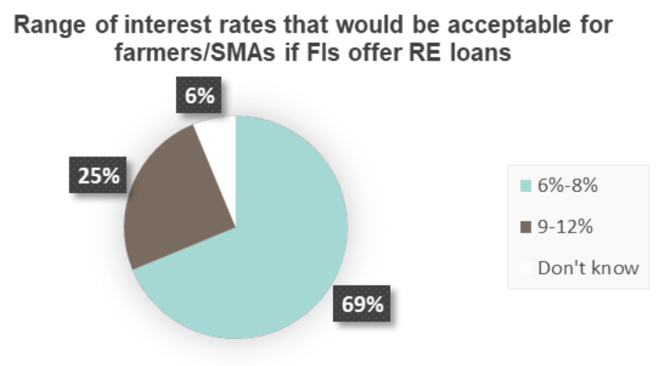
Most FIs in Cambodia require the borrowers to pledge collateral. Our survey indicates that about 62% of respondents are willing to pledge collateral if a bank offers RE loan products. Furthermore, all surveyed farmers are interested in loan products to support RE investments if the repayment structure is calculated based on energy savings realized by transitioning to RE.

If FIs could consider other forms of collateral such as the contracts that are entered into for contract farming, this would also open up new opportunities. For example, CP Cambodia develops modern farming management systems and engages in contract farming of various types with Cambodian farmers throughout the country; especially for pig farms. As CP is a large international organization of relatively stronger credit quality, any contract that a farmer may have with CP serves to some extent as guaranteed revenues. This is further supported by the fact CP has high standards that the farmers must adhere to and facilitates the higher probability that the pigs will be purchased. In pig contract farming, CP provides piglets and sows, feed and drugs, as well as technical assistance. In addition, CP places great emphasis on pig farm management technology through providing a series of trainings to the pig farmers and ensures that the farmers adhere to strict guidelines to ensure they are selling a consistently high quality product.

Interest Rate

In 2017, the National Bank of Cambodia enacted a fixed ceiling on interest rates for microfinance institutions (MFIs), which sets a cap for interest rates at 18% per annum. For SME loans, some MFIs and banks will lend at rates between 9% and 18% per annum, with loan sizes of up to $100k. When asking about what range of interest rate would be acceptable for farmers and SMAs if banks were to offer RE loans, about 69% of respondents consider having between 6% and 8% interest annually as acceptable, and about 25% of farmers said they could afford between 9% and 12% per annum. Only 6% abstained from responding. Given the overlap in interest rate ranges from the FIs and the borrowers perspective, it indicates that there could be an opportunity for FIs to explore.

Figure 2: Range of interest rates that would be acceptable for farmers and SMAs if FIs offer RE loans



What are some of the Specific Challenges within the Cambodian Agri-food Sector?

Price volatility impacts on farmers debt service capacity

• Agricultural products such as mango, pepper and longan are mainly exported to neighboring countries like Thailand and Vietnam, and the prices are often volatile as they are set by intermediaries. In addition, as many farmers do not have written purchase agreements with the traders this exposes them to risk.
• The prices of Non-PGI pepper continues to drop in 2019, and at the current prices of between $1.80 and $2.00 per kilogram, this leaves most farmers with little cash flow to meet any loan payment obligations.
• The prices of longan are volatile as well, however, the farmers are happy with the current prices. The farmers surveyed for this report are able to sell their product at prices between $0.85 and $1.00 per kilogram. One way to mitigate price risks is for farmers to join associations or cooperatives. An example of such is the Pailin Longan Product Agricultural Cooperative, which is an organization that assists members to negotiate better prices with the traders and works to disseminate information on price development.

Climate and environmental risks

• Drought and hot weather; especially in March and April serve as a main threat to fruits and spice farmers. Some longan and pepper farmers in Pailin and Mondulkiri have no back-up sources of water for irrigation. During these seasonal cycles, ponds are typically dried up as well, and in some areas digging wells where the water table has changed (i.e. are at greater depths) does not provide a solution to the challenge. As a result, careful planning is required and collecting rainwater in ponds during the rainy season becomes a critical action to secure water for the dry season.

Disease

• Citrus trees in Cambodia have been affected by many different diseases which can cause considerable damage to orange crops. The most serious threat has been caused by Huanglongbing (HLB), which is known in Khmer language as "Slek Prak" disease[47]. Orange farmers in Battambang have been impacted by this as they could not stop the widespread of this deadly tree disease[48]. This can be considered as the main risk and challenge for orange farmers.
• The major risk for pig farms is swine disease, which spreads rapidly and killing the livestock and causing significant losses for farmers. Particularly, pig farmers are worried about African swine fever, which has now spread to the border of Cambodia, namely to Ratanakkiri and Kratie provinces. For contract farming projects with CP Cambodia, in such circumstances both farmers and the company are responsible for sharing the losses.

What are Possible Repayment Structures for RE Investments?

Through Nexus's experience of managing the Clean Energy Revolving Fund (CERF), the portfolio's average loan tenor was between three and five years. The tenors for all of the loans in the portfolio were designed based on a simple payback period that was calculated based on the savings recognized as a result of transitioning away from fossil fuels; CERF borrowers were able to reduce up to 80% in diesel consumption. The next section illustrates the feasibility of using cost savings (in different cases) that could facilitate loan repayments.

All surveyed respondents were interested to invest in RE technologies if the financial institutions were able to link their loan payments to realized energy savings. For example, as described in Case Study 4, a longan farmer (Mr. Un Theng) is interested in purchasing a solar water pump system (capacity: 15kW) to replace his three diesel engine pumps, but this may require a $35,000 RE investment. If a bank were to finance the purchase of this system, the approximate savings realized from not having to purchase diesel fuel, $15,120, could be used to repay the loan. Table 23 illustrates the scenario where Mr. Un Theng takes a loan at 12% per annum and utilizes the $15,120 of cost savings to meet his monthly loan payments.

Table 23: Loan terms for longan farmer (Mr. Un Theng)

Loan Terms Summary monthly – Mr. Theng's longan farm	
Loan amount	$35,000
Interest rate	12%
Term (years)	3
Term (months)	6
Monthly payment with financing	$1,163
Monthly cost savings	$1,260

Mr. Theng has been able to achieve considerably higher profit compared to farmers of other crops and can sell longan fruit at prices of $1 per kilogram. Table 24 illustrates a hypothetical income statement for Mr. Theng and demonstrates that with his yearly profit, he may have additional financial capacity to make even higher monthly payments than what is structured in the previous table based on energy savings alone. Of interest, in Mr. Theng's specific case, his energy cost savings will exceed the total yearly loan payments, which provides Mr. Theng with the option of making higher principal payments per month and could accelerate the early repayment of the loan.

[47] Setha & Ji Su, 2011
[48] Interviewing some orange farmers in Battambang province during workshop on the registration procedure and protection of Geographical Indication Mark on the 29th January 2019.

Table 24: Mr. Un Theng sample annual income statement

Example: Income Statement for Mr. Theng	Amount ($)
Revenue	$60,000
Expenses	$35,480
Fuel & maintenance	$17,080
Fertilizers	$10,000
Workers	$8,400
Net profit	$24,520

If we examine another case and repayment structure suitable for a pig farm (case study # 3), the investment cost for biogas system is about $56,500, but Mr. Chang Touch took loan from a local bank with the 12% interest rate[49]. It takes him five to six months to produce fattening pigs. Without investment in a biogas system, he spends about $15,000 per meat production cycle on electricity. If Mr. Touch were to invest in a biogas digester system this would reduce his electricity costs to $5,000 per meat production cycle, plus $1,200 for maintenance, representing significant cost savings.

Table 25 explains how much he could repay on a loan with a 12% per annum interest rate, if the repayment schedule is constructed based on pig collection cycles and the energy savings from the biogas digester system are integrated. In this scenario the repayment period is approximately 4.2 years, if he chooses to use the entire annual savings realized of $8,800 to repay the loan.

Table 25: Loan terms for pig farmer (Mr. Touch)

Loan Terms Summary monthly – Mr. Touch's pig farm	
Loan amount	$56,500
Interest rate	12%
Term (years)	4.2
Term (months)	50
Total payments (semi-annual)	$8,596
Semi-annual cost savings	$8,800

Table 26 illustrates that Mr. Touch's pig farm is profitable, with a yearly profit of $68,600. With this additional profit Mr. Touch could potentially make even higher payments than what has been structured in table 25, which is solely based on energy savings alone.

Table 26: Mr. Touch sample annual income statement

Income Statement for Mr. Touch	Amount ($)
Revenue	$87,500
Expenses	$48,900
Electricity bill	$30,000
Workers and food	$18,900
Net profit	$38,600

As a final case example, Table 27 illustrates the repayment structure for a hybrid solar system installation for a pig farmer in Kampong Speu province. Mr. Chanrath was financed through Nexus's CERF with a loan at an 8% per annum interest rate. The cost of the hybrid solar system is $18,738.60, but Mr. Chanrath elected to apply for a smaller loan amount of $16,864.74 to purchase the hybrid solar system. The pig owner and CERF agreed on a loan tenor of five years, with monthly payments of $341.96. This repayment structure aligns with the revenue stream from the pig farm as the piglets are collected every 3 weeks. Notably, the exact cost savings from the solar investment is $450 per month, and if Mr. Chanrath chose to pay this entire savings amount towards the CERF loan, it would take him about 3.6 years to repay the entire loan.

Table 27: Loan terms for pig farmer (Mr. Chanrath)

Loan Terms Summary monthly – Mr. Chanraths' pig farm		
Total cost of the system	$18,738.60	$18,738.60
Loan amount (~90% of investment)	$16,864.74	$16,864.74
Co-investment from pig farm (~ about10%)	$1,874	$1,874
Interest rate	8%	8%
Term (years)	5	3.6
Term (months)	60	36.5
Monthly payment with financing	$342	$450
Monthly cost savings	$450	$450

Table 28 illustrates that Mr. Chanrath's pig farm is very profitable and provides another indicator for his additional financial capacity and potential to make even higher monthly payments.

Table 28: Mr. Chanrath sample annual income statement

Income Statement for Mr. Chanrath	Amount ($)
Revenue	$200,000
Expenses	$72,600
Diesel expenses	$32,400
Maintenance and oil	$1,800
Workers	$30,000
Food for workers	$6,600
Others (feeding facilities and spare parts)	$1,800
Net profit	$127,400

[49] Mr. Chang Touch a large amount of loan from a local bank for other business activities, but some proportion of loan is used to invest in biogas system.

Photo credits: Jeremy Meek

RECOMMENDATION

The agricultural sector is the backbone of the Cambodian economy. However, energy access represents a significant challenge and expense for SMAs and farmers when it comes to production, processing, and distribution, which prevents them from establishing viable businesses that can successfully compete in the local and regional markets. There are increasing opportunities for farmers to gain access to electricity through the installation and use of RE technologies.

The five practical case studies included in this report focused mainly on the longan, pepper, livestock, and vegetable sub-sectors, which demonstrate strong suitability for RE technologies; particularly solar water pumps, hybrid solar systems, and biogas digesters. Two other fruit sub-sectors, orange and mango, also present potential opportunities for the adoption of solar water pumps, but a further assessment of the specific energy requirements for these sub-sectors would need to be conducted and is out of scope of this research. Some additional market information on these fruit crops is provided in the appendix. From a broader market perspective, it is also interesting to note that in early May 2019, Cambodia reached a trade agreement with the eastern Chinese province of Shandong to increase the export of Cambodian agricultural products to China. Cambodian SMAs and large-scale farms may benefit from this trade agreement as the Cambodian government is encouraging Chinese counterparts to invest in agricultural products, especially milled rice, mango, cassava, longan and bananas for export to China[50].

Based on our focused survey, all respondents are willing to adopt RE technologies. They are interested in loans from banks if the interest rate is below 12% per annum. In addition, the survey indicates that about 62% of respondents are willing to consider the pledge collateral. If FIs wish to broaden their services beyond business lending, RE financing for SMAs and farmers emerges as a new market segment. By exploring this new market, the FIs have an opportunity to play a key role in increasing access to RE technologies in the agri-food sector in Cambodia, and to achieve this at scale.
It is acknowledged that the FIs may initially face challenges due to a lack of expertise in the technical aspects of RE products, however this barrier can be overcome. The major knowledge gaps include (1) a lack of expertise in helping farmers to assess product quotes

[50] https://www.khmertimeskh.com/50603733/new-trade-centre-opens-in-shandong/

and to assist with comparisons as it relates to the quality of products, (2) no or limited expertise in offering technical support to clients for maintenance, and (3) a lack of knowledge to ensure that RE technologies are installed properly and are generating the estimated energy cost savings. FIs should be able to overcome all of these challenges by forming partnerships with technology providers, NGOs and other organizations whom hold the required know-how and expertise.
The FIs should also engage with other stakeholders such as government agencies who are working in the RE sector to support the successful design and delivery of their RE loan products.

From an engagement perspective, one specific recommendation is for FIs to explore concessional loans which are made by multinational development banks, government agencies or development agencies. The loans generally provide below-market interest rates that can help mitigate risks or reduce an FIs cost of capital. For example, in early 2019, the Cambodian Rural Development Bank (RDB) received a concessional loan from the International Fund for Agriculture Development (IFAD) through the Ministry of Commerce, which dedicated financing to small landholder farmers and agricultural cooperatives in Cambodia. RDB is also considering to expand their portfolio to include RE loan products such as solar technology and biogas digester systems[51]. In 2018, IFAD also pledged an additional $64 million in concessional loans to the Cambodian government to boost the local agriculture industry[52].

One example of an innovative financing vehicle that aims to support the energy transition is Nexus for Development's pilot fund called the Clean Energy Revolving Fund (CERF), which aims to provide affordable financing to SMAs and farmers in Cambodia to catalyze the adoption of RE technologies. CERF has so far financed 14 RE projects by disbursing loans to farmers across the country. The loans were used to invest primarily in the installation of clean energy technologies such as solar-powered water pumps and hybrid solar systems. Nexus is also positioned to provide technical assistance or deliver on discrete consultancy projects to FIs interested in this new market, specifically in the design of RE loan products, to support knowledge transfer on best practices for the due diligence process, and to leverage our technical services team to provide support on energy assessments for technologies suitable for SMAs and farmers.

We acknowledge that further research could be conducted to tie our initial findings with policy recommendations and would also suggest that in any next stages both legal and compliance matters be taken into consideration, especially if any of the recommendations shared in this report were to replicated as a model for other countries in Southeast Asia.

[51] Interview with representative of Rural Development Bank
[52] https://www.khmertimeskh.com/495310/ifad-pledges-64-million-in-concessional-loans/

REFERENCES

ADB 2015, Renewable Energy Developments and Potential in the Greater Mekong Subregion. Mandaluyong City, Philippines: Asian Development Bank.

ACIAR 2017, Cambodian Vegetable Forum Handbook. Australian Centre for International Agricultural Research.

Bansok. R, Phirun. N, and Chhun. C 2011, Agriculture Development and Climate Change: The Case of Cambodia, CDRI Working Paper Series No. 65.

CIRD 2015, Memot Pepper Market System Analysis, Phnom Penh: Cambodian Institute for Research and Development.

CIRD 2017, Report on Orange Value Chain Assessment, Phnom Penh: Cambodian Institute for Research and Development.

Goletti, F., & Sovith. S 2016, Development of Master Plan for Crop Production in Cambodia by 2030, Tonle Sap Poverty Reduction and Smallholder Development Project (TSSD), Phnom Penh: Ministry of Agriculture Forestry and Fisheries.

Hans. H & Lucie. P 2018, the benefits and risks and solar-powered irrigation – a global review: Food and Agriculture Organization of United Nations.

Kunal.S, & Anish. G 2017, Black Pepper Market Analysis & Outlook 2017, Nirmal Bang.

Mekong Institute 2016, Study on Market and Value Chain Mapping: Study of SME Cluster Value Chain of 19 Provinces along the Southern Economic Corridor and Southern Coastal Corridor of the Greater Mekong Subregion.

MEF 2017, GDP: Sectoral Performance, Phnom Penh: Ministry of Economy and Finance.

NEA 2018, Skills Shortage and Skills Gaps in the Cambodian Labour Market: Evidence from Employer Survey 2017, Phnom Penh: National Employment Agency

NIS and MAFF 2015, Census of Agriculture of the Kingdom of Cambodia 2013, Phnom Penh: National Institution of Statistics and Ministry of Agriculture, Forestry and Fisheries.

Seng. S, Bruce. LD, Keartha. C and Sokmao. C 2016, Preparedness of Cambodia Small Landholder Farmers toward ASEAN Economic Community (AEC) Integration, Phnom Penh: the NGO Forum on Cambodia.

Setha.V and Ji Su. H 2011, Controlling Citrus Huanglongbing (HLB) for the Rehabilitation of Citrus Orchards in Cambodia, International Journal of Environmental and Rural Development.

Seav 2017, Market Assessment on the Potential of Solar Powered Irrigation Systems in Cambodia.

SAC 2011, Contract Farming Study: Understanding Contract Farming Operations in Cambodia, Phnom Penh: Social Action for Change.

Thorng. R, Net.N, and Medialdia. MT 2013, An Assessment of Longan Value Chain in Pailin Province, Cambodia. Mekong Institute Research Working Paper Series no. 06/2013.

WWF 2016, Power Sector Vision: Towards 100% Renewable Electricity by 2020, Greater Mekong Region, Cambodia Report: World Wildlife Fund.

The World Bank 2019, International Development Association Project Appraisal Document on a Proposed Credit for a Cambodia Agricultural Sector Diversification Project.

Youssey. L 2018, 'Value Chain Analysis of Memot Pepper in Cambodia', Australasian Agribusiness Perspectives, vol. 54, no. 21, pp. 24 – 42.

Additional Market Data – Orange and Mango Sector

Overview

Like other fruit crops, access to reliable water resources for irrigation is the main challenge for orange farmers as they rely heavily on annual rainfall[53]. Orange farmers require water for about four to five months during the dry season, with orange fruit trees requiring water every two to three days. According to the Chief of Angkrong Orange Cooperative, most orange farms in Kravanh and Veal Veng districts of Pursat are in the off-grid area and farmers rely on diesel engine pumps during the dry season.

Mangoes do not consume as much water, however, as mango farmers attempt to increase fruit production during the off-season, it is necessary to water trees more regularly. As a result, mango farmers understand the importance of investing in a system of irrigation pipes and sprinklers to achieve growth production targets in the off-season.

While the merit of adopting solar water pumps appears feasible for orange and mango sectors, further research on the energy requirements for these sectors is recommended.

Market – Oranges

"Pursat Oranges" are popular in Cambodia – green and yellow fruits; known for being sweet and having a pleasant smell. The combination of its rich sweet and sour flavors makes the fruit special[54]. Pursat sweet orange was first introduced to Cambodia during the Angkor period from China. After the French occupation, sweet orange cultivation spread nationwide, and it became the second most important fruit crop next to mango[55]. The main plantation areas of Pursat Oranges are in Battambang and Pursat provinces, with a total production cultivated area of 51,675 hectares and 4,071 hectares, respectively[56].

According to the orange value chain assessment in 2017, which conducted by CIRD, oranges grown in four districts of Battambang province namely Banan, Sangke, Ek Phnom, and Thmor Kol have a distinct special sweet flavor, which allows them to demand a significantly higher price as compared to normal orange grown in different districts of Battambang and Pursat provinces. The rich soil condition, climate, organic fertilizer application, and planting technique support the strong demand for this fruit from these four districts. The orange fruits from these districts are mainly collected and redistributed by wholesalers and collectors to Phnom Penh, Siem Reap, Kampong Cham and other regions within the country as well as exported to Thailand[57]. The average yield per orange tree is estimated at 440 fruits in one season (August to October). The current prices vary from $5 to $10 per "Phloun" (44 pieces of fruit = 1 Phloun)[58].

In Pursat province, there has been large scale cultivation of orange fruit crops since 2012 when the Cambodian government provided land titles for people who live in Kravanh, Veal Veng and Kra Kor districts, jurisdictions located near Cardamom Mountain.

The Cambodian Institute for Research and Rural Development (CIRD)[59] and Ministry of Commerce (MOC) are now working together to have the orange fruit recognized under the Protected Geographical Identification (PGI) status. This type of action will be favorable for farmers as labeling oranges as PGI will not only allow the fruit to gain greater market exposure, but it will allow the fruit to sell at higher prices. In this stage, orange farmers are encouraged to form an association with technical assistance from CIRD[60].

Market – Mango

Mango is a common fruit tree in Cambodia and there are different varieties such as Keo Romeath, Keo Chin, Phomsen, Kbal Damrey and others. The main producing season for all kinds of mango is between April and May. Keo Romeath has become the most popular for both local consumption and export. This variety can produce two additional crops per year in the off-season during

[53] https://www.khmertimeskh.com/50509947/orange-farmers-feel-the-squeeze/
[54] https://www.phnompenhpost.com/travel/juicy-journey-orange-country
[55] Setha & Ji Su, 2011
[56] CIRD, 2017
[57] CIRD 2017
[58] Mekong Institute 2016.
[59] Cambodian Institution and Rural Development (CIRD) is a nonprofit organization working to promote GIP and to find the market for producers. CIRD also plays role to link producers/farmers to traders in order to get their products commercialized.
[60] CIRD has conducted several workshops already with orange farmers from both Battambang and Pursat to discuss and explain about the registration procedure and protection of Geographical Indication Mark.

the period of September to February, with the first off-season harvest occurring from September to November and the second off-season harvest from late January to February.

An increasing number of farmers and investors have become interested in mango cultivation, encouraged by increasing prices and the opportunity of producing in the off-season. Large areas in Kampong Speu and other provinces are now covered with mango trees and the production is expected to increase substantially in the years to come. According to MAFF, mango trees are already grown in all 25 provinces of Cambodia and the total cultivated area reached 65,251 hectares in 2014 compared with 23,980 hectares in 2010. The total cultivated area in Kampong Speu alone is over 39,500 hectares, which accounts for about 60% of total mango plantation areas in 2014, followed by Kampot, Siem Reap, Battambang and Kratie[61].

Cambodian mangoes are typically exported to Vietnam and Thailand informally by individual traders. Often the fruit is then packaged and exported to China and other countries. The formal trade channels for mangoes from Cambodia are essentially non-existent. GDA and MAFF statistics indicate that export volumes of mangoes were 600 tons in 2013, decreased to 30 tons in 2014 and rapidly increased to 9,117 tons in 2015. However, informal export to Thailand and Vietnam is estimated to be more than 20.000 tons per year[62].

[61] Francesco & Sovith, 2016
[62] Francesco & Sovith, 2016

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Nexus for development

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