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Briefing Note

Private Sector-initiated Solar Irrigation Scheme for Rice Cultivation: Case Study from Banteay Commune, Kampong Cham Province, Cambodia

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IP 7: Farmer-Led Irrigation for Climate-Resilient Agri-Food Systems

Synopsis

Irrigation is crucial for maintaining high crop yields. In Cambodia, costly diesel pumps are primarily used for such purposes due to a lack of grid electricity in rural areas. With rising fuel prices and environmental pollution, solar pumps have emerged as an alternative. However, individual solar pump systems have traditionally been unable to cover large rice field areas. Since 2021, a new irrigation model has taken shape in the form of "solar water irrigation services for fees", initiated by Solar Green Energy Cambodia (SOGE), which has to date expanded similar schemes in five provinces to cover rice, orange, and vegetables. This report focuses on only one of the solar irrigation schemes implemented by SOGE in Batheay Commune, Batheay District, Kampong Cham Province, 48 km north of Phnom Penh. The scheme is located in the floodplains of the Tonle Sap River, where rice is intensively grown. In the study location, there are two prominent irrigation service models: using large diesel pumps operated by conventional irrigation service providers (CISP), and using solar pumps operated by a solar irrigation service provider (SISP). Thus, the report details the solar scheme startup and comparative studies between that scheme and the largest conventional irrigation service provider. The scheme started with the investment of SOGE and an international donor, who paid half and half, to purchase an existing pumping station operated by one of the CISPs. It then renovated the main canal to suit gravity irrigation, starting with 200 farming households at the initial stage on a total land area of 500 ha. Within a period of two years, both the number of service recipients and land coverage have increased by almost three-fold. Meanwhile, the largest CISP has about 1,000 farmers, but the land coverage is only 630 ha. Water fees are about 1.1-1.4 times higher for farmers who use solar irrigation services for the same land unit area per cycle, but farmers who use conventional services have to spend more on using their own diesel pumps to convey water to their rice fields. In contrast, farmers using services from SOGE tend to reduce the utilization of diesel pumps, largely due to gravity irrigation. Additionally, about half of them can grow rice up to three times per year, while those who use conventional services can only grow two crops per year. The reason is that at SOGE, water is scheduled better to ensure equal and sufficient distribution, but higher competition for water is found with farmers who use conventional services. More interestingly, the CISP may contribute significantly to greenhouse gas emissions (about 100 tons CO2-equivalent/crop cycle), which highlights the benefit of a private sector-initiated solar irrigation scheme, which can save time and energy, while increasing yields, boosting incomes, and conserving the environment.

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Company Profile

Solar Green Energy Cambodia (SOGE) is a private company established in Cambodia in 2014, specialized in installing large-scale solar irrigation and supplying solar pumps and related products (Table 1). SOGE began to offer a new business model in 2021 by investing in large-scale solar irrigation schemes. Until now, five large-scale solar irrigation schemes have been constructed in several key provinces, providing irrigation services for fees, as presented in Table 2. The capacity of each solar irrigation schemes is large, ranging from 50 to 390 kW and covering total areas of 56 to 1,300 ha, as presented in Table 2. However, this study focuses solely on the solar irrigation scheme implemented in Kampong Cham Province.

Table 1. Profile of Solar Green Energy Cambodia (SOGE)

Description	**Information**
Company name	Solar Green Energy Cambodia (SOGE)
Year operations started	2014
Number of staff	36
Technical staff	70%
Number of total solar schemes	5
Solar scheme in Kampong Cham:	
Starting year	2021
Total investment	0.5 million USD
Share of investment	50%

Table 2. Description of the five solar irrigation schemes implemented by SOGE in Cambodia

Place	Year	Target crop	Solar pumping Capacity (kW)	Land coverage (ha)
Kampong Cham	2021	Rice	390	1300
Pursat*	2022	Rice	315	1000
Kampong Thom	2022	Rice	50	300
Kampong Chhnang	2023	Vegetable	30	56
Battambang	2024	Rice & orange	70	300

Note: Asterisk "*" denotes that in Pursat, solar pumping capacity and land coverage are the combined totals for 10 solar sub-schemes.

Context and System Design

A solar irrigation scheme implemented by SOGE is situated in Batheay Commune, Batheay District, Kampong Cham, 48 km north of the capital city, Phnom Penh (Figure 1). Irrigation services are commonly provided in the commune, and before the SOGE scheme started, there were four conventional irrigation service providers (CISP) that used large, repurposed diesel pumps modified from trucks to provide water to rice farmers for fees. However, one CISP stopped operations, largely due to poor canal infrastructure and ineffective fee collection, and then sold the service in 2020 to SOGE, known as a solar irrigation service provider (SISP). Then, in 2021, a solar irrigation scheme in the commune started the first operation with 200 households. Currently, there are only 4 service providers - 3 CISPs and 1 SISP - that offer irrigation services for fees. Irrigation services are made possible under five-year permits issued by local authorities to ensure sufficient coverage within the commune, and the CISP that sold the service to SOGE also intended to resume offering the service elsewhere in the commune, but had to wait a few years until a new permit became open for bidding. In the studied location, the main water source comes from the Tonle Sap River, while rice is the main and only crop grown on the floodplains, east of the river, almost year-round, except for the period from August to October due to seasonal flooding. Over 90% of the residents are farmers who grow rice, largely for sale.

Before the solar scheme was introduced to the commune, farmers depended largely on service providers to pump water from the river into streams and canals that flowed past their rice fields. They then used their own diesel pumps to convey water into their fields. With that, farmers could grow rice two times per year, from April to July and from November to March. They had to pay fees on a seasonal basis, which was 350,000 riel/ha/season (about 85 USD/ha/season). Due to rising fuel prices and constant fees, one service provider decided to sell a pumping station to SOGE, and the solar scheme then started in 2021. At first, about 200 farming households from an agricultural cooperative in the commune signed a contract to use the services provided by SOGE, which covered about 500 ha of land. However, within two years, the number of households who have joined the scheme has increased to 470, while the coverage area increased to 1,300 ha. In fact, SOGE planned the current solar pumping capacity of 390 kW for 1,000 ha only, but the number of participating farmers rose to a level higher than expected, so SOGE decided to use grid electricity to pump water at night to cover the remainder (300 ha).

More and more farmers are interested in using the SOGE services due to several factors: competitive fees, time savings, and reduced dependency upon their own diesel pumps. Although SOGE charges fees 15-25% higher than CISPs, its farmers tend to pay less for the overall pumping costs. The reason is that farmers can reduce time associated with conveying water into their rice fields because SOGE uses gravity irrigation. As a result, farmers whose rice fields are along the main canal rely on gravity and can avoid secondary pumping. Additionally, other farmers in the scheme can also

save money by reducing the use of diesel pumps, and this also links to reduction in greenhouse gas emissions. In contrast, farmers who use conventional services have to pay more for using their individual pumps to convey water into their fields.

Figure 1. Location of a solar irrigation scheme implemented by SOGE in Batheay Commune, Batheay District, Kampong Cham Province

Farmers' Survey on Benefits of the Solar Irrigation

Part of the report also focused on utilizing the results of a farming household survey conducted in Batheay District, Kampong Cham Province, Cambodia, where SOGE provided solar-powered water irrigation for rice farmers. The survey was conducted in August 2024, interviewing two distinct groups of farmers: those using the SOGE service and those relying on conventional irrigation service providers (CISP), which used large diesel pumps. In each group, 15 farmers were purposively chosen for interviews, while a structured questionnaire was the main survey tool. The main questions focused on household size, labor needed for daily irrigation work, irrigation time, number of annual crop cycles, average yield, and annual income. The data was compared between the two groups to present contributions of solar irrigation to the improvement in irrigation-related work, along with consequent yield and income.

Benefits of the Solar Irrigation Scheme

In Batheay commune, there are two prominent irrigation schemes: using large diesel pumps by CISP and solar pumping by SOGE. There are three CISPs in the studied location, but only the largest one was used for comparison with SOGE (Table 3). In 2024, the largest CISP offers irrigation services up to 1,000 farmers, covering 630 ha of rice fields. In contrast, SOGE has only 470 farmers in their scheme, but the numbers have been rising significantly. Despite the lower farmer number, its irrigation services cover about 1,300 ha, which is around two times larger than the land area under the conventional services. Rice cultivation areas owned by farming households in both groups are slightly different, with SOGE farmers having smaller land sizes (2.2 ha/household). Nevertheless, daily irrigation time and labor were reduced by at least half for SOGE farmers compared to CISP farmers. Normally, farmers grow rice two times a year, but with solar irrigation, 50% of the farmers who use SOGE services can grow rice up to three times a year, largely due to better irrigation schedules and canal infrastructure improvements. Additionally, rice yield did not differ between the two groups, averaging about 6.5-6.7 tons/ha. The annual income varied in SOGE farmers, depending on the number of crop cycles. If they grew rice three times a year, the income could reach 9,728 USD/year compared to CISP farmers (7,436 USD/year).

The main source of irrigation water come from the Tonle Sap River, immediately west of the commune. The pumping capacity differs among the two groups. CISP uses multiple diesel pumps with a total capacity of 298 kW, while SOGE uses solar panels with a total solar capacity of only 390 kW, which is more than 1.3 times higher compared to CISP. However, the current capacity of SOGE is enough for 1,000 ha only, so the company uses grid electricity to aid the pumping at night. SOGE plan to continue using grid electricity until it can expand the solar capacity to cover the rest. In terms of fees, CISP charges a relatively lower fee than SOGE, whose price is about 1.1-1.4 times higher. However, farmers who uses conventional services have to use their own diesel pumps to convey water from the designated streams to their rice fields, which may cost the same as fees. Meanwhile, many farmers who use SOGE services reduce dependency upon diesel pumps, largely due to the improved canal infrastructure by SOGE, which enables gravity irrigation. Regardless of diesel consumption by individual farmers, CISP consumes 630 L of diesel per day, and for continuous pumping of two month per cycle, it is equal to 37,800 L/ crop cycle. Thus, CISP has to spend 35,150 USD per cycle. Meanwhile, the majority of power for SOGE comes from solar energy and one-fourth comes from grid electricity, so SOGE has to spend about 2,809.8 USD per cycle for grid electricity. Because of huge diesel consumption, CISP is estimated to emit about 100 tons CO2-equivalent/cycle over a total land area of 630 ha, or 0.16 tons CO2-eq/ha/year. The total emission would be even higher if the pumps owned by individual farmers were included in the calculation. As SOGE also used grid electricity, it also emitted CO2. Based on its annual electricity consumption, emission is estimated at 24.49 tons CO2-eq/year, which is much lower than CISP.

Table 3. Comparison of farmer number, land coverage, diesel use and emission by CISP and SOGE

Description	**CISP[(a)]**	**SOGE[(b)]**	**Ratio (b/a)**
Farmer information:			
Number of farmers	1,000	470	0.5
Total land coverage *(ha)*	630	1,300	2.0
Household land size *(ha/household)*	2.6	2.2	0.8
Labor needed for irrigation work *(person/household)*	2	1	0.5
Time for daily irrigation in each household *(h/day)*	7.1	3.1	0.4
Cycle	2	2-3[a]	1-1.5
Rice yield *(ton/ha)*	6.5	6.7	1
Annual income *(USD/year)*[b]	7,436	6,485-9,728	
Pumping type and service:			
Type of power for irrigation	Diesel	Solar	
Solar panel capacity *(kW)*	-	390	
Pumping machine capacity *(kW)*	298	65	0.2
Fees *(USD/ha/cycle)*	61-85	85-96	1.1-1.4
Diesel consumption per day *(L)*	630	-	
Diesel consumption per cycle *(L)*[c]	37,800	-	
Diesel expenses *(USD/cycle)*	35,154	-	
Electricity consumption *(kWh/cycle)*[d]	-	23,415	
Electricity expenses *(USD/cycle)*	-	2,809.8	
CO_2 emission equivalent *(ton-eq)*	100.17[e]	24.49[f]	
CO_2 emission equivalent *(ton-eq/ha/year)*	0.16	0.008	

Note: the superscripts "a" denotes that 50% of the farmers using SOGE services can grow rice three times a year; "b" refers to the annual income calculation based on the dry-season rice price of 0.22 USD/kg; "c" means the calculation of the total diesel consumption per cycle is based on two months of continuous pumping; "d" refers to the electricity cost estimated at 0.12 USD/kWh for nighttime use; and "e" denotes that CO_2 calculation is based on a diesel-to-CO_2 coefficient of 2.65 kg CO_2 per liter of diesel. Meanwhile, "f" is based on an electricity-to-CO_2 coefficient of 1.046 kg CO_2/kWh (Initiative for Climate International Finance, 2021).


Figure 2. A 75-kW pumping motor submerged into the Tonle Sap River (left) and a line of solar panel along the renovated canal used for connecting power from the sun (right)


Figure 3. Rice fields submerged for two months, from August to October, on the lower parts of the canals (left) and rice fields on the upper part of the canal under preparation for rice sowing (right)


Figure 4. Large diesel pumping machines, modified from trucks, stationed and unused during flood seasons from August to October

Major Learnings

(1) Large-scale solar irrigation initiated by the private sector brings service delivery and economic benefits to farmers

A solar irrigation scheme implemented in Batheay commune is an ideal example of delivering irrigation services to hundreds of rice farmers over a large land area. It seems competitive with conventional irrigation services provided by local investors that use modified diesel pumps as a means of water conveyance. In two years, the number of service recipients and the land cover tripled, which indicates not only the satisfaction but also a cost-effective method for local farmers to adopt climate-smart irrigation.

(2) Timely scheduling and securing adequate water leads to trust and increase crop cycles

With SOGE, farmers are not worried about not having sufficient water for their crops because they will be paid back the fees if their crops fail due to lack of water. This kind of practice has created trust, motivating other farmers to join the scheme although the fees are slightly higher. In contrast, farmers who use conventional services have to compete with each other to convey water to their crops because the service provider pumps water from the river into distributing streams only. This led to complaints, disputes, and poor behavior.

(3) New farmers participate after seeing successful farmers who use solar irrigation services

At the initial stage of the solar irrigation scheme, SOGE started with only 200 farming households, but in two years the number rose to 470 households. Although the number seems to be smaller than the CISP, the increase happened in a short period of time. In fact, other farmers also want to use the solar irrigation scheme, but their farms are out of the reach of SOGE. Therefore, increasing the pumping capacity is important and requires more investment.

(4) A private sector-initiated solar irrigation scheme reduces irrigation time and costs

Farmers who use SOGE's services can benefit from gravity irrigation due to the canal renovation. With this innovative design, farmers reduce significant amount of time when compared to the time before the scheme when they had to stand by their pumping machine half a day to irrigate crops. However, this is still common for farmers who use conventional services. Such practices lead to higher irrigation costs when compared to the SOGE farmers.

(5) Large scale solar irrigation may need partial funding to reduce initial investment cost

SOGE decided to set up a large solar irrigation scheme when they found a source of funding. They had expertise and capital, but to expand, partial funding may be needed from farmers.

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