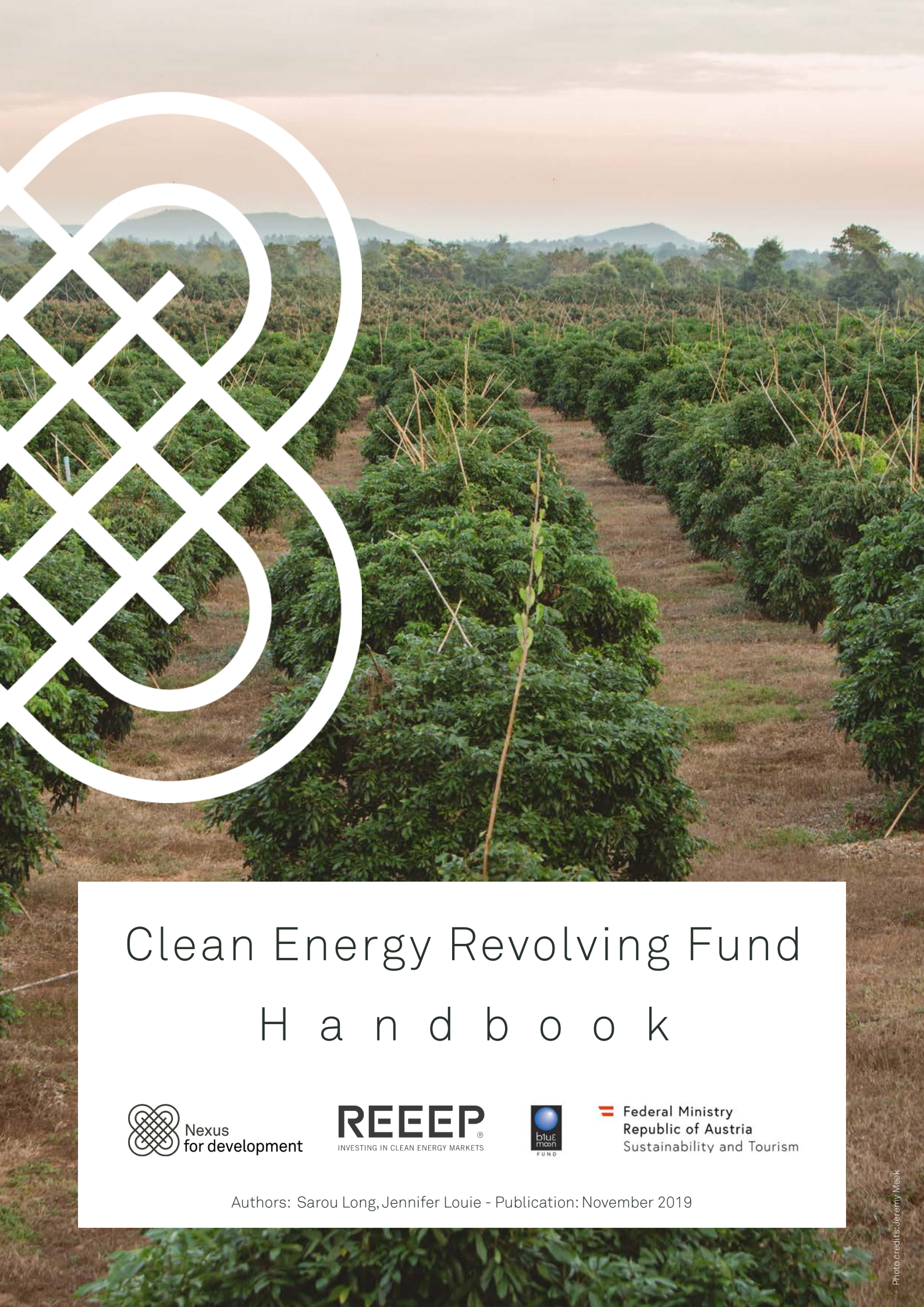

# Clean Energy Revolving Fund

# Handbook

Nexus for development

REEEP
INVESTING IN CLEAN ENERGY MARKETS

blue moon FUND

Federal Ministry
Republic of Austria
Sustainability and Tourism

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# ABBREVIATIONS

| | |
|---|---|
| ADB | Asian Development Bank |
| BMF | Blue Moon Fund |
| CBC | Credit Bureau Cambodia |
| CERF | Clean Energy Revolving Fund |
| DD | Due Diligence |
| Ecosun | Ecosun Energy Cambodia |
| EDC | Electricite du Cambodge |
| GMB | Greater Mekong Basin |
| IC | Investment Committee |
| IMB | International Multi-Business |
| INDC | Intended National Determined Contribution (INDC) |
| IRENA | International Renewable Energy Agency |
| MIFs | Microfinance Institutions |
| Nexus | Nexus for Development |
| NBC | National Bank of Cambodia |
| PGI | Protected Geographical Identification |
| PV | Photovoltaic |
| RDB | Rural Development Bank |
| RE | Renewable Energy |
| REEEP | Renewable Energy and Energy Efficiency Partnership |
| SDG | Sustainable Development Goal |
| SMAs | Small and Medium Agri-businesses |
| SOGE | Solar Green Energy Cambodia (SOGE) |
| TPs | Technology Providers |


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# EXECUTIVE SUMMARY

Nexus for Development (Nexus) launched the Clean Energy Revolving Fund (CERF) as a climate change mitigation project; it commenced in 2016 and was scoped to end after a three-year period. The innovative finance model began with an initial investment from the Renewable Energy and Energy Efficiency Partnership (REEEP) with support from the Austrian Government and the Blue Moon Fund (BMF). By providing affordable finance, the CERF catalyzed the adoption of clean energy technologies by Small and Medium Agri-businesses (SMAs) and farmers in Cambodia, which in turn reduced CO2 emissions, encouraged an early shift away from fossil fuel-based energy, and increased food processing productivity.

The absence of flexible finance instruments for RE technology investments coupled with low levels of end-user knowledge and trust in RE caused low-adoption rates across the country for decades. CERF's financing conditions are truly innovative in the Cambodian context, as financial institutions currently only provide SMAs and farmers with expensive and fully collateralized loans (usually with land titles serving as the preferred form of collateral). CERF provided SMAs and farmers with unique and flexible financial terms (whereby both loan tenors and repayment schedules were structured to fit agricultural cycles), accompanied by technical assistance and capacity building. The RE technology was used as collateral, and low financing fees were charged. This dynamic mechanism allowed the fund to learn, adapt, and respond quickly to agricultural market realities, and the results exemplify these successes. CERF borrowers or farmers reported that they would not have made the RE investments without CERF, while technology providers, who had previously struggled to match their offer with a financial product, highlighted CERF's role as trust brokers with their target clients. When given access to renewable and affordable energy technologies, CERF SMAs and farmers significantly reduced on farm and agricultural processing costs and improved the resiliency of their businesses. CERF enabled SMAs and farmers to capitalize on energy cost savings by reinvesting this as funding to scale their businesses. As the payback period of RE investments for SMAs and farmers was typically realized within three to five years, businesses could expect to see further growth in the medium and long-term.

Over the three-year project life, 15 loans were approved by the CERF Investment Committee (IC), and to-date the fund has received repayments of principal and interest for the majority of the loan portfolio. Only one loan has defaulted, and Nexus was able to recover part of the initial capital lent. The clean energy investments made mainly were in solar water pumps and on-grid solar systems for SMAs growing fruit, vegetable and pepper, and livestock farms such as pig farms. The loan portfolio also included one community based water treatment plant. The loan sizes varied from 7,000 to over 50,000 USD, with most investments falling within the range of 10,000 to 15,000 USD. CERF loans funded up to 90% of the technology cost, with the remainder co-financed by the investees. The total portfolio of clean energy investments is 331,204 USD, of which 261,014 USD was funded by CERF capital.

CERF investments have enabled the installation of 85.76 kW of solar energy and produced 115,264 kWh of clean energy, which is equivalent to a reduction of 168 tonnes of CO2e pollution each year.

It is estimated that there are more than 7,000 SMAs and larger farmers in the pepper, pig, and longan sub-sectors alone. Each CERF project contributed about 10 tonnes of avoided CO2e emission per year. If Nexus were to finance 7,000 SMAs to adopt RE technologies, we would be able to reduce about 70,000 tonnes of CO2e emission per year.

The overall goal of this handbook is to share our learnings from managing CERF. The handbook seeks to provide background on the history of the design and set-up of CERF, CERF due diligence processes, lessons learnt, case studies, and to objectively review the challenges that were met in managing CERF. The handbook also aims to demonstrate the practicalities of financing RE investments and to build the case for why local FIs should consider this market. It offers suggestions for necessary steps or processes that should be considered when designing RE financing structures. Our desired outcome is that the handbook supports the development of the ecosystem of financiers and provides insights for FIs to gain a greater understanding of RE market opportunities and products needed for effective lending in the agri-food sector to farmers and SMAs in Cambodia. Nexus is not suggesting that FIs solely adopt the CERF model; in fact to the contrary, Nexus hopes that FIs will modify the financial model to determine what works best for them whilst still supporting the broad adoption of renewable energy.

# INTRODUCTION

## Renewable Energy in the Agri-Food Sector

CCambodia has experienced rapid development over the last two decades. Driven mainly by garment exports and tourism, Cambodia's economy has sustained an average growth rate of 7.7% between 1995 and 2018, making it among the fastest-growing economies in the world[1]. The agricultural sector plays a key role in this economic development having contributed about 20% of GDP in 2017[2]. Furthermore, 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[3].

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 which is usually associated with climate change has adversely affected crop production[4]. 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[5]. 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 contributes to greenhouse gas emissions.

Without access to affordable and reliable sources of energy, it hinders agricultural productivity, which has negative impacts on sustainable economic growth and development. The additional direct implications of this being urbanization, whereby farming is deemed by rural populations as an uneconomical activity for livelihood. Although this is acknowledged it is out of scope of this paper.

[1] http://www.worldbank.org/en/country/cambodia/overview
[2] Ministry of Economy and Finance, 2017
[3] National Employment Agency, 2018
[4] Bansok et al, 2011.
[5] WWF, 2016.

Photo credits: Jeremy Meek

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"[6]. Solar power 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[7]. 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. Looking at the global trend, International Renewable Energy Agency (IRENA) indicated that solar PV module prices have declined by around 80% between the end of 2009 and the end of 2015. IRENA also projects that average electricity costs could decrease 59% for solar PV by 2025 compared to 2015 prices[8]. 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[9].

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 commercial pig farming. 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 odors and methane emissions, in addition to reducing the energy cost of the farm owners[10].

Based on the experiences of Nexus's Clean Energy Revolving Fund (CERF)[11] 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 a potential market by these banks. 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 offered in the market, the requirements or in-house knowledge for an energy assessment, or an understanding of the possible return prospects on such investments. Another noticeable reason RE financial products have not been a priority of the FIs is because they are concerned about the quality of RE products, and after sale servicing by technology providers.

## What is renewable energy and why it is important?

Renewable energy is energy from sources that are naturally replenishing but flow-limited; renewable resources are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time[12]. Renewable energy technologies are considered the clean sources of energy that have a much lower environmental impact than conventional energy technology.

Cambodia has one of the lowest electrification rates in Southeast Asia. The Royal Government of Cambodia has set an ambitious target to reach 100% of the villages with a certain type of electricity by 2020 (including battery power) and 70% of households connected with grid-quality electricity by 2030. Currently, 62% of villages and 53% of households have access to grid quality electricity in Cambodia[13]. Energy security, environmental concerns, and sustained economic growth are the essential drivers for the renewable energy deployment. In early 2019, Cambodia experienced power outages of around six hours per day. As a large amount of Cambodia's electricity is generated from hydropower dams (i.e. about 48%) and as a result of very dry and hot weather between January to April, the hydropower dams were unable to produce enough electricity. Reflecting on the experience of power outages and in an effort to reduce the country's dependency on hydropower dams, Electricite du Cambodge (EDC), the national electric utility, is now aiming to diversify energy production and is considering to increase the amount of renewable energy sources used to include solar energy within the next few years[14]. The government aims to produce at least 20% of energy from solar energy in the next three

[6] SEVEA, 2017
[7] ABD, 2015
[8] IRENA 2016
[9] Hans. H & Lucie. P 2018
[10] 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.
[11] 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.
[12] https://www.eia.gov/energyexplained/?page=renewable_home
[13] http://www.aseanenergy.org/articles/universal-access-to-energy-in-asean-case-of-cambodia-and-lao-pdr/
[14] https://www.khmertimeskh.com/50621694/solar-energy-to-be-prioritised/

years[15], supporting the fact that renewable energy will play an increasingly important role in helping Cambodia to develop energy security. The other types of renewable energy sources in Cambodia include hydropower, biomass, biogas, and wind power, which could also address the rising energy demand in the country[16].

CERF was a pilot project, which aimed to provide low-interest loans to farmers and SMAs to adopt clean energy technologies. In the early stages of the pilot fund, Nexus was able to assess other renewable energy technology applications in the agri-food sector to address different needs of the end users in the sector. This assessment showed that solar energy is a proven technology with wide applicability in Cambodia, and it is considered as more suitable for the agri-food sector particularly for vegetable, fruit, spice and pig farms. Simply understood, solar energy is radiant light and heat from the sun that can be used to heat water or buildings and can be converted into electricity via solar photovoltaic (PV) panels (PV panels change sunlight directly into electricity). Solar energy has benefits and some limitations. The solar energy systems do not produce air pollutants or carbon dioxide, and systems on buildings have minimal effects on the environment. The amount of sunlight is a key factor influencing the output of solar energy and the greatest drawback as battery technology is still relatively expensive[17].

The CERF experience, which is described below is mainly related this type of technology. Solar energy investments under CERF are implemented as either stand-alone systems or grid-connected systems. Most solar projects are stand-alone systems, which means they are not connected to the national grid; they produce energy for use at the production or farm sites (examples include solar water pumps and hybrid solar systems). These off-grid systems represented the majority of the CERF portfolio. Only two solar investments in the portfolio are grid-connected systems.

Nexus for Development (Nexus) and Renewable Energy and Energy Efficiency Partnership (REEEP) are using our experience of piloting CERF as an innovative financing instrument to answer important structural questions about the role of climate finance in helping to achieve the United Nations Sustainable Development Goal (SDG) 7. This is aimed at ensuring access to affordable, reliable, sustainable and modern energy for all. Some of the questions we have sought to address include:

- How can public funds be used most effectively to help commercial financiers identify, assess and manage their risks in funding clean energy projects,
- How can project implementers help reduce high transactions costs in small projects to attract larger scale investment, and
- How can commercial financiers be incentivized to utilize blended finance models to progress this SDG agenda?

Cambodia made extensive progress in developing processes for implementing climate change interventions over the last decade. The overarching development plan for the country, the National Strategic Development Plan (2014-2018), states the importance of implementing Cambodia's Climate Change Strategic Plan (2014-2023) and contains indicators to track the implementation of climate change actions. Furthermore, Cambodia's Intended Nationally Determined Contribution (INDC) proposes to cut greenhouse gas emissions by 27% by 2030. Promoting use of renewable energy and adopting energy efficiency are identified as one of the mitigation strategies in the INDC. From the 14 CERF investments, approximately 168 tonnes carbon dioxide equivalent are avoided every year, which is considered micro-scale, but nonetheless could be counted towards Cambodia's INDC from mitigation actions in manufacturing and other sectors. More importantly what this pilot project sought to demonstrate is the positive impact towards achieving INDCs that this type of innovative financing could provide if scaled and supported by local financial institutions.

## Why the CERF Handbook?

The overall goal of this handbook is intended to share our learnings from managing CERF. The handbook seeks to provide background on the history of the design and set-up of CERF, CERF due diligence processes, lessons learnt, case studies, and to objectively review the challenges that were met in managing CERF. The handbook also aims to demonstrate the practicalities of financing RE investments and to build the case for why local FIs should consider this market. It offers some necessary steps or processes that should be considered when designing RE financing structures. The purpose for the handbook is to help develop the ecosystem of financiers and support FIs to gain a greater understanding of RE market opportunities and products needed for effective lending in the agri-food sector to farmers and SMAs in Cambodia. Nexus is not suggesting that FIs solely adopt the CERF model; in fact to the contrary, Nexus hopes that FIs will modify the financial model to determine what works best for them whilst still supporting the broad adoption of renewable energy.

[15] https://www.khmertimeskh.com/630482/kampong-speus-solar-farm-completed/
[16] Kongchheng, 2013
[17] https://www.eia.gov/energyexplained/solar/

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# CLEAN ENERGY REVOLVING FUND

## Background

Nexus for Development ("Nexus", the fund manager), with financial support from the Government of Austria through the Renewable Energy and Energy Efficiency Partnership ("REEEP"), started working together in 2015 to create a pilot revolving loan fund to provide access to finance for the adoption of renewable energy solutions in the Cambodian agri-food sector. The initial focus for the fund was on biomass gasification technology for rice millers. The Blue Moon Fund (BMF) supplemented the initial funding to allow the pilot phase to double in size, and to help REEEP and Nexus for Development implement the fund's growth strategy – in respect of geographic scope, technology and business model, and to engage with potential investors to further capitalize and scale the fund.

The strategic objective of the fund was to provide affordable loans to the agri-food sector leveraging a blended finance model to increase the adoption of renewable energy technology in Southeast Asia. The original objective sought to focus firstly on Cambodia. During the course of implementation of the fund, other agri-food sub-sectors, clean energy technologies, and regional neighboring markets within the Greater Mekong Basin (GMB) were investigated for potential expansion and scaling-up.

The initiative was regionally unique, bringing to the clean energy market an innovative concept based on a blended finance approach. It is consistent with Nexus's mission and synergistic to the interests of the objectives of its Foundation Investors. It was designed to become a model for a more flexible and market-oriented source of finance in the form of low-interest soft loans, for small and medium agri-businesses (SMAs) in the GMB who wished to apply clean energy solutions. As such, the fund aimed at de-risking clean energy business models and to open up space for larger donors, local banks, commercial lending and other private investors.

Development of the fund's growth strategy in Cambodia in terms of technologies financed began earlier than expected following a change in the economics of the initial pilot concept. While biomass gasification continues to be an interesting technology, the sharp decline in diesel prices in 2015 and rising prices for rice husks reduced rice millers' interest in investing in gasification technology. After further market research, Nexus focused its efforts on a variety of segments in the agri-food sector, such as livestock, fruit, vegetable and spice farms, processors, and water treatment plants with technologies such as off-grid solar system and solar water pumps. CERF was open to financing other technologies such as biogas systems, but solar energy proved most suitable for the agri-food sector in Cambodia in the current market.

The goal of the Clean Energy Revolving Fund (CERF) was to increase productivity and help Cambodian producers, processors and distributors compete in the regional export economy. CERF helped reduce CO2 emissions from the agri-food sector by funding renewable energy investments, and in so doing encouraged an early shift away from fossil fuel based energy sources as the sector grows.

The absence of flexible finance instruments for RE technology investments coupled with low levels of end-user knowledge and trust in RE caused low-adoption rates across the country for decades. CERF's financing conditions are truly innovative in the Cambodian context, as financial institutions currently only provide SMAs and farmers with expensive and fully collateralized loans (usually with land titles serving as the preferred form of collateral). CERF provided SMAs and farmers with unique and flexible financial terms (whereby both loan tenors and repayment schedules were structured to fit agricultural cycles), accompanied by technical assistance and capacity building. The RE technology was used as collateral, and low financing fees were charged. This dynamic mechanism allowed the fund to learn, adapt, and respond quickly to agricultural market realities, and the results exemplify these successes. CERF borrowers or farmers reported that they would not have made the RE investments without CERF, while TPs who had previously struggled to match their offer with a financial product highlighted CERF's role as trust brokers between them and their clients. When given access to renewable and affordable energy technologies, CERF SMAs and farmers significantly reduced on farm and agricultural processing costs and improved the resiliency of their businesses. The CERF financing enabled SMAs and farmers to capitalize on energy cost savings by reinvesting this as funding to scale their businesses. As the payback period of RE investments for SMAs and farmers was typically realized within three to five years, businesses could expect to see further growth in the medium and long-term.

Following the fund review in May 2019, the investment committee (IC), REEEP and Nexus have reached a consensus to close CERF to any new loan applications as it was acknowledged that the potential for scale was limited due to national regulations. As Nexus/CERF is not a registered financial institution, we could not continue with lending as per the requirements of the National Bank of Cambodia (NBC). Nexus is still keen to provide necessary capacity building services and technical assistance to any local finance providers who are interested to learn, adopt or modify the CERF model.

## Blended finance approach

Under the current regulatory environment in Cambodia, Nexus/CERF would be required to obtain a banking license to continue making loans in Cambodia. Nexus's strategic objectives were to continue to make more clean energy loans accessible to SMAs and farmers in Cambodia and to ensure continuity of the fund, and Nexus's exit strategy was to build partnerships with Cambodian FIs so they may further demonstrate the bankability of clean energy technologies and design appropriate financial products for the market. Since 2018 Nexus has been exploring the modalities of working with Cambodian FIs such as rural credit operators, MFIs and commercial banks, and shared our vision of supporting SMAs and farmers to become more sustainable and competitive.

Our initial partnership proposal to Cambodian FIs was to provide a small amount of capital as an interest-free contribution, or as a cash-back (funded) guarantee. The intention was that the bank or MFI could use this to pilot clean energy loans to farmers and SMAs for technologies such as solar off-grid systems for pumping and/or lighting. Nexus's envisioned role with this partnership was to help transfer our knowledge and experience in conducting due diligence on SMAs in target CERF sectors, and with conducting energy assessments, payback calculations, etc. While Nexus would train and provide oversight during the initial phases, the medium-term plan included an eventual transfer of loan management of the CERF loan portfolio to FIs over time. Nexus's expected long-term outcome is that other financial intermediaries are encouraged to follow the CERF model and develop financial products for technological innovation in the agri-food sector.

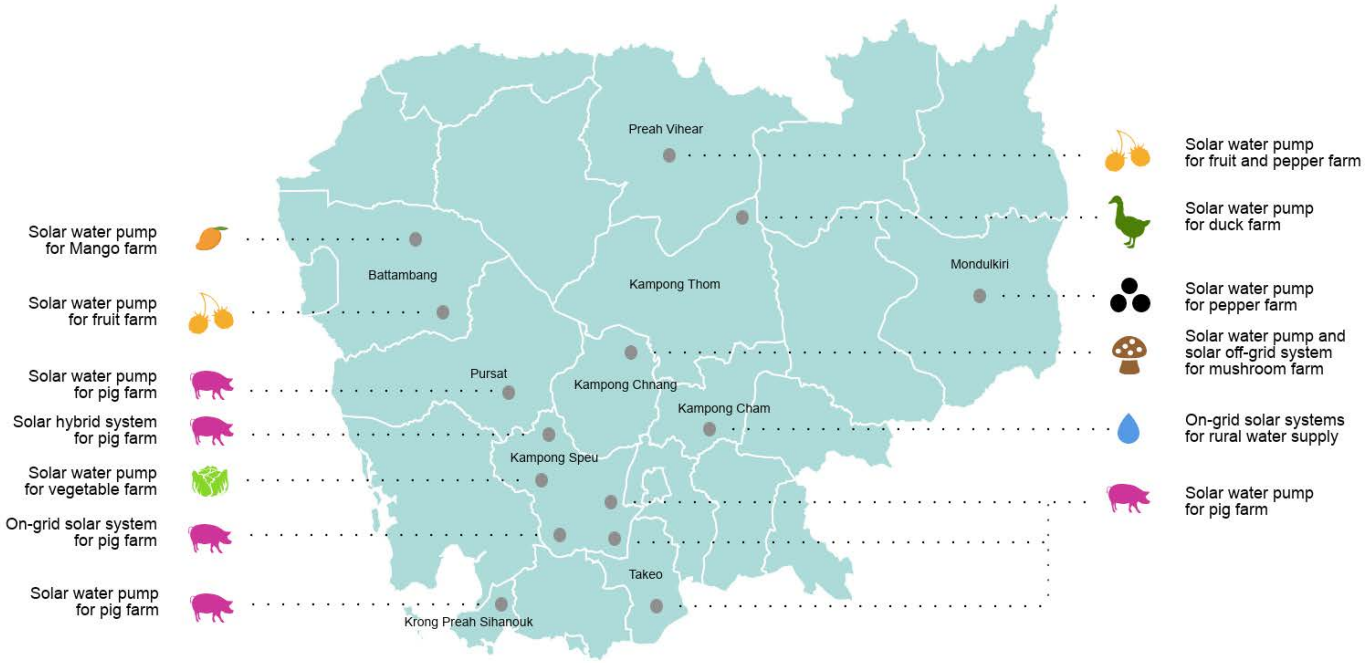
If FIs are interested in adopting the CERF model, Nexus is able to demonstrate the feasibility and impact of deploying RE financial products so that we could attract additional funding from donors seeking to support market-based mechanisms for sustainable development. However, despite the engagement with the local Cambodian FIs, interest in this proposed modality from banks was low. They were reluctant to launch RE financial products in Cambodia because they did not have a good understanding of RE technologies, its quality, and after sale servicing from technology providers. From the FIs' points of view, they generally consider that loans in the agricultural sector carry more risk than do loans to other business sectors. In addition, the price of entry for working in collaboration with banks or MFIs is quite high. They were not interested in the small amount of capital that was proposed by Nexus, as they generally target project sizes between a half million and one million USD, which we understood to the scale required to achieve the required economics of pursuing a new market segment. Furthermore, it became clear through dialogues with the FIs that they would not be able to maintain a model that included low interest rate loans, such as the 8% pricing in CERF because of their higher operational costs and higher cost of capital, which we understand to be in the range of 8 to more than 10% percent. Some FIs also suggested that Nexus or its donors offer risk guarantee instruments to mitigate the risk of RE investments and to cover the losses if a loan defaulted.

In parallel to our discussions with the local FIs, Nexus investigated potential ideas for adapting and replicating the CERF model in other countries within the Mekong region, namely Myanmar and Laos, where the agricultural sector employs a sizable proportion of the population, yet many farms are not grid connected. However, we were not able to study in detail how to adapt and replicate the CERF model in these countries because we lacked human resource and financial capacity, and thus we were not able to thoroughly explore the market potential in these countries. The key challenges for us included the criticality of understanding energy requirements in the agri-food sector, the financial regulation, the incumbent policy setting, and identification of local implementation partners.

## Current investments and successes to date

Nexus completed due diligence on 22 loan applications of which 15 were approved for investment by the IC. Clean energy investments mainly were in solar water pumps and on-grid solar systems for clients such as fruit, vegetable and pepper farms, pig farms and one water treatment plant. While CERF mainly focused on agri-food and food processing sectors, one application was received from a rural water purification enterprise. The loan sizes varied from 7k to over 50k USD, with most investments falling within the range of 10k to 15k USD. CERF loans funded up to 90% of the technology cost, and the remainder was co-financed by the investees. In this way, the investees shared the investment risk and had "skin in the game". The total amount of clean energy investments for all projects is 331,204 USD, of which 261,014 USD was funded by CERF capital.

## CERF Investvements - Snapshot 2018




CERF investments have enabled the installation of 85.76 kW of solar energy and produced 115,264 kWh of clean energy, which is equivalent to a reduction of 168 tonnes of $CO_2$ pollution each year.

It is estimated that there are more than 7,000 SMAs and larger farmers in the pepper, pig, and longan sub-sectors alone. Each CERF project contributed about 10 tonnes of avoided $CO_2$e emission per year. If Nexus were to finance 7,000 SMAs to adopt RE technologies in these sub-sectors, we would be able to reduce 70,000 tonnes of $CO_2$e emission per year.

The map above provides a snapshot of the types of clean technologies and types of agricultural farms financed through CERF.

### Fruit, pepper, and vegetable farms

Finance was provided to six farms producing either vegetables, longan fruit, pepper, or mangoes. The farms switched to solar powered water pumping systems to irrigate their crops. The baseline source of energy was diesel generated power.

The first financing agreement was approved for a farm called "Angkor Eden", a new vegetable farming business in Kampong Speu province of Cambodia. As the farm is off-grid, solar technology provided a reliable source of power for their operations. Another two investments were to support a longan and pepper farm, and other pepper farms in Preah Vihear, and Mondulkiri provinces. Proper management of watering operations is very important for both longan and pepper farms. Many farmers use diesel engine powered pumps to irrigate pepper and longans with high intensity of water usage especially in the dry season and during rainy season dry spells. For example, the longan and pepper farmer in Preah Vihear consumes about six liters per day of water to irrigate the farm, and the pepper farmer in Mondulkiri uses about 120 liters every three days. Both farmers requested CERF financing to purchase solar water pump systems so that they could save on diesel costs. The remaining three investments were to support longan, mango, and mushroom farms, located in Kampong Chhnang, and Battambang provinces. Longan and mango farmers use hormones and chemical treatment to encourage mango and longan trees to flower off-season and to increase yields and profits, but this process is also water intensive. Although the longan, mango and mushroom farms are connected to the grid, the unreliability of the electricity supply impacted the regularity of irrigation for crops and hence instigated their interest in making a RE investment.

### Pig farms

The CERF IC approved investments in solar water pump systems for seven pig contract farmers in Kampong Speu, Takeo, and Pursat provinces. These farmers are all contracted by "C.P. Cambodia", established in Cambodia in 1994 as a subsidiary of the Thai conglomerate Charoen Pokphan Company Limited. The greatest energy consumption in pig raising operations comes

from lighting and water pumping to support evaporation cooling systems. The water is also required every day to clean the animals and the facilities where they are kept. All six pig farms are in off-grid areas with electricity generated by diesel generators. The generators run all day on some farms and frequently were down for maintenance, requiring intensive repair and money. The solar pump and hybrid systems help pig farmers to save on diesel costs. One pig farm in Kampong Speu uses grid electricity but purchased a solar on-grid system as a complementary means of energy and to reduce electricity costs.

### Rural water supply/water treatment plant

The Cambodian government has prioritized the supply of potable water and sanitation in rural areas, aiming to improve living conditions and health while reducing poverty. The government encourages national and international investors to invest in the water sector. The CERF received a loan application from a rural clean water operator (operating two water treatment plants in different locations in Kampong Cham province) to invest in 2 on-grid solar systems. The operator supplies clean water to nearly 5,000 households. The water service provider is connected to the grid but is expecting to reduce his electricity consumption through the use of solar power. Although this investment was not strictly in the agri-food sector, the IC approved the loan given the positive impacts associated with supporting such an enterprise.

The CERF model exemplifies that by removing the barriers of access to finance and providing affordable loans, farmers and SMAs benefit from greater economic activity and increased access to clean energy. To date, the fund has received repayments of principal and interest although a small portion of the portfolio loans are delinquent. Only one loan has defaulted, and Nexus was able to recover part of the investment as the technology provider, IMB, agreed to buy back the equipment at a discount.

The CERF model has the potential to scale up, but Nexus could not continue to invest in its growth without registering as a financial institution under NBC, which was not of interest to our organization. Given the regulatory framework constraints for Nexus, local FIs in Cambodia are best positioned to take up the market opportunity. Local FIs could offer RE financial loans in the agri-food sector by modifying the financial model or designing a different structure to determine what works best for them. As FIs have more robust credit processes, operations, and have wide networks with an established footprint in many provinces this could allow for increased scale up and reach to SMAs and farmers, which in turn could result in economies of scale.

There is already a shift in mindset toward green lending underway in the country, as a few local FIs such as Rural Development Bank (RDB) have shown interest in expanding their bank portfolio to offer RE loan instruments. However, in order to incentivize local FIs to develop financing products for technological innovation in the agri-food sector, donors should offer guarantee instruments to mitigate the risk of RE investments and to cover the losses and to encourage a reduction in collateral requirements.

Photo credits: Jeremy Meek

Table 1: Risk mitigation strategy

| Risk | Risk mitigation strategy |
|---|---|
| Loan default by a loan recipient | The relationship established between Nexus and SMAs, which is developed during the early stages of the sourcing and due diligence process is crucial, and it helped Nexus further understand the SMAs and farmers and enabled us to identify and assess risks. Nexus maintains the relationship with CERF borrowers throughout the repayment period.<br><br>In the event of a default by a CERF borrower, the TPs were engaged and assisted with repossessing the system on behalf of Nexus; where possible the TP also managed the promotion of the equipment for re-sale. Nexus experienced only one loan default, where we negotiated with TPs to buy back the system at a 50% discount. |
| Technology-related risk | The technology itself plays a crucial role in successful RE financing. RE financial products are carrying credit risk because borrowers may not want to repay when there are technical issues. As a means of mitigating risk associated with our technology partners Nexus conducted due diligence on the TPs as well. This was done to ensure that the TPs' business would still be operating for the life of the CERF loan, as they are responsible for the product maintenance and making sure that the equipment is functioning at optimal service quality levels and within certain standards. |
| Fund disbursement | The money for RE projects was transferred directly to TPs, not to farmers and SMAs. This helped Nexus to ensure that the capital provided was being utilized for the intended purpose and that the TP could be held accountable for proper installation (a prerequisite for receiving the tranched payment). When the RE investment was approved by the IC, a contract was signed between Nexus and the farmers/SMAs. The first tranche was disbursed in parallel, representing 50% of the investment, to the TPs for purchase and installation of the systems. When the system is fully commissioned, Nexus engaged with the farmers and SMAs to confirm customer satisfaction and to ensure they received sufficient training from the TPs on the technology. Upon receiving positive confirmation from the farmers or SMAs the other half of the loan was disbursed to the TPs. |
| Delinquency | As Nexus has a centralized base of operation, we maintained low loan delinquency rates by having regular phone calls with borrowers allowing us to monitor the portfolio closely, and to learn early on about potential issues that may trigger delinquencies. In some cases, Nexus also conducted visits to borrowers to investigate the reasons for delinquency and discuss alternative repayment plans. Nexus's team also maintains a loan tracking tool to manage loan repayments. |

# Funds management team

Nexus's funds management team manages CERF on behalf of the donors and is supported by an independent IC that makes investment decisions. Nexus sources projects, conducts comprehensive due diligence and prepares investment proposals for the IC's consideration. The IC is currently made up of three members: (1) Mark Fogarty, REEEP Board Member (Chair), (2) Jennifer Louie, Nexus's Executive Director, and (3) John McGinley, Director of Mekong Strategic Partners.

Nexus draws on the expertise of the IC for all decisions regarding technology provider partners, as well as investment strategy and credit risk matters. Nexus's team also coordinates and manages the IC meetings, drafts and circulates minutes, and serves as the conduit of information to the investees.

The funds management team is comprised of individuals from different backgrounds including, finance and fund management, technical expertise, and stakeholder engagement. There is a team member who is responsible for field based due diligence as well as stakeholder engagement with key groups within the agricultural value chain. This key staff person manages Nexus's relationships with prospective SMAs or farmers and solar technology providers. For the technical staff, they help with conducting energy assessments and the calculation of the payback period of the solar investments. Over the years, Nexus has significantly increased its capacity as a fund manager with well-established processes, increased knowledge, and visibility with farmers and technology providers in Cambodia.

# Risk Management

Any lending operation has to ensure that the inherent portfolio risk is managed, and CERF is no exception. For CERF, actions were taken by the funds management team to reduce the likelihood of a risk event occurring. The method of addressing and mitigating risks are outlined in the table 1.

# CERF model

## Who is eligible for the Fund?

Eligible investments have the following characteristics:
- Small and Medium Agri-food Businesses (SMAs): SMAs in Cambodia including farms, farmer cooperatives, food processors, distributors, transporters and exporters.
- Renewable energy: Any type of renewable energy technology with proven quality and reliability in its application, including solar energy, biogas, and gasification.
- SMAs in Cambodia who wish to adopt renewable energy technologies and are interested to access financing from CERF need to demonstrate cash generation to service the loan payments and an ability to make a 10-15% upfront payment for the purchase of the technology.

## General terms of CERF loans

The following are the general terms and conditions for CERF:
- Loan sizes vary depending on the size of the renewable technology unit required and ranged from 10,000 to 100,000 USD.
- SMAs and farmers pay back the principal amount plus 8% per annum in interest.
- Loan tenors of 3 to 5 years adjusted to the needs of the SMAs.

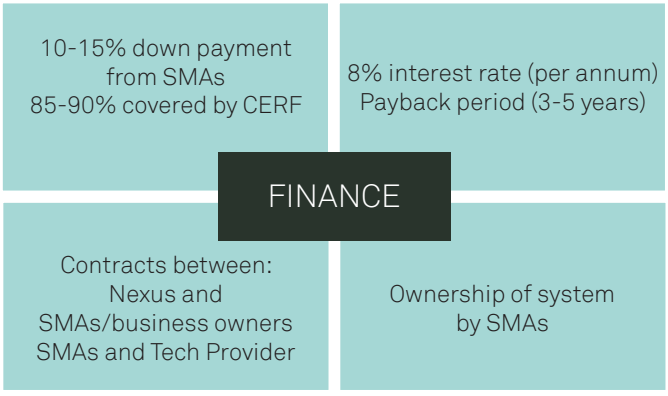
## How are the funds disbursed?

- Nexus signs a contract with the SMAs and farmers. The contract includes a conditional clause that the TP provides a warranty and minimum maintenance on the equipment. Separately, the farmers or SMAs need to sign a purchase agreement with the TPs directly before signing the financial agreement with Nexus.
- Upon approval by the IC and receipt of the upfront payment from the business owner, Nexus will disburse the loan funds directly to the technology providers for purchase and installation of renewable energy technologies.

## What is the repayment structure?

- Various repayment structures are utilized, however, none of the portfolio loans included grace periods for principal or interest. Payments commenced after the equipment is installed and commissioned, and according to a fixed repayment schedule (paid either monthly or quarterly).
- Where possible, repayments will be linked to fuel or electricity savings as the fund's objective was reduce the operational costs of SMAs.

Figure 1: Finance model



# CERF process

## Sourcing projects

Nexus established partnerships with three local technology providers (TPs) in Cambodia including, International Multi-Business Group (IMB), Ecosun Energy Cambodia (Ecosun) and Solar Green Energy Cambodia (SOGE).There are over 20 local solar TPs in Cambodia working in different segments of the market (i.e. household scale distributed energy system, rooftop solar systems for residential buildings, SMEs, etc.). CERF used a transparent and open application and selection process to select our TPs, and our decision to work with the aforementioned three TPs was based on our own criteria and should not be construed as an endorsement. The main role of TPs is to source potential projects by offering qualifying candidates the opportunity to apply for a loan. These TPs have direct sales experience to farmers and SMAs, and knowledge of how to engage with farmers and SMAs. Nexus's role in the CERF model was unique – for pipeline and approved investments Nexus served as a technical advisor to the SMAs and farmers to facilitate an understanding of the technology and provide capacity building.

Nexus also engaged with a broad range of agri-food actors to promote the fund such as government agencies, international and local NGOs who are working with the agricultural sector, as well as some associations and cooperatives.

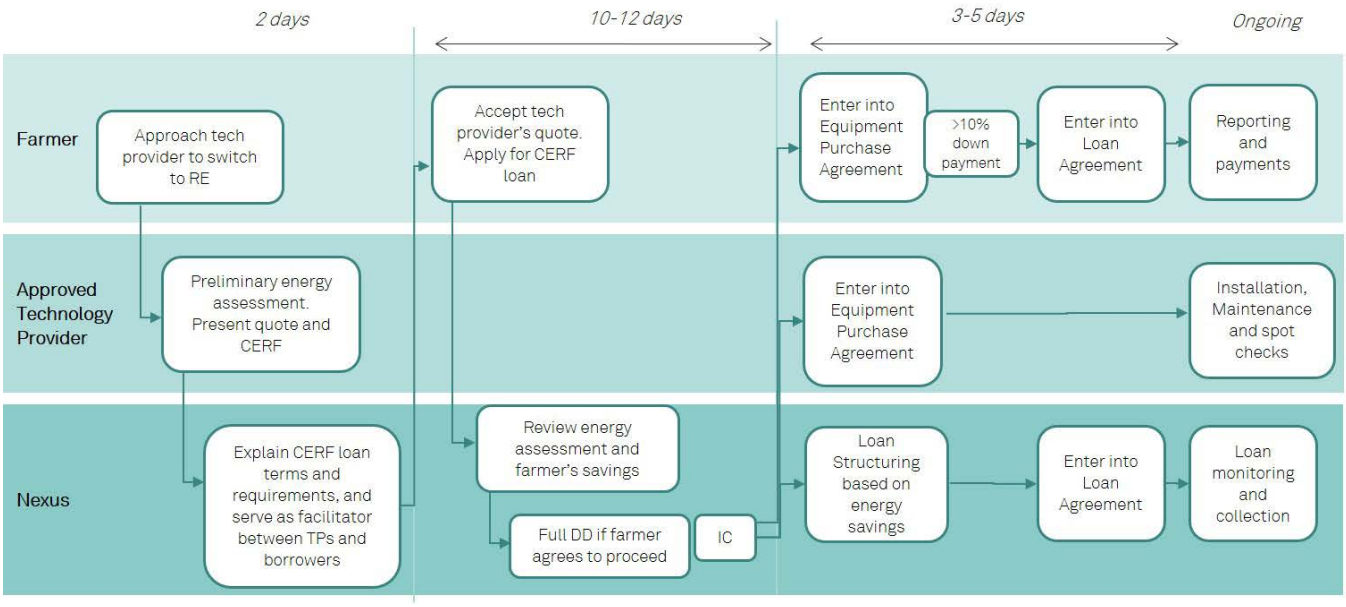
## Due-diligence process

Nexus' funds management team was tasked with managing the fund and its portfolio of loans on behalf of the donors and the IC. The process from due diligence (DD) to loan approval took approximately four to six weeks and consisted of three stages:

(1) Energy assessment: When TPs found potential SMAs or farmers interested in applying for a CERF loan, an energy assessment was conducted in consultation with the Nexus team. At this stage, the TPs assisted with the collection of the necessary information on energy consumption, source of energy and expenses. The specific information is related to the type of baseline technology, and capacity of system, diesel liters consumed per day, cost of diesel, electricity bills, and cost of maintenance, etc. This type of information is crucial for Nexus to provide the feedback to the farmers and SMAs, with a manageable proposal for the payback period of the investments. The term "payback period" is used to estimate the length of time that it will take a farmer to breakeven and recover the costs associated with the purchase of the technology. This is based solely on the savings recognized from transitioning away from diesel engines or other fossil fuel power energy sources and shifting to renewable energy source.

At this stage, Nexus also takes on the additional role as an advisor and trust broker between farmers and technology providers. Farmers often lack awareness

Figure 2: Loan approval and monitoring



and do not trust fully in the technology, and thus they seek for the advice from Nexus on the quality of new technology.

(2) Full due diligence: When farmers are satisfied with the technology and the proposed payback period of the clean energy investment, Nexus conducts full DD on the farmers. Nexus analyzes the borrowers' capacity to service debt by reviewing financial history, crop production per month or year, and other financial details. The process requires on-site visits to the farms and a review of documentation (often reviewed with SMAs and farmers due to low financial literacy and record keeping systems). The full due diligence informs a risk-based analysis that is then presented to the IC.

(3) Validation by the IC: Nexus presents the analysis and investment to the IC, which has the authority to approve the loan.

### Loan agreement

If the investment is approved by the IC, Nexus reviews the purchase contract with the TPs and negotiates the terms of the loan agreement with the investee, allowing for reasonable flexibility in terms of how the capital is disbursed. In practice, when Nexus signs a loan agreement with a farmer, Nexus schedules the transfer of the agreed co-financing amount to the TPs upon receiving evidence that the agreed upfront payment from the farmer or SMA has been made. Half of the remaining purchase price is transferred to the TPs and another half upon acceptance of delivery of the system by the CERF borrower.

### Loan monitoring and payments

Regular monitoring of farmer activities and follow-up calls on a weekly basis are implemented by Nexus team, which are costly and timely, but it helps establish more points of engagement and relationship building with borrowers. Nexus prefers farmers to pay through the network of ACLEDA branches in the country, but some farmers are interested to use mobile payments through Wing or True Money. A Wing business account was opened by Nexus in June 2019, facilitating both more robust payment tracking and a simpler payment channel for borrowers. However, Nexus still expends a great deal of effort and time to follow-up and remind borrowers about payment obligations.

### Loan repayment structure

Through Nexus's experience of managing the 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 fuel usage; CERF borrowers were able to reduce up to 80% in diesel consumption and each project contributed about 10 tonnes of avoided CO2e emission per year. The below section illustrates an example of the feasibility of using cost savings (Mr. Oeurn Chanrath's pig farm) to facilitate loan repayment.

Table 1 illustrates the repayment structure for a hybrid solar system installation for a pig farmer in Kampong Speu province. Mr. Chanrath received financing through Nexus's CERF with a loan at an 8% per annum interest rate. The cost of the hybrid solar system is USD 18,738.60, but Mr. Chanrath elected to apply for a smaller loan of USD 16,864.74 to purchase the hybrid solar system. The pig owner and CERF agreed on a loan tenor of five years, which equated to monthly payments of USD 341.96. This repayment structure aligns with the revenue stream from the pig farm as the piglets are collected every three weeks. Notably, the exact cost savings from the solar investment is USD 450 per month, and if Mr. Chanrath chose to allocate this entire savings amount towards the CERF loan, it would take him about 3.6 years to repay the entire loan. Additional details on this farm are included in the case study section.

Table 1: 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 |

# Lessons Learnt

Through managing CERF, Nexus has identified the following learnings:

• Sourcing potential projects in frontier markets such as Cambodia involves many steps and high due-diligence costs. As a financial intermediary, Nexus had to take on the additional role of an advisor and trust broker between businesses and technology providers. Technology providers have, to some extent, fulfilled this role by promoting the use of solar technology through user campaigns and demos. However, until CERF the effectiveness of their campaigns were low as they weren't able to offer a fit for purpose financial solution.

• No standardization in due-diligence process could be applied to the pipeline of investments, which resulted in longer due diligence processes and higher costs than had been envisioned when designing the model. CERF borrowers come from different sub-sectors of agriculture such as fruit, pepper, vegetables and livestock farms and hence required the team to establish specific market knowledge of each loan underwritten.

• In Cambodia most businesses are not registered entities and have no financial records. This makes it extremely difficult for them to apply for loans with banks or to attract investors. Although a CERF loan is not registered with a regulated financial institution, our view is that the due diligence process can prepare these businesses to apply for future loans and build a credit history that can be supported by the documentation prepared for their CERF loan. Nexus developed a process and tools to efficiently assess the financial performance of businesses based on relationship building, collected verbal information and available records (e.g. receipts of their expenses, purchase agreements, and others). In certain circumstances, Nexus requested farmers and SMAs to go to the Credit Bureau Cambodia (CBC) themselves so that they could collect their credit history or report, which was shared with Nexus to allow us to accurately evaluate risks.

• By offering unsecured loans and flexible repayment terms adapted to the needs of farmers, CERF has proven to be a unique vehicle to fill local financing and capacity gaps.

• While demand for energy is seasonal in some sectors (fruits, vegetables, spice farms), it is consistent year-round in others (pig farms, ice factory, rural water operators). As a result, Nexus can anticipate demand and focus on different investment pipelines depending on season.

• The most effective way to connect with SMAs has been through technology providers who invest in maintaining close relationships with potential customers. Initially, Nexus's strategic focus was to continue working closely with the existing technology providers and to identify others to become CERF accredited.

• Investments in solar water pumps often go together with associated infrastructure such as drip irrigation systems, water storage tanks and lightning protection. Several investees sought CERF co-financing for such related infrastructure. CERF has been supportive of this demand, seeing clean energy technology as part of a package that would allow businesses to achieve energy efficiency, cut costs and reduce the negative environmental impacts of their operations.

Photo credits: Jeremy Week

# Challenges

## Changing energy market in Cambodia

The main challenges in CERF's inception phase were external market factors that changed the economics of investing in biomass gasification technology. The main contributing factors were substantial reductions in the price of diesel and high prices for rice husk, resulting in rice millers showing diminished interest to switch to gasification technology. In early 2016, Nexus started to assess other renewable energy technology applications in the agri-food sector to address the needs of different end users. After a desk review and consultations with various stakeholders, Nexus was able to identify new opportunities for CERF to support the uptake of clean energy technologies in different agricultural and food businesses in Cambodia.

## Technological issues and repayment

Some issues with the technology have been faced by a segment of farmers. Specific cases include the pepper farmer in Mondulkiri province and pig farm in Kampong province, where the systems are not working properly. Nexus is trying to work closely with the TP to address the farmers' concerns. Through portfolio management, Nexus has witnessed the sensitivity of repayments during technology down times - borrowers do not pay during months when they cannot use their equipment because they associate repayments with promised energy savings. Nexus works with the technology providers to offer alternative solutions when equipment use is affected by factors outside the farmer's control.

## Adverse weather condition and repayment

There are borrowers that were affected by adverse weather. The first case was in Mondulkiri province with the pepper farm. The original design for solar water pump was to match with water levels of 50m in the well, but during the dry season in February 2019 the water level dropped to 70m. As a result, the pepper farmer could not use the pumping system. Nexus is pushing the TP to quickly provide solutions in the event equipment becomes unusable due to adverse weather, as during these months the farmer refused to make loan payments and reverted back to diesel usage.

In another project, the water treatment plant in Kampong Cham province, was negatively impacted by changes in weather conditions. The plant was unusable during the floods in August 2018, and as a result the owner was not able to repay the CERF loan for several months. It should be noted that the floods did not cause any damage to the solar system itself.

## Installation Delays

TPs who provide RE equipment for clients are key to the success of RE lending. They need to make sure that the projects are installed without delay. Through CERF's experience, most projects are installed on time, and we had only one instance where the TP delayed the installation of the solar system. This was caused by the fact that the TP was in short supply and they did not have sufficient equipment in stock, which required them to purchase from another overseas supplier. As compensation to the borrower, Nexus agreed in this specific instance to delay the loan repayment schedule.

## Overdue payment and restructuring of loan repayment schedules

Another challenge has been to manage borrowers facing difficulties in repaying their loans. Nexus is working closely with borrowers to understand their problems, and Nexus has offered to restructure loans that are at higher risk of default to encourage repayment. This process requires additional and continual follow-up with the farmers on a weekly basis. The restructurings have come up for various reasons. Some are related to technological issues, and some are specific to farming activities (i.e. times during which the farmers do not earn enough revenue).

## Centralized base of operation

Nexus has a centralized base of operation, unlike some FIs that have broad national branch or kiosk networks. Local FIs that have these broad networks will be able to leverage this to facilitate the ease of payment collections. For Nexus, given this limitation, establishing mobile money payment channels for borrowers was an important step, and it is acknowledged that this should have been leveraged sooner.

## Reporting to the Credit Bureau Cambodia (CBC)

In circumstances where CERF has delinquent loans, as Nexus is not a member of CBC this limited our recourse options and required greater emphasis on our ability to maintain strong relations with borrowers. Only financial institutions licensed by the National Bank of Cambodia (NBC) are eligible to become members of CBC, which provides them with access to the CBC system allowing them to report on lending relationships and delinquent borrowers. Many of the CERF borrowers are aware that the fund did not have to register with the NBC, and that as a result Nexus was unable to leverage the CBC to report them for delinquent payments.

In addition, CERF borrowers were aware that Nexus is a non-profit. We sensed that this resulted in some borrowers taking advantage and were more lax with their repayments. It is likely that the borrowers would have taken their debt obligations more seriously if CERF were registered with the NBC and could access CBC.

### Loan default and repossession of equipment

Nexus has experience with the repossession of equipment for the one defaulted loan in the CERF portfolio. The owner of a vegetable farming business in Kampong Speu province had a promising business plan but was still an early stage enterprise when it received a CERF loan and invested in two solar water pumps for vegetable irrigation. The owner's business partnership failed and given the limited technical expertise to operate, and despite all reasonable efforts, the farm was forced to close. Nexus worked with the owner to reschedule the loan but ultimately decided to write it off. In order to limit the impact of the defaulting loan, Nexus negotiated with the technology provider to buy back the equipment in May 2017 at a 50% discount. To date, this is the only defaulted loan in the portfolio.

### Solar regulation

Changes in solar regulations enforced in 2018 negatively affected grid-tied projects and limited the growth of the CERF portfolio into this market segment. Based on the regulation, only medium and high voltage consumers could legally install grid-connected solar systems for self-consumption under special permits and subject to a special charge. CERF's customers fall under low voltage consumers, who are excluded under this regulation, meaning they could not legally install grid-connected solar systems. As a result of this change in regulation CERF's target market was limited to off-grid systems. Although the regulation has limited our project pipeline to on-grid systems, there was still an ample market of off-grid users.

### Banking regulation

Although Nexus was able to identify ample market demand for the fund's financial product offering, CERF's growth was limited by an NBC restriction on non-licensed lenders. Nexus decided to slowdown its origination work in 2018 to avoid breaching NBC lending thresholds for unlicensed finance providers. Although technology providers had projects in their own pipelines, the Nexus team put project sourcing on hold. Nexus intentionally did not pursue new investors or grants as having to disburse more loans in Cambodia could require Nexus to obtain NBC registration or a banking or finance institution license.

Photo credits: Jeremy Veal

# RENEWABLE ENERGY LOAN PRODUCTS

## Why Financial Institutions for RE Loan Products

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; 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.

A "Case Study Analysis for Small and Medium Agri-Food Businesses in Cambodia" report, which was published by Nexus in June 2019, explored the feasibility of clean energy alternatives for pepper, fruits, vegetable and livestock farms in Battambang, Pailin, Mondulkiri, Tbong Khmum, Kampong Speu, Kampot and Pursat. The report illustrated that farmers and farm owners are looking for different options to reduce energy costs. Further to this, all surveyed respondents expressed interest to invest in renewable energy technologies, even though it was self-acknowledged that they had limited information or are less familiar with new technologies.

Energy costs for the surveyed parties in our study represent between 6% to more than 50% of the operational costs depending upon the size of the farm and type of crops or 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 financing options 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 financing?

As mentioned the study referenced in the previous section showed 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 RE technologies, even though it was self-acknowledged that they have limited information or are less familiar with new technologies. The study suggested that by offering RE financing, the FIs can receive the following benefits:

### New Market Segment

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 all of these are suitable enterprise sizes 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 indicated that about 62% of respondents are willing to pledge some form of 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 actual cost savings realized.

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 with a relatively stronger credit profile, any contract that a farmer may have with CP could serve to some extent as guaranteed revenues. This is further supported by the fact that CP has high standards which 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 and provides training to the pig farmers to ensure that the farmers adhere to strict guidelines.

### 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 an interest rate of between 6% and 8% per annum as acceptable, and about 25% of farmers said they could afford interest payments of between 9% and 12% per annum. The remaining 6% of the surveyed group 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.

## How can financial institutions set up RE financing for the agri-food sector?

The following section provides recommended steps or processes that should be considered when designing RE financing products.

### Establish partnership with RE suppliers

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 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 TPs.

An effective TP partnership could allow for the following support:

- Contribute to the sourcing of loan recipients by offering qualifying candidates the opportunity to apply for loan,
- Supply farmers and SMAs with a quote so that it helps them to make the decision to apply for loan,
- Conduct an energy assessment of farmers and SMAs,
- Collect the necessary information of the due-diligence process,
- Provide good product and high service quality in the installation and maintenance of technologies to loan recipients as per the companies' policies and procedures,
- Provide a good warranty and after sales service,
- Provide high quality training on the use and maintenance of the technologies to loan recipients as dictated by the purchase agreement, and
- In the event of a potential loan default the TP could uninstall, remove, and store equipment, and where appropriate also promote the equipment for re-sale to a new client at a price agreed by the parties.

For CERF, Nexus conducted due diligence on TPs who expressed strong interest to work in partnership. Nexus aimed to understand the governance and management, enterprise (business plan), technology, and financial history of the TPs. This helped to ensure that their respective business existed for the tenor of the underlying CERF loan, and that they could be held responsible for the product and service quality.

### Technical assistance from experienced organizations on RE loans

Besides working with TPs, FIs could also partner with 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. Building partnerships with these relevant stakeholders is crucial because development and implementation of new products and services or marketing approaches may require more resources and efforts. Through the partnerships, FIs may be able to access the requisite information on market segments, data collection and analysis.

Nexus is willing to support any financial institutions in Cambodia, who are interested in adopting the CERF

model so that they can develop financial products for innovative RE products in the agri-food sector. Nexus will build upon its success of managing CERF to prepare the FIs to lead credit operation set-up and management. The technical assistance that can be provided to the FIs includes transfer of knowledge on the due diligence process as well as ability to perform both energy and financial assessments of potential borrowers.

Nexus can work together with TPs to provide basic training to the FIs' staff and to explain technical knowledge of proper installation, costs and maintenance associated with the solutions selected. The FIs may find it difficult to source clean energy projects themselves at the beginning of taking this market, but Nexus could initially help the FIs to source the potential projects through working with current CERF's TPs – IMB, Ecosun, and SOGE. Furthermore, Nexus could make introductions to TPs, who ultimately could assist with sourcing RE projects.

### Staffing and training

The FIs do not need to have a separate division to handle RE financing, but could instead recruit specialized staff for the RE portfolio, who in turn could train the FIs' existing staff. Specialized staff should work to promote RE financial products through existing networks and platforms such as agricultural cooperatives, associations, NGOs and technology providers, as well as the government agencies.

### Identifying appropriate RE technologies and quality

Based on CERF experience, there is a strong market of solar technologies and biogas digester technologies. FIs should work together with technology providers and other relevant stakeholders to assess alternative RE technology applications in the agri-food and to meet the different needs of the end users. This kind of assessment may help the FIs to identify market segments within the agricultural value chain for RE investment in Cambodia.

FIs need to understand the fundamentals of the RE market in order to develop an effective business model for achieving scale and profitability. A RE market assessment identifies the sectors and technologies that should be targeted. Leveraging discussions with experts, technology providers, RE NGOs and government agencies on potential RE technology applications to make sure that the RE product is feasible and appropriate for the targeted client and locations is critical. Nexus could serve as a renewable energy advisor who can provide assistance on market research, which is critical to understand market variables such current RE technology provision, and RE investment demand.

### Due-diligence process

In addition to understanding the financial position of SMAs and farmers, FIs need to have internal RE technical expertise to evaluate and advise on the suitability and quality of a particular RE technology,

Photo credits: Jeremy Meek

the cost of obtaining that technology, the cost of maintenance the technology. In cases where the FI does not have this in-house knowledge, it is recommended that they partner with experienced organizations and experts. In addition, FIs need to work closely with TPs to conduct energy assessments so that they can assess the payback period of RE investments.

## Key risks in delivering RE financial products

Based on the CERF experience the following provides an overview of certain risk areas related to RE loan products (please refer to the sections of CERF lesson learnt, challenges and risk management in understanding other associated risks).

- Delinquency in RE financial product – Delinquency in RE loans are caused by a number of factors. The delinquency in RE financial products can be linked to technological issues, which results in nonpayment. Based on our experience with CERF, borrowers do not pay during months when they cannot use their equipment. Sometimes, TPs do not provide maintenance service in a timely manner, which could lead to further loan delinquencies. For this particular issue, the FIs could work closely with TPs so that they provide technical support as quickly as possible.
- In the event of a default by a loan recipient – the FIs should establish a MoU with TPs by indicating that they can assist to un-install the RE technologies from the loan recipients, and purchase back the equipment at a discounted price - determined by the age of the system and to be agreed between FIs and TPs. A further challenge is that it may be difficult for the TPs to resell the secondhand technologies. FIs and TPs should actively look for a client for the used equipment or to resell the equipment to a potential new borrower.
- Regulatory risk – RE financing products may face regulatory risk or a change in legal framework. For example, the Cambodian government passed solar regulations in 2018 that negatively affected grid-tied projects and limited the growth of the solar market. Based on the regulation, only medium and high voltage consumers can legally install grid-connected solar systems for self-consumption under special permits and subject to a special fee. In this current environment, FIs can focus on the off-grid systems, as many SMAs are in off-grid areas.
- Market risk – similar to what Nexus experienced with CERF when it was initiated in 2015, market dynamics can change quickly. Nexus was able to adapt the CERF model because of its flexible structure and relatively broad mandate of assisting SMAs with energy transition.

## Specific Challenges within the Cambodian agri-food sector:

- Price volatility impacts 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. This volatility is further exasperated as many farmers do not have written purchase agreements with the traders, which exposes them to even greater price 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, from our discussions we understand that the farmers are happy with the current prices. The surveyed farmers that conducted by Nexus in June 2019 said that they were 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 dry 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 . Orange farmers in Battambang have been impacted by this as they could not stop the widespread of this deadly tree disease . 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 killing the livestock and causing significant losses for farmers. Currently, pig farmers are most worried about African swine fever, which has now spread to the border of Cambodia, an poses the greatest risk in to Ratanakkiri and Kratie provinces. We note that one mitigant that exists for contract farming projects who have signed contracts with CP Cambodia, is that the losses are shared by the farmers and the company.

[18] Setha & Ji Su, 2011

[19] Interviewing some orange farmers in Battambang province during workshop on the registration procedure and protection of Geographical Indication Mark on the 29th January 2019.

# CONCLUSION

It is important to reiterate that CERF was set up to incentivize the transition to renewable energy in agriculture, a key sector of Cambodia's economy. It provided uncollateralized loans with low interest rates and adapted to the farming production cycle, as an innovative financing tool in the Cambodian context, it offered flexible repayment terms. CERF addressed a financing gap in the market that MFIs and commercial banks did not have an interest in, and sought to support the SMAs who are often without financing alternatives because of limited credit history. With 14 loans in the portfolio, the CERF has continued to receive repayments of principal and interest.

Over the three-year period of managing the CERF, a key learning for us was understanding the borrower's perception of the financing that was offered. As CERF sought to provide unsecured loans to Cambodian farmers and SMAs to purchase clean energy technology, borrowers felt less pressure to repay the loans especially during times when the technology was not performing or generating the projected cost savings. This has caused CERF loans to often fall into a delinquent state, requiring more time resource to identify and negotiate resolutions. Given Nexus's centralized base of operation and lean team, collections became a time intensive process for our organization as we do not have human capital or branches to leverage. This is an area where MFIs and banks could potentially benefit. Nexus is not suggesting that FIs adopt the CERF model, but we instead hope that FIs will modify the financial model or design a different structure to determine what works best for them whilst still supporting the adoption of renewable energy. As FIs generally have more robust credit processes, operations, and have broad networks with an established footprint of branches in multiple provinces, there is high potential to scale up the envisaged loan portfolio and achieve economies of scale. Furthermore, with a network of branches, loan monitoring and portfolio management could be less onerous.

Since commencing the CERF project in 2016, we have noticed a change in mindset toward RE lending is already underway as a few local FIs such as RDB have shown interest in taking up RE loan instruments similar to CERF. In order to incentivize local FIs to develop financing products for technological innovation in the agri-food sector, donors should offer guarantee mechanisms to mitigate the risk of RE investments, to cover potential losses and to reduce collateral requirements.

Nexus understands that limited knowledge of RE technologies, trust of the technology's quality, and technology providers ability to provide ongoing after sales service are not the only factors that discourage FIs from exploring RE market. Generally, FIs in Cambodia consider loans to farmers and SMAs to carry more risk than do loans to other sectors. According to the Cambodia Agriculture Competitiveness Opportunity Assessment in 2019, although there are a variety of financial institutions in Cambodia, they are currently only funding 11% of capital investment required in the agriculture sector .This data further supports the size of the opportunity for FIs if appropriate risk mechanisms are deployed.

With the decision to close the CERF pilot project, Nexus is instead positioned to provide technical assistance or to 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.

[20] USAID, 2019

Photo credits: Jeremy Meek

# 01 Case Study

# PEPPER FARM AND SOLAR WATER PUMP

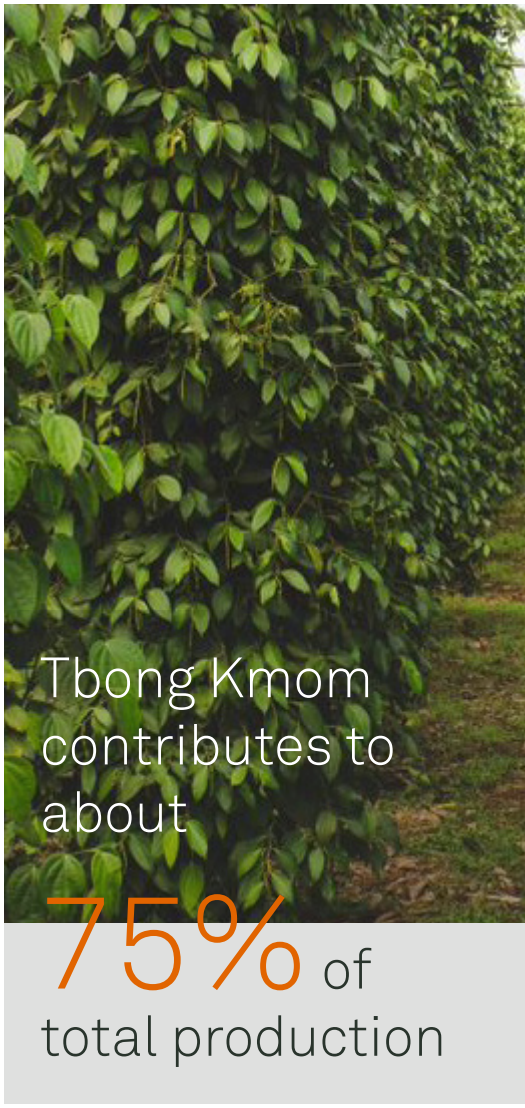
## Overview

Table 2: 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.




## Market – Pepper

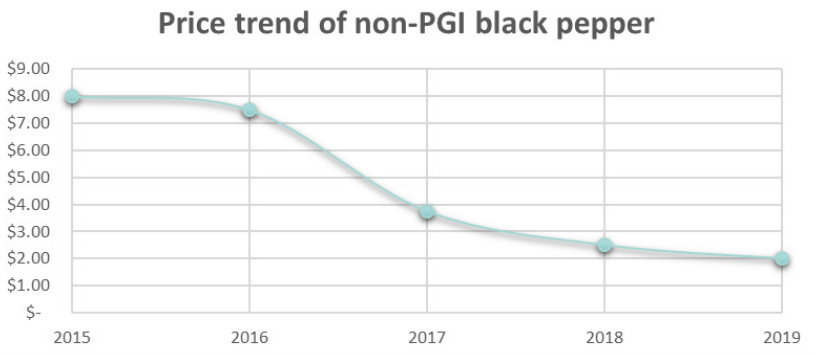
Although it is still a small industry compared to other Cambodian agricultural commodities, pepper has become a "Top Ten Product' in five provinces in Cambodia, including Kampot, Kep, Tbong Khmum, Kratie and Sihanoukville[21]. The Cambodian pepper production has expanded since 2013 when Cambodian farmers started to convert much of their land to cultivate pepper. As prices started to increase, additional investments into pepper cultivation soared[22]. 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[23], 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[24].

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

Photo credits: Sarou Long

Photo credits: Jeremy Meek

Figure 3: 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[25]. 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[26].

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)[27].

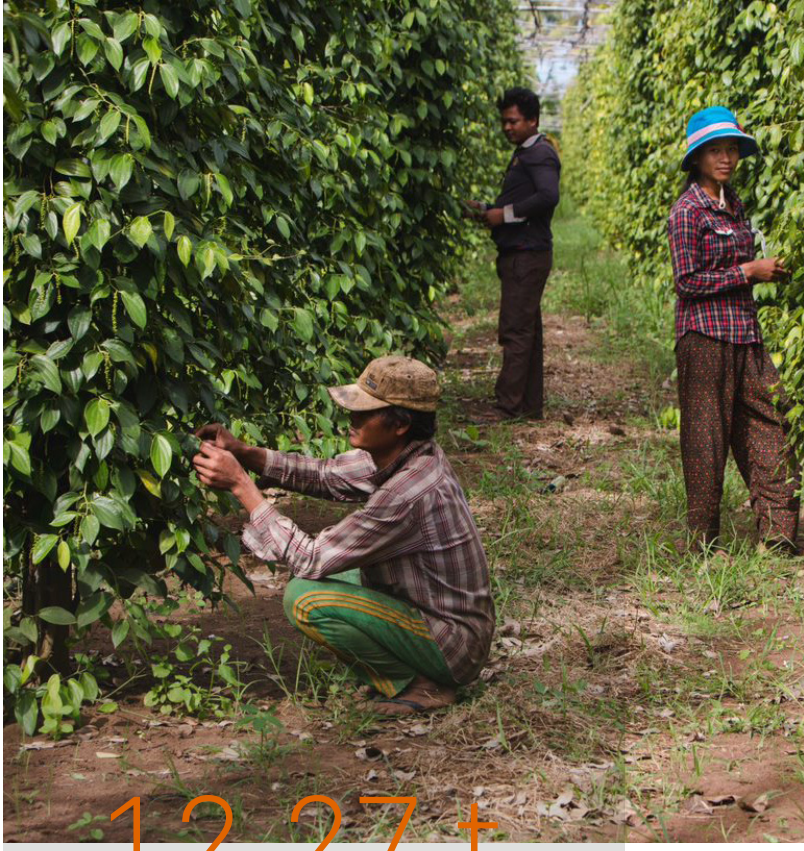
However, the Kampot pepper which won the European Union's Protected Geographical Identification (PGI) continues to maintain the high prices. The price of Kampot pepper is approximately $15 per kilogram for black pepper, $25 per kilogram for red pepper and $28 per kilogram for white pepper[28]. The Ministry 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[29].

[25] CIRD, 2015.
[26] Interviewed with the president of Kampot Pepper Promotion Association
[27] Interviewed with pepper farmers in Mondulkiri and Tbong Khmum
[28] https://www.phnompenhpost.com/business/price-woes-kingdoms-non-gi-pepper-farmers
[29] 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 3: 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 seven 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.

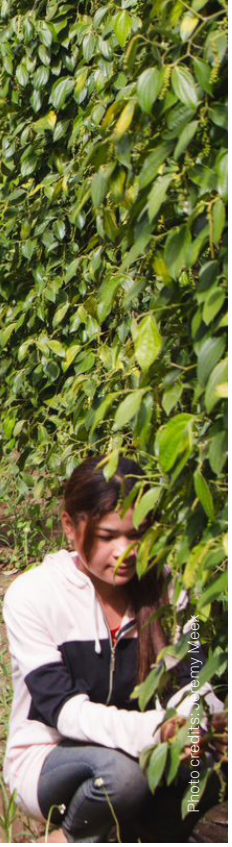


Photo credit: Tommy Meas

Table 4: 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[30] |
| 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, in August 2017 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 5: Solar water pump

| Technology | Solar water pump |
|---|---|
| Capacity of system | 2.48kW |
| Cost of system | $11,268 |
| Payback period | 4 years |
| Amount of diesel fuel avoided | 4,200 liters per year |
| Energy saving | $ 2,940 per year |
| Emission reduction potential per annum | 12.27 tonnes of $CO_2$e 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 4 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 4,200 liters of diesel being used per year, and equivalent savings of $2,940 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 $CO_2$e 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 6: 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 | $20,582 | $17,580 |

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

## Maintenance service and weather conditions

For nearly two years, Mr. Youmeng was very satisfied with the system as he could save a significant amount that was being spent on diesel fuel. He was a good borrower, who made timely payments in full. In February 2019, the pepper farmer faced challenge in using the solar water pump system as it was severely dry in Mondulkiri province. The solar water pump system was originally designed by the TP to extract water at a depth of 50m in the well. During the dry season the water level dropped to 70m from 50m. Nexus was working closely with Mr. Youmeng and the TP in order to solve this problem. The TP suggested the farmer to purchase a new pump, which has capacity to pump the water from the deeper level. The TP did not have the pump in stock, and thus they needed to order it from an overseas supplier. The issue is that it has taken so long to purchase the new pump for the farmer, the TP said that they need to ask the manufacturer in China to produce this special pump and it takes many months. Therefore, it makes farmer unhappy, and thus the farmer does not pay during these months. The rainy season has started in May so that the water level went up again. The TP requested the farmer to continue using the old pump while waiting for new pump. However, the farmer is still not happy with the provider, and refuse to repay during the period of waiting for new pump. The pump has just arrived in the late September, and the TP installed new pump in the first week of October.

This special case is lesson learnt from Nexus working with the provider and farmer. If this loan is provided the FI, it could consider as a default. As the new pump has already been installed the farmer will start paying again by the end of October 2019.

Photo credits: Jeremy Meek

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

## Overview

Table 7: 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 |

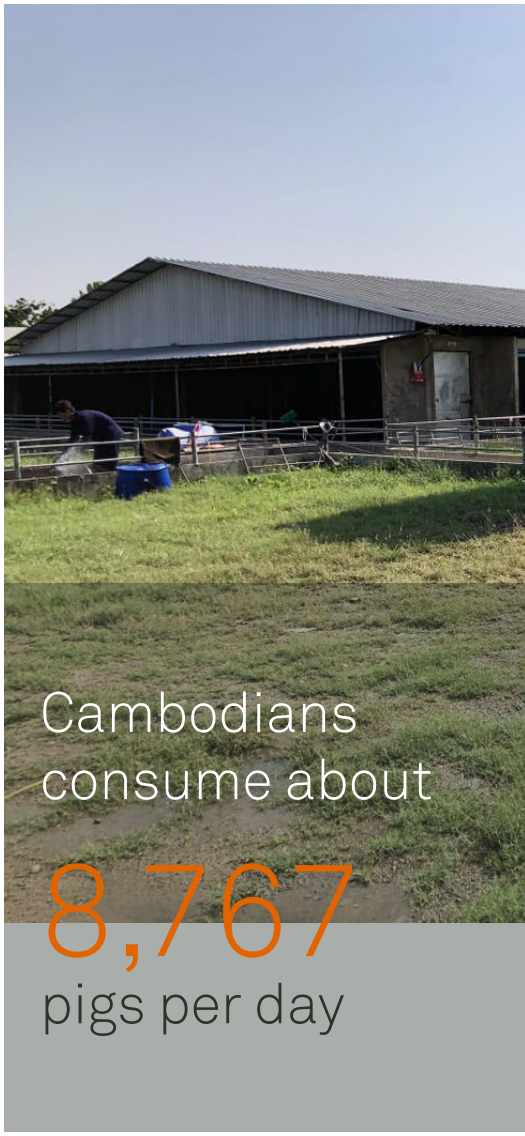
Pig farms require significant amounts of energy to operate specifically when using the enclosed swine stable system for pumping water to clean pigs and stables, lighting (required both day and nighttime) and for running an evaporative cooling system. This case study demonstrates the positive impact or 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[31].

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[32]. Despite this demand, the Cambodian government claims most of imported pigs are illegal, which drives down the price of local livestock[33]. MAFF data indicates that Cambodians consume about 8,767 pigs per day[34].

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




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

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

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

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

Photo credits: Sarou Long

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

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[35].

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[36]. 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[37].

## 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.

[35] CI SAC, 2011
[36] SAC, 2011
[37] 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 $CO_2$e emission per year

Table 8: 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.

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 9: 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 10: 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

# SOLAR WATER PUMPS FOR CAMBODIAN LONGAN FARMS

## Overview

Table 11: Summary of solar water pump project with longan farm

| | |
|---|---|
| Farm owner | Mr. Seng Sokhom |
| Farm type | Longan farm |
| Technology | Solar water pump |
| Capacity of technology | 2.60 kW |
| Simple payback period | About 6 years |
| Cost savings per year | $1,320 |
| kWh of clean energy produced | Approx. 3,700 kWh 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. The next case study provides experience of longan farmer through adopting solar water pumps.

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.

## 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[38], and this gradually increased to 2,437.3 hectares by 2013[39]. 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[40].

[38] Thorng et al (2013)
[39] Census of Agriculture of the Kingdom of Cambodia 2013
[40] http://www.khmertimeskh.com/5089584/push-increase-longan-exports/

Photo credits: Jeremy Meek

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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[41]. 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[42].

Most farmers in Battambang and Pailin have chosen to grow a specific type of longan fruits, known as "Tagan". Tagans 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 April, which 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

[41] Thorng et al (2013)
[42] Interviewed with deputy president of Pailin Longan Cooperative

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.

## Farmer's Profile

Mr. Sokhom worked as bank manager in Phnom Penh until, about ten years ago, he decided to change careers and start cultivating longan fruit in Cambodia's north-western Battambang Province. The farm comprises 25 hectares of land and about 3500 longan trees. Mr. Sokhom harvests longan fruits three times per year, in March, October and December. He is able to produce around 100 tons of longan fruits per year. He mainly sells the longan fruits through the middlemen, who normally transport the longan to Thailand. To support his growing business, Mr. Sokhom has hired seven farm workers, who used to cross the border into Thailand illegally looking for work. They now live on the farm and are paid a decent salary.

50%
operational costs saved per year

## 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. Sokhom set up a supplemental irrigation system to manage water supply better, and he has put a lot of investment into digging 7 ponds, 3 wells and a sprinkler irrigation system. Mr. Sokhom's farm is grid-connected but the grid is unreliable in that location, with power cuts sometimes lasting for weeks. In the wet season, Mr. Sokhom spends around $140 and $150 per month, and about $250 and $300 per month in the dried season.

Table 12: 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/


Photo credits: Jeremy Meek

# Investing in Solar Water Pumps

Mr. Sokhom decided to invest in a solar water pumping system because of regular power cuts, which sometimes last a week. The solar water pump is mainly used for pumping the water from well into the ponds. The system's pumping capacity is about 40 m3 of water per day. Mr. Sokhom is very happy, as the solar pump is working well. The solar pump helps him maintain the farm's daily water use, and it is estimated that a cost saving of around $1,320 per year. The payback period is about 5.5 years, which is a bit longer, but the main motivation for the solar investment is because of irregular supply of electricity from the grid. Mr. Sokhom's example is interesting because despite his farm being grid-connected, the solar water pump investment has proven to be extremely beneficial. It also demonstrates CERF's innovation and value in providing critical access to finance for an underserved market segment.

Table 13: Solar water pump

| Technology | Solar water pump system and lightning protection |
|---|---|
| Capacity of system | 2.6kW |
| Cost of systems | $10,968 |
| Simple payback period | 5.5 years |
| Cost savings | $1,320 per year |
| Emission reduction potential per annum | 3.14 tonnes of CO2e reduced per year |
| kWh of clean energy produced | Approx. 3,700 kWh per year |
| kWh of clean energy produced | Approx. 17,919.35 kWh per year |

Table 14: Operational cost per year before and after solar installation

| Items | Before ($) – Pre-investment | After ($) – Post-investment |
|---|---|---|
| Staff | 18,000 | 18,000 |
| Grid electricity | 2,700 | 1,380 |
| Chemicals | 30,000 | 30,000 |
| Other expenses and maintenance | 600 | 600 |
| Total operational cost per year | $51,300 | $49,980 |

Before investing in solar energy, Mr. Sokhom spends about $2,700 per year, but he now spends less money on the electricity bill, about $1,380 annually, representing savings of nearly 50%.

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