PEREZ-GUERRERO TRUST FUND FOR ECONOMIC AND TECHNICAL COOPERATION AMONG DEVELOPING COUNTRIES

(G77 Project)

Final Report

on

Development and Application of Solar Pumping Irrigation Technology for the ASEAN Countries

NATIONAL RESEARCH INSTITUTE FOR RURAL ELECTRIFICATION, MINISTRY OF WATER RESOURCES, P. R. CHINA / HANGZHOU REGIONAL CENTER (ASIA-PACIFIC) FOR SMALL HYDRO POWER

March 2025, HANGZHOU, CHINA

G77 PGTF Project Final Report

Introduction

The Group of 77 approved the project entitled "Development and Application of Solar Pumping Irrigation Technology for the ASEAN Countries" with the funding source from the Perez-Guerrero Trust Fund (PGTF)-Reference Number INT/23/K08 at the 46th Annual Meeting of Ministers for Foreign Affairs of the Group of 77, which was submitted by National Research Institute for Rural Electrification, Ministry of Water Resources, P. R. China (hereinafter referred to as NRIRE). The duration of the project is 1 year, and according to the signed project document, it started in November 2023, and completed in November 2024.

The Final Report included the project implementation activities, expenses and other related content.

I. Project Overview

1. **Project Title:** Development and Application of Solar Pumping Irrigation Technology for the ASEAN Countries

2. **Abstract:** With the serious shortage of freshwater resources and the rising demand for food, the freshwater limit has become a security threat to agricultural development and food supply in ASEAN countries. Therefore, developing water-saving irrigation and rational utilization of groundwater has become the key to solve the problems of limited arable land, shortage of freshwater and rising food demand. The ASEAN countries are areas with good light intensity and long illumination time, the research and application of solar pumping irrigation technology is of great significance to increase the irrigation efficiency, save energy resources, improve the local people's livelihood in ASEAN countries, and promote the achievements of SDGs globally.

3. **Background Analysis:**Agriculture plays an important role in most of the ASEAN countries. About 70% of the population of the Philippines is in rural areas, and about 50% of the labor force is engaged in agricultural production. Indonesia is the second largest tropical crop producer after Brazil. The agricultural irrigation technology level of ASEAN countries is relatively backward, and the irrigated area is small. Taking Laos as an example, as the country with the most abundant water resources in ASEAN countries, the development of irrigated agriculture is lagging behind. The irrigated area only accounts for about half of the national farmland, along with severe waste of water resources and poor agricultural production. In the Philippines, the irrigated area of farmland only accounts for about 50% of its irrigable area, and it relies mostly on diesel water pumps, which leads to high irrigation costs and difficult maintenance. The Indonesian Ministry of Agriculture also stated that among the 7.3 million hectares of paddy fields in Indonesia, the

irrigation systems for at least 2.4 million hectares need to be rehabilitated. 50% of the irrigation systems in Vietnam are outdated or underutilized. The problem of wasting water resources in paddy field irrigation is prominent, and the irrigation system needs to be improved and updated urgently. With the serious shortage of freshwater resources and the rising demand for food, the freshwater limit has become a security threat to agricultural development and food supply in ASEAN countries. Developing water-saving irrigation and rational utilization of groundwater have become the key to solve the problems of limited arable land, shortage of freshwater and rising food demand. Coupled with global climate change in recent years, ASEAN countries have been affected by El Ninos, and there have been frequent problems of drought and water shortage in farmland, reduction of crop yield and farmers' income. Therefore, the research and application of solar pumping irrigation technology that suitable for ASEAN countries is of great significance to promote the development of agricultural economy in ASEAN countries.

How to make a breakthrough development in agricultural economy becomes a common challenge to all ASEAN countries since it needs advanced technology and proven practice. China is also a large agricultural country. In recent years, many scientific and technological achievements and successful practical experience have been made in the field of agricultural irrigation. Especially with the rapid development of solar power technology, the production capacity of photovoltaic panels in China has accounted for 70 % of the world market, and the solar water pumping irrigation technology has also been widely applied. The ASEAN countries are areas with good light intensity and long illumination time. Using solar power to solve the problem of insufficient electric energy in local area, allowing the irrigation system and equipment to operate in the period of effective sunlight will help to improve the agricultural irrigation technology, save energy resources, solve the problem of local people’s livelihood in ASEAN countries, and promote the achievements of SDGs globally.

To address the issue of the constraint in developing the agricultural economy, the ASEAN countries initiated a series of activities for improving the irrigation systems to achieve sufficient experience and know-how. The result is still far from being expected, because there is neither advanced and practical technology, nor competent technical & managerial talents. There needs a mode of multilateral South-South and Triangle cooperation inside which China is willing to share his know-how and proven practice to the ASEAN countries and enhance the development of agricultural economy for the beneficiary countries. Technical and economic cooperation between China and the ASEAN countries has been put into reality for a long run, but there is still an urgent need to improve the technical

capability in most ASEAN countries.

The project was initiated to address the critical challenges faced by ASEAN countries in water resources management, energy sustainability, and rural development. It intends to further understand the irrigation needs of different crops in different regions based on the condition of solar power and water resources in agricultural irrigation areas of ASEAN countries, and explore the solar pumping irrigation technology suitable for different environmental needs of various countries. By proposing the scheme for demonstration project in one of the ASEAN countries to popularize the application of solar pumping irrigation technology in island and mountainous countries such as Indonesia, the Philippines, and the technology will be gradually extended to other countries of ASEAN. Through technical training and communication, the technical ability of the development, operation and maintenance of solar pumping irrigation technology will be enhanced, and the irrigation facilities and modes will be improved in ASEAN countries. Meanwhile, by making full use of water resources in developing modern agriculture, the development of green energy will be promoted, the sustainable development of agricultural economy will be obtained, and the improvement of people's livelihood will be guaranteed in ASEAN countries.

II. Implementation

The project is implemented in three distinct stages. The first two stages are relevant to this current project document, with the last stage representing ongoing strategies into the future.

Supporting and Partner Institutions:

★China International Center for Economic and Technical Exchanges

★ Department of Science, Technology and International Cooperation, Ministry of Water Resources of the People's Republic of China

★ASEAN Centre for Energy (ACE)

★Ministry of Energy and Mineral Resources of Indonesia

★Lao Institute for Renewable Energy Promotion(IREP)

•The first phase of the project involved the investigations, data collection, compilation of a comprehensive feasibility and economic study report, and formulation of a demonstration project scheme for solar pumping irrigation system in Lao PDR.

•The second phase of the project involved the organization of the Seminar on the Development and Application of Solar Pumping Irrigation Technology for the ASEAN Countries in Indonesia.

•The third phase of the project involves the follow-up cooperation and promotion of the development and application of solar pumping irrigation technology, and exploring the possibility of implementing a demonstration project of solar pumping irrigation technology in other ASEAN Countries.

2. Benefits:

The successful implementation of the project has yielded significant benefits aligned with the overarching goals of sustainable development and South-South cooperation. Below are the key benefits:

- The project has raised awareness and deepened understanding among stakeholders in ASEAN countries about the potential of solar pumping irrigation technology as a sustainable solution to address water scarcity and agricultural challenges, laying groundwork for future exploration.
- Through technical training and communication, the project has bolstered the technical prowess of local professionals in developing, operating, and maintaining solar pumping irrigation systems, fostering self-sufficiency and long-term development in this field.
- The project has created a platform for knowledge exchange and collaboration among ASEAN countries, as well as between China and ASEAN. This cooperation has laid the groundwork for future joint efforts to address shared agricultural and environmental challenges, emphasizing the importance of South-South cooperation in driving regional development.
- By introducing advanced solar pumping irrigation technology, the project has stimulated discussions and dialogue on sustainable agricultural practices in ASEAN countries. This dialogue is critical for identifying pathways to improve water resource management and agricultural efficiency in the long term.
- The project has contributed to broader discussions on sustainable farming practices and environmental protection. This dialogue aligns with global efforts toward achieving the Sustainable Development Goals (SDGs) and serves as a reference case for re

gions facing similar challenges.

III. Completed Activities at the First Stage

Activity – 1: Carrying out investigation and formulating the feasibility and economic study report

Time: November 2023– April 2024

Location: China

Participants: National Research Institute for Rural Electrification (NRIRE);

Lao Institute for Renewable Energy Promotion(IREP)

Implementation:

The first phase of the project focused on conducting a comprehensive assessment of solar pumping irrigation technology's applicability and economic viability in the ASEAN region. Given the diverse agricultural and energy landscapes across ASEAN countries, National Research Institute for Rural Electrification (NRIRE) prioritized Lao PDR as the initial case study due to its representative challenges and opportunities. Laos was selected based on its

abundant solar resources, underdeveloped irrigation infrastructure, and alignment with national priorities to enhance agricultural productivity through sustainable energy solutions. The selection aimed to establish a replicable framework that could be adapted to other ASEAN countries with similar climatic and socio-economic conditions.

Through iterative consultations and technical exchanges, NRIRE organized experts to work with Lao counterparts to gather critical data on Lao PDR's solar resource potential, hydrological conditions, and agricultural challenges, such as seasonal water scarcity and low irrigation efficiency. Key activities included a thorough evaluation of Lao PDR's solar irradiation patterns, groundwater utilization capabilities, and grid connectivity limitations, particularly in remote agricultural zones. The team analyzed technical barriers such as low irrigation efficiency, seasonal water scarcity, and reliance on diesel pumps, which hinder sustainable agricultural productivity. Special emphasis was placed on aligning findings with broader goals of sustainable agriculture and energy transition in ASEAN countries.

The study also reviewed national policies, agricultural demands, and regional energy plans to align the proposed technology with local development priorities. Economic viability was preliminary assessed by comparing operational costs of traditional irrigation methods with projected savings from solar adoption. Through synthesizing technical, environmental, and socio-economic insights, the NRIRE team compiled the Feasibility and Economic Study Report on Solar Pumping Irrigation Technology Development in Lao PDR, which outlines actionable pathways for scalable implementation.This report serves as a foundational document for subsequent demonstration projects and regional knowledge-sharing initiatives.

Activity – 2: Compilation of the scheme for demonstration project

Time: April 2024– June2024

Location: China

Participants: National Research Institute for Rural Electrification (NRIRE);
Lao Institute for Renewable Energy Promotion(IREP)

Implementation:

During the implementation phase of formulating the demonstration project scheme for solar pumping irrigation systems, the project team collaborated closely with Lao partners to identify and evaluate potential pilot sites. Based on technical criteria such as solar resource availability, water demand, agricultural suitability, and local stakeholder engagement, three candidate sites were initially proposed by Lao counterparts. Following a rigorous assessment process, two optimal sites were selected in Khong Xe Don County (Salavan Province) and Vapi County, ensuring alignment with regional agricultural priorities and solar energy potential.

NRIRE organized experts to conduct assessments in both districts to gather critical data, including solar irradiance patterns, hydrological conditions, soil characteristics, and existing irrigation practices. Field surveys were complemented by consultations with local authorities to align technical designs with socio-economic needs. Technical discussions centered on optimizing system configurations to ensure adaptability to varying terrain and climate conditions.

The finalized scheme outlines tailored solar pumping solutions for each site, integrating photovoltaic panels, inverter systems, and high-efficiency pumps. System specifications were developed to balance energy output, water delivery capacity, and cost-effectiveness, with

detailed equipment configurations (e.g., solar array sizing, pump selection) tailored to local requirements. The resulting plan emphasizes scalability, sustainability, and alignment with Lao PDR's agricultural development priorities, providing a replicable model for similar regions in ASEAN.

Excerpts from the Feasibility and Economic Study Report and Demonstration Project Scheme

Contents

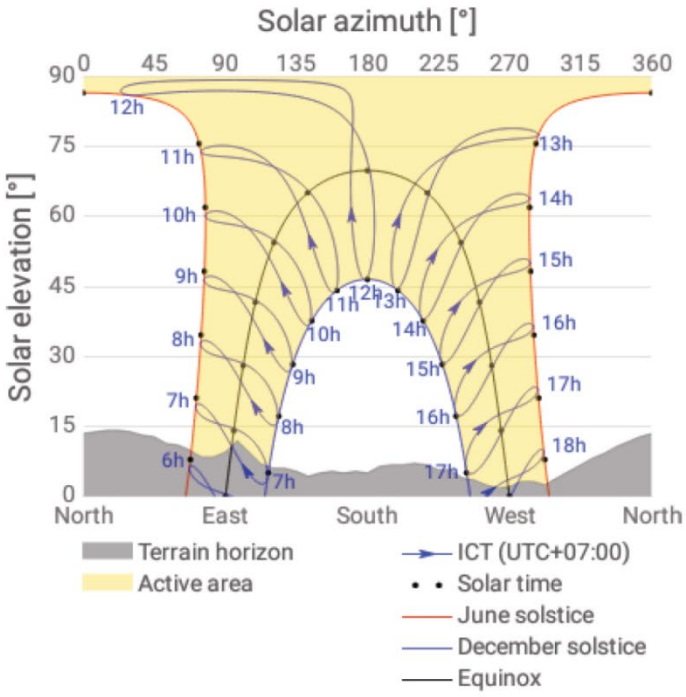
2.1 Solar Energy Resources in Laos

2.1.1 Overview of Solar Energy Resources

The total annual solar radiation in Laos gradually decreases from south to north and from west to east, ranging from 1,314 Wh/m² to 1,899 kWh/m². The western and southern regions have the most abundant solar resources, with average radiation exceeding 1,800 kWh/m² in the southwestern plains, making them ideal for development. The eastern and northern border areas have poorer resources. Small-scale photovoltaic (PV) systems have been installed in remote regions, but total installed capacity remains limited.

Map data			Per year
Specific photovoltaic power output	PVOUT specific	**1345.5**	kWh/kWp
Direct normal irradiation	DNI	**1056.9**	kWh/m²
Global horizontal irradiation	GHI	**1610.0**	kWh/m²
Diffuse horizontal irradiation	DIF	**868.3**	kWh/m²
Global tilted irradiation at optimum angle	GTI opta	**1693.2**	kWh/m²
Optimum tilt of PV modules	OPTA	**22 / 180**	°
Air temperature	TEMP	**22.6**	°C
Terrain elevation	ELE	**766**	m

Horizon and sunpath



PV ELECTRICITY AND SOLAR RADIATION

Annual averages

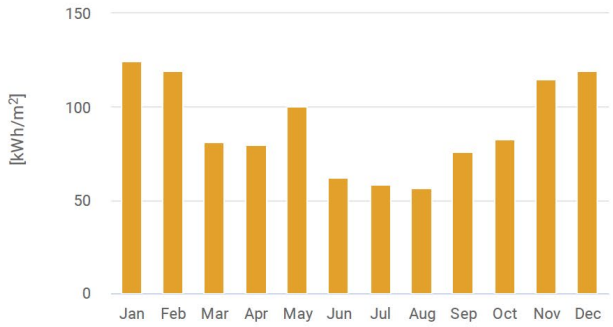
Direct normal irradiation

1075.0

kWh/m^2 per year

Monthly averages

Direct normal irradiation



Average hourly profiles

Direct normal irradiation [Wh/m^2]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 - 1												
1 - 2												
2 - 3												
3 - 4												
4 - 5												
5 - 6												
6 - 7				23	85	61	49	25	31	31	25	
7 - 8	129	151	84	115	167	92	69	69	111	161	229	161
8 - 9	244	307	191	194	255	147	118	104	150	188	280	261
9 - 10	311	403	278	273	332	198	175	162	239	277	365	339
10 - 11	437	507	357	342	373	210	195	200	310	346	471	450
11 - 12	521	571	390	365	380	233	210	222	318	344	493	508
12 - 13	552	570	383	359	378	254	247	249	327	329	492	531
13 - 14	528	526	335	323	358	225	228	235	312	306	456	511
14 - 15	494	468	266	274	325	218	203	196	285	281	422	463
15 - 16	437	389	193	208	263	182	167	163	219	232	362	383
16 - 17	312	292	116	134	199	147	133	124	171	150	227	241
17 - 18	42	73	27	48	112	100	84	66	63	15	9	11
18 - 19					6	10	9	4				
19 - 20												
20 - 21												
21 - 22												
22 - 23												
23 - 24												
Sum	4008	4257	2620	2660	3233	2077	1888	1818	2538	2662	3829	3859

Approximately 80% of Laos consists of mountains and plateaus covered with forests. The terrain slopes from high in the north to low in the south, with the northern region

bordering China's Yunnan Plateau, the eastern border formed by the Truong Son Range, and the west comprising the Mekong River valley and plains. The country is divided into Upper Laos, Central Laos, and Lower Laos. Upper Laos has the highest elevations, including the Xiangkhoang Plateau (2,000–2,800 meters) and Phou Bia Peak (2,820 meters). According to the study, the suitable area for PV development in Laos covers 20,751.0 km² (9.02% of the national territory), mainly located in the southern plains.

A Levelized Cost of Energy (LCOE) analysis based on data from the ASEAN Center for Energy (ACE) shows that western Laos, with higher solar irradiance, has significantly lower LCOE compared to the east. As PV module efficiency improves, LCOE across ASEAN countries, including Laos, will continue to decline, enhancing investment attractiveness, making it more attractive for investme

Currently, Laos lacks updated feed-in tariff policies for solar energy. Most solar applications are off-grid systems for residential use. Approximately 18,657 households (1.64% of the national total) in 430 villages rely on solar power. In addition to small-scale systems, the government has recently initiated larger projects, such as a 10 MW plant in Vientiane, with plans to expand to 100 MW by 2020. Optimal PV sites are in the southern provinces like Champasak, Attapeu, Savannakhet, and Salavan, while the northern provinces and Vientiane also show potential.

Laos is interconnected with China, Thailand, and Vietnam. Solar development could alleviate hydropower shortages during the dry seasons.

Over the past five years, Laos has experienced an average annual growth rate of 14.2% in electricity consumption and 12% in peak load, indicating significant growth in power demand. Although seasonal shortages in hydropower supply exist, the rapid growth in installed capacity has far outpaced demand growth, leading to periodic difficulties in electricity absorption. Currently, Laos' domestic power supply has achieved short-term balance and is in surplus in the medium term . Strong electricity import demands from neighboring countries including Thailand, Vietnam, Cambodia, and Myanmar have been a major driving force for Laos' economic growth and power sector development, with nearly 70% of its generated electricity being exported.

Sequence	Product Name	Model	Specifications	quantity
26 kW Solar Water Pumping System for Vapi Country	PV Pump Inverter Integrated Unit	MNE-SPCS37KV4	Drives 37 kW 3-phase 380V pump; includes inverter and filter box. With convergence, lightning protection and anti-reverse functions, IP54 can be installed outdoors.	1
	Water Pump	SJ150-1	13 kW, 3-phase, 50 Hz, 380 V submersible pump with a head of 18 meters and a flow rate of 180 m^3/h.	2
	Solar Panels & Mounting	M540	52.92 kW monocrystalline A-grade solar panels (98 pieces, 540W per panel at peak power). Custom ground-mounted galvanized steel wind-resistant mounting system.	1
	Cables & Accessories	Custom	Includes motor cables, PV cables, signal cables, and spare components.	1
19 kW Solar Water Pumping System for Khong Xe Don County	PV Pump Inverter Integrated Unit	MNE-SPCS22KV4	Drives 22 kW 3-phase 380V pump; includes inverter and filter box. With convergence, lightning protection and anti-reverse functions, IP54 can be installed outdoors.	1
	Water Pump	SJ150-1-1	9.2 kW, 3-phase, 50 Hz, 380 V submersible pump with a head of 11 meters and a flow rate of 180 m^3/h.	2
	Solar Panels & Mounting	M540	37.8 kW monocrystalline A-grade solar panels (70 pieces, 540W per panel at peak power). Custom ground-mounted galvanized steel wind-resistant mounting system.	1
	Cables & Accessories	Custom	Includes motor cables, PV cables, signal cables, and spare components.	1

IV. Completed Activities at the Second Stage

Activity – 1: Preparations of the Seminar
Time: June-August 2024
Location: China
Participants: NRIRE;
ASEAN Centre for Energy (ACE)
Implementation:
Entrusted by Ministry of Water Resources, Ministry of Commerce, China International Development Cooperation Agency, Ministry of Science and Technology, Ministry of Foreign Affairs, UNDP, UNIDO, ILO, FAO, ASEAN Secretariat, etc., NRIRE has been engaged in organizing technical training programs for other developing countries, and has so far completed in total 172 training programs, seminars or workshops, which have embraced around 6000 participants from 133 countries. All the seminars were highly appraised by the officials and experts attending the event. Based on the experience in training programs and considering the features of this project, a targeted curriculum was developed to address the specific needs of ASEAN countries. The course design focused on practical applications of solar pumping systems, technical requirements for irrigation in diverse agricultural settings, and strategies for sustainable water resource management. The curriculum incorporated both theoretical and hands-on components, including case studies from China's successful implementation of solar pumping technology, as well as technical guidelines for adapting these solutions to the climatic and geographical conditions of ASEAN countries. Renowned experts and practitioners in the fields of solar pumping irrigation technology and renewable energy were invited to serve as presenters. These experts brought extensive experience in designing, implementing, and maintaining solar-powered irrigation systems. Their contributions ensured that participants received up-to-date knowledge and best practices tailored to the challenges faced by ASEAN countries. Meanwhile, experts from ASEAN Centre for Energy (ACE) put forward suggestions and provide assistance at the preparation stage through extensive contact with NRIRE. Training materials of the lectures were well prepared, checked, translated and compiled.
Key topics included:
•Solar Powered Irrigation System- A Clean-energy, Low-emission Solution for Irrigation Development and Modernization (by NRIRE)
• Photovoltaic Generation Technology and Application (by Carbon Free Tech Pte.Ltd)
• Photovoltaic Water-lifting Sprinkler Irrigation Technology and System Design Method (by Institute of Water Conservancy Science in Pastoral Areas)
• Application and Popularization of Photovoltaic Pumping Irrigation System in Laos (by Kunming Engineering Corporation Limited, Power China)
• Renewable Energy Development in China (by NRIRE)
• Household Solar Technical Application (by NRIRE)
Concurrently, participant recruitment was conducted in close partnership with the Ministry of Water Resources of China and the ASEAN Centre for Energy (ACE). As a result, around 50 representatives from Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Thailand, and Vietnam attended the seminar. The participants included technical officers,

policymakers, and practitioners from the water and energy sectors, ensuring a diverse and engaged audience capable of translating the seminar's insights into actionable solutions for their respective countries. The event facilitated cross-border collaboration, with participants engaging in hands-on demonstrations, group discussions, and site visits to operational solar irrigation projects in Indonesia.

In addition, extensive preparatory work was carried out to ensure the smooth running of the seminar. Key activities included:

Organizational Framework: A dedicated working team was established to oversee seminar logistics, with clear roles assigned for coordination, reporting, and liaison with relevant authorities. Progress updates were regularly submitted to the Ministry of Water Resources and ASEAN partners.

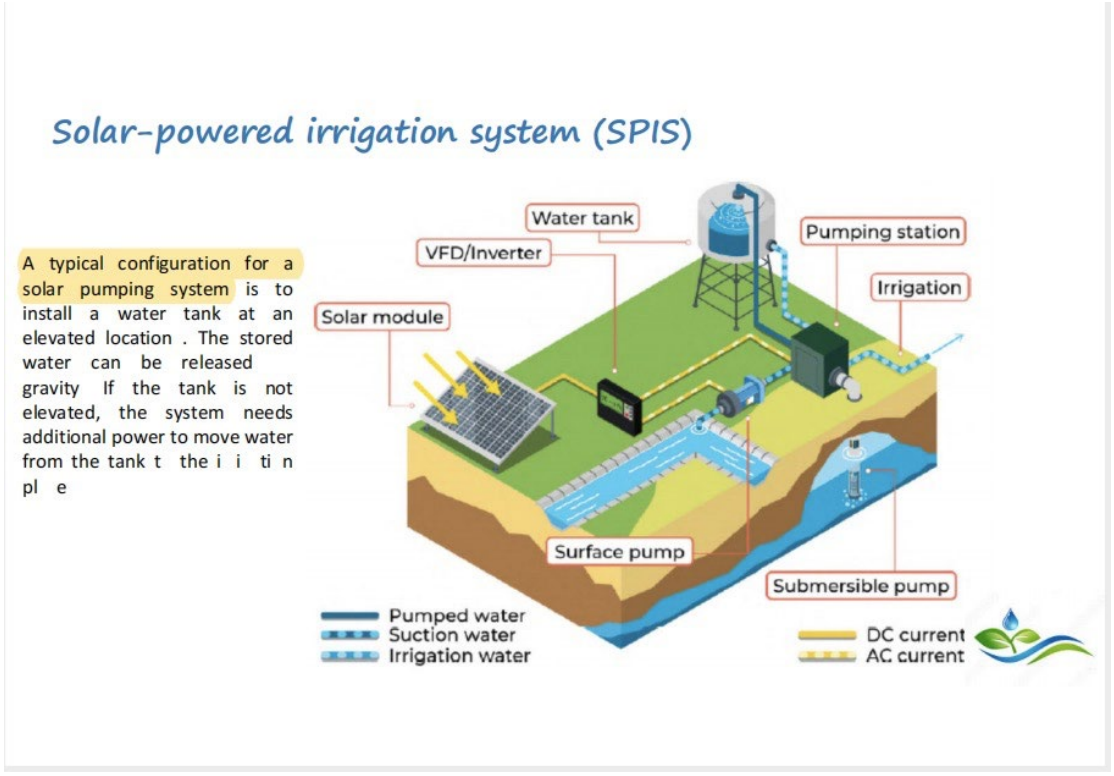
Venue and Accommodation: A hotel with conference facilities was selected as the seminar venue, offering proximity to solar power demonstration sites for field visits. Accommodation, meals, and meeting rooms were booked to accommodate all attendees.

Event Infrastructure: Necessary facilities such as audiovisual equipment, printed seminar materials (agendas, technical manuals, and presentation slides), and venue decorations were arranged to enhance participant engagement.

Transportation Services: Airport transfers, daily shuttles, and site-visit transportation were organized, including dedicated vehicles for punctual movement between locations.

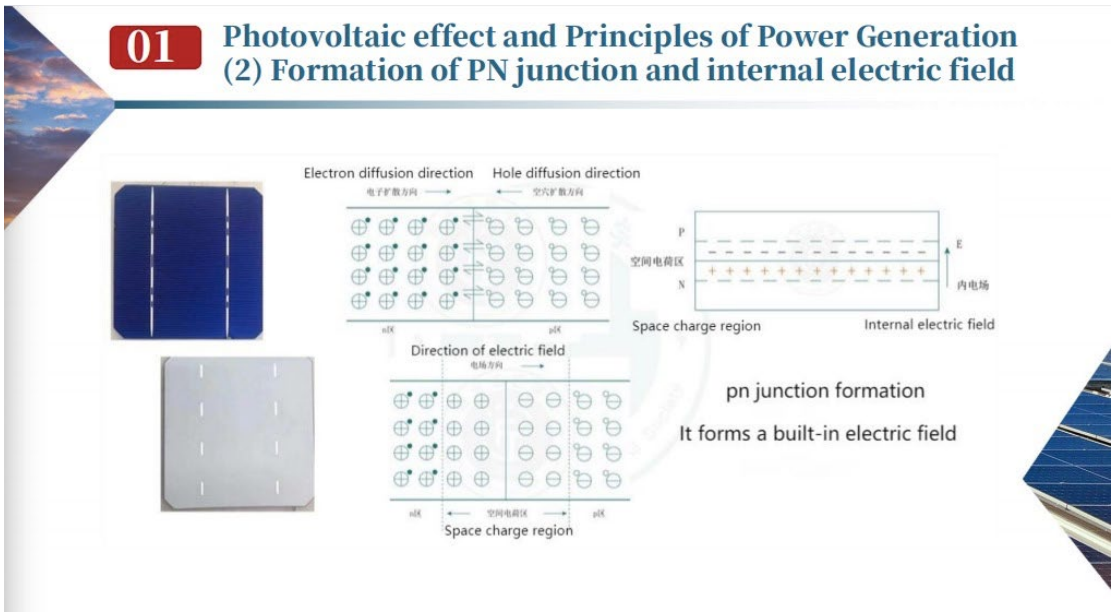
Content Preparation: Speeches and technical presentations were drafted in advance, with translation services arranged to ensure clarity and accessibility.

Excerpts from Training Materials

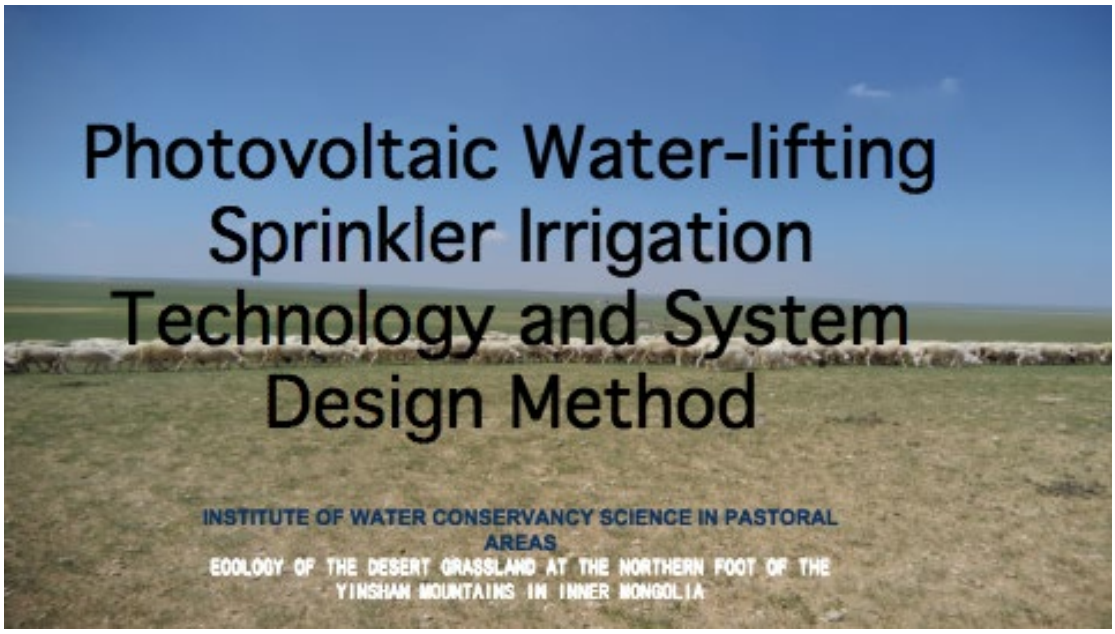


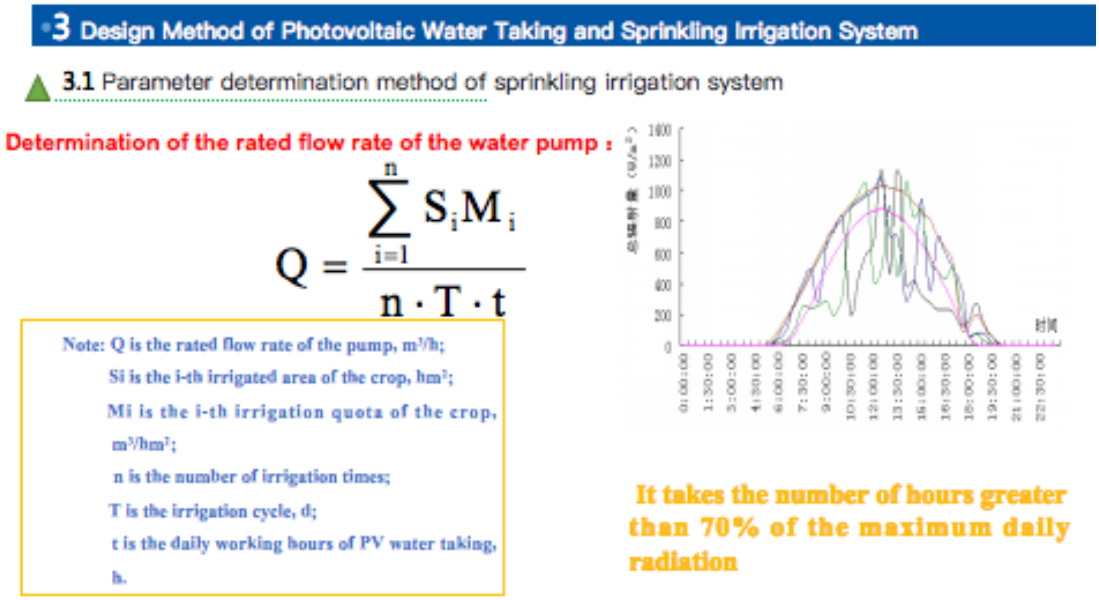
Solar Pumping System Technology Application and Development-The presentation provides a comprehensive overview of Solar-Powered Irrigation Systems (SPIS), highlighting its role as a sustainable solution to address food crises and support farmers in remote and upland areas. Traditional irrigation systems, such as diesel-powered and grid-powered pumps, face challenges like high operational costs, environmental impact, and limited accessibility in remote regions. SPIS offers an environmentally friendly alternative, leveraging solar energy to power water pumps with minimal operational and maintenance costs, a lifespan of at least 25 years, and increased crop production, particularly in areas with limited rainfall or challenging

terrain. The system consists of key components such as solar panels, inverters, water tanks, and pumps, and can be configured to work with elevated tanks for gravity-fed irrigation or additional power for non-elevated setups. SPIS is economically viable due to declining costs of photovoltaic (PV) panels and improved technology, making it more affordable and efficient compared to diesel pumps. Case studies from the Philippines demonstrate SPIS's practical benefits, including increased crop yields, expanded agricultural land, and improved livelihoods for farmers. Additionally, SPIS can integrate with traditional irrigation infrastructure, such as dams and canals, to enhance water distribution and reduce greenhouse gas emissions. The presentation concludes that SPIS has significant potential for future adoption, driven by abundant global solar resources, technological advancements, and its contribution to food security and sustainable agriculture.



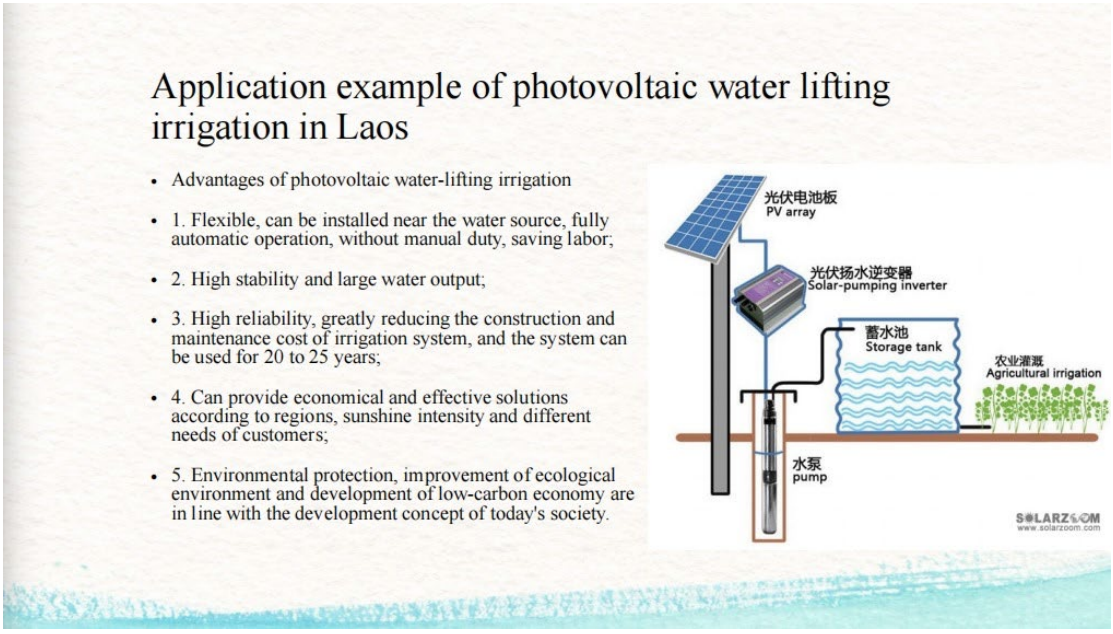
Photovoltaic Generation Technology and Application-The presentation provides an overview of photovoltaic (PV) power generation technology and its diverse applications. It begins by explaining the fundamental principles of PV technology, including the photovoltaic effect, the formation of PN junctions, and the conversion of sunlight into electricity through solar cells. The presentation then explores various applications of PV systems, such as ground-based and water surface photovoltaic power stations, industrial and commercial rooftop installations, household solar systems, and innovative uses like photovoltaic air conditioning, hydrogen production, and off-grid solutions for remote locations. Specific case studies highlight the benefits of PV technology, such as reduced energy costs, environmental sustainability, and enhanced energy independence. The presentation concludes by emphasizing the broad potential of PV technology across different sectors and its role in addressing energy challenges through renewable solutions.





Photovoltaic Water-lifting Sprinkler Irrigation Technology and System Design Method - This presentation provides a comprehensive overview of photovoltaic (PV) water-pumping irrigation technology and system design methods, focusing on addressing water supply challenges in remote and pastoral areas. It begins by highlighting the difficulties in accessing drinking water in these regions and introduces wind and solar energy as viable solutions. The presentation details the principles of PV technology, including the photovoltaic effect and the conversion of solar energy into electricity. It then explores various applications of PV systems in irrigation, such as ground-based and water surface photovoltaic power stations, industrial and commercial rooftop installations, and innovative uses like photovoltaic air conditioning and hydrogen production. Specific technical routes and system integrations are discussed,

emphasizing the importance of optimal design, resource assessment, and decision analysis. Case studies demonstrate the practical benefits of PV water-pumping systems, including reduced operational costs, environmental sustainability, and enhanced water supply reliability. The presentation also covers the design methods for PV water-pumping and sprinkler irrigation systems, including parameter determination, PV array design, and efficiency analysis. Finally, it showcases several demonstration projects and their significant environmental and economic benefits, underscoring the potential of PV technology in promoting sustainable water management and agricultural productivity in arid and pastoral areas.



Application and Popularization of Photovoltaic Pumping Irrigation System in Laos-The presentation outlines the application and promotion of photovoltaic (PV) pumping irrigation systems in Laos, emphasizing their significance in addressing agricultural irrigation challenges. It starts by discussing the various forms of natural energy, highlighting solar energy as a clean and abundant resource. Despite its advantages like wide distribution and environmental friendliness, solar energy faces challenges such as dispersion and instability. The presentation then explores different utilization scenarios of solar energy, including PV power stations, PV buildings, PV agriculture, and PV transportation. Focusing on Laos, it details the country's

abundant solar resources and the current state of agricultural irrigation, which is hampered by outdated facilities and inefficient practices. The advantages of PV pumping irrigation systems are highlighted, such as flexibility, high stability, cost-effectiveness, and environmental benefits. Several implemented projects in Laos are showcased, demonstrating the practical application and effectiveness of these systems. Finally, the presentation looks ahead to the future development prospects of PV pumping irrigation in Laos, suggesting that with proper funding and international support, these systems could significantly improve irrigation conditions and reduce the burden on farmers, promoting sustainable agricultural development.

China Renewable Energy Development

National Research Institute for Rural Electrification, MWR, P.R.China

Hangzhou Regional Center (Asia-Pacific) for Small Hydro Power

27th August, 2024

5.2 Wind Power and Solar Power

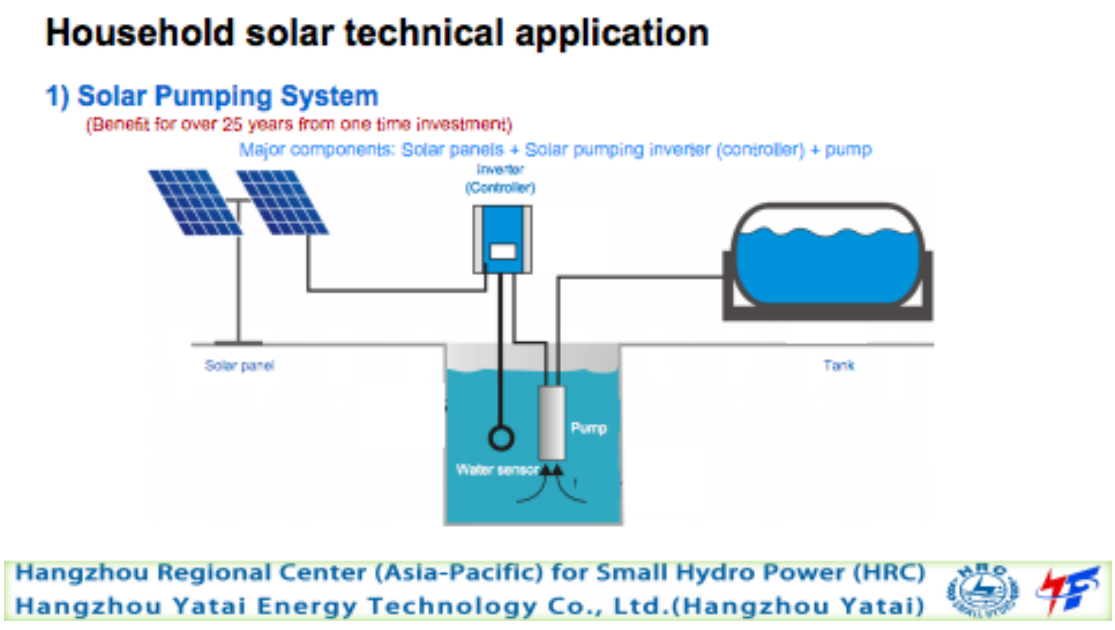
Solar power

- The conversion efficiency of the battery continues improved, with the mass-produced P-type PERC monocrystalline battery achieving an efficiency of 23.4%, representing a 0.2 percentage point increase from 2022; while the N-type TOPCon battery achieves an efficiency of 25.0%, showing a growth of 0.5 percentage points.
- The energy consumption of polysilicon production continues to decrease, with a reduction of approximately 9%. Furthermore, there is a further decrease in the thickness of silicon wafer slices. Additionally, there is an ongoing increase in component power.
- Advancements in thin-film battery technology upgrades continue to progress.

2016-2023 evolving trend of conversion efficiency in crystalline silicon cells in China

China Renewable Energy Development -The presentation provides an overview of the development of renewable energy in China and globally, highlighting the significance of renewable energy in addressing climate change and the increasing investment in the sector. It details China's substantial progress in renewable energy, with installed capacity exceeding 1.5 billion kW and significant growth in solar and wind power. The presentation also explores various renewable resources such as hydro, wind, solar, geothermal, and biomass energy, discussing their reserves and utilization in China. Furthermore, it examines the existing

development situation, including the rapid growth of conventional hydropower, pumped storage, wind, and solar power, as well as the steady development of other energy types like biomass and geothermal energy. The utilization of these resources is also discussed, with a focus on the generation and consumption of different energy sources. In terms of technological development, the presentation highlights advancements in conventional hydropower, pumped storage, wind power, and solar power technologies. International cooperation is emphasized, showcasing China's involvement in global energy governance and international production capacity cooperation in the renewable energy sector. Finally, the presentation outlines the development outlook for renewable energy in China, suggesting a continued push for energy independence, enhanced systemic support for renewable energy consumption, and the promotion of technological progress and policy improvements to support the large-scale development of renewable energy.



Household Solar Technical Application-This presentation provides a comprehensive overview of household solar technical applications, highlighting their benefits and diverse uses. It begins by introducing the workflow of understanding customer demands, designing customized solar solutions, and providing complete equipment supply and after-sales maintenance. The presentation details various solar systems, including solar pumping systems,

which offer long-term benefits with minimal investment, and household solar generating systems, which have a short payback period and contribute to energy savings. It also explores hybrid generating systems that combine solar power with other energy sources for stable power supply, solar air conditioners that utilize direct current from solar panels, and off-grid solar monitoring systems suitable for remote areas. The advantages of solar power, such as being green, free, and inexhaustible, are emphasized throughout. Project cases from different countries demonstrate the practical application and effectiveness of these systems. Additionally, the presentation touches on the development of new solar-powered products like sewage treatment systems, showcasing the continuous innovation and expansion of solar technology applications.

Participants' Information

Seminar on Development and Application of Solar Pumping Irrigation Technology for the ASEAN Countries

No	Full Name	Name of Organization/Company	Position/Job Title
1.	Andriah Feby Misna	Ministry of Energy and Mineral Resources of Indonesia	Director of Various New and Renewable Energy, Directorate General of New, Renewable Energy,and Energy Conservation
2.	Zawani binti Zainuddin	Ministry of Energy Transition and Water Transformation Malaysia	Assistant Secretary
3.	Dimas Kaharudin Indra Rupawan	PT Pembangkitan Jawa Bali Masdar Solar Energy (PMSE)	President Director
4.	Boualom Saysanavong	Department of Energy Efficiency and Promotion, Ministry of Energy and Mines	Director of Division
5.	Lane Phung Hui Chiun	Sarawak Energy Berhad	Senior Engineer
6.	Nicanor I. Castro, Jr.	National Power Corporation	Principal Engineer B
7.	Pel Cheapanhasith	Electricite du Cambodge	Deputy Chief of Technical Section

8.	Eunice F.Bernabe	National Transmission Corporation	Corporate Staff Specialist A
9.	Ye Myat Aung	Ministry of Electric Power Myanmar	Staff Officer
10.	Phoumsavath Souvannalath	Electricite Du Laos	Electrical Engineer
11.	Hoang Anh Tuan	Vietnam Electricity (EVN)	Specialist
12.	Atiwit Chirasuthtrakul	Electricity Generating Authority of Thailand (EGAT)	Engineer Level 7
13.	Prum Mengly	Electricite du Cambodge	Deputy Chief of Section
14.	Nazrul Very Andhi	PLN Indonesia Power	Senior Manager
15.	Arry Erawan	PLN Indonesia Power	Assistant Manager Information Technology
16.	Rahmat Rizeki	PLN Indonesia Power	Maintenance planner
17.	Ari Bimo Prakoso	Yayasan Energi Bersih Indonesia	Executive Director
18.	Shamsir Bin Shamsudin	Ranhill SAJ Sdn Bhd	Head of Department
19.	Tuan Sanusi Asmadi bin Tuan Hamat	Ranhill SAJ Sdn Bhd	Division Head
20.	Beni Suryadi	ASEAN Centre for Energy (ACE)	Deputy Executive Director
21.	Andy Tita	ASEAN Centre for Energy (ACE)	Head of Corporate Affairs
22.	Deva Wijaya	Ministry of Energy and Mineral Resources of Indonesia	

23.	Praptono Adhi Sulistomo	Ministry of Energy and Mineral Resources of Indonesia	
24.	RA Ayuthia Herdiani	Ministry of Energy and Mineral Resources of Indonesia	
25.	Ratna Ayu Kusumaningtyas	Ministry of Energy and Mineral Resources of Indonesia	
26.	Aung Zaw Hein	Ministry of Electric Power Myanmar	Assistant Director
27.	Narathip Rujanapun	Ministry of Energy	Engineer
28.	Tanai Potisat	Koh Jik ReCharge Project	Founder
29.	Mohd Farhan bin Mohd Mukelas	Ranhill AJ Sdn Bhd	Senior Executive
30.	Muhd Faizul bin Ismail	Ranhill SAJ Sdn Bhd	
31.	KR Raghunath	PT KIS Green Technology Projects	CEO
32.	Yasmine Surachman Umar	PT KIS Green Technology Projects	Komisaris KIS Green Technology Projects
33.	Dilla Octavia	PT KIS Green Technology Projects	Executive Assistant to CEO
34.	Maya Lynn	Generasi Energi Bersih	National Chairperson
35.	Yudha Permana Jayadikarta	Masyarakat Energi Terbarukan Indonesia	Executive Director
36.	Erwin Dharmawan Sutalilima	Medco E&P Indonesia	Energy Optimization &GHG Reduction Specialist
37.	Ferdinan Simanullang	PT PLN	Manager

38.	Danny Raharto	Total Energies	Sr Business Development Manager
39.	Dinita Setyawati	Ember Climate	Senior electricity policy analyst
40.	Mahammad Khadafi	Ministry of Industry of Indonesia	Policy Analyst
41.	Yayan Suryana	Ministry of National Development Planning of indonesia	Tenaga Ahli
42.	Syed jarrar pirzada	Ministry of Energy and Mineral Resources of Indonesia (KESDM)	Sub-coordinator
43.	Raditya Pramudiantoro	PT Sarihusada Generasi Mahardika	Climate and Conservation Senior Manager
44.	Dynta Trishana Munardy	ASEAN Centre for Energy (ACE)	Senior Officer of APAEC
45.	Monika Merdekawati	ASEAN Centre for Energy (ACE)	Senior Research Analyst
46.	Zahrah Zafira	ASEAN Centre for Energy(ACE)	Associate Research Analyst
47.	Veronica Ayu Pangestika	ASEAN Centre for Energy (ACE)	Associate Research Analyst
48.	Cut Sarah Mutia	ASEAN Centre for Energy (ACE)	Finance Officer
49.	Amara Zahra Djamil	ASEAN Centre for Energy (ACE)	Junior Associate Officer or Communications
50.	Bayu P.Effendy	ASEAN Centre for Energy (ACE)	Graphic Designer Intern
51.	Irfan Nasrullah	ASEAN Centre for Energy (ACE)	ICT Officer
52.	Rizki Awanta Jordhie	ASEAN Centre for Energy(ACE)	ICT Intern
53.	Qirana Ashilah	ASEAN Centre for Energy(ACE)	Research Assistant

54.	Genta Harrison S.	ASEAN Centre for Energy(ACE)	Research Assistant

Activity – 2：Implementation of the Seminar
Time: August 27th-29th, 2024
Location: Hangzhou, China
Participants: NRIRE
Implementation: From August 27 to 29, 2024, the *Seminar on Development and Application of Solar Pumping Irrigation Technology for the ASEAN Countries* was successfully organized by the National Research Institute for Rural Electrification (NRIRE), China, under the sponsorship of the Perez-Guerrero Trust Fund (PGTF) for South-South Cooperation. The event brought together about 50 participants from Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Thailand, and Vietnam. The seminar aimed to strengthen regional collaboration and share China's expertise in solar pumping irrigation technology, aligning with ASEAN's needs for sustainable agricultural development and energy transition.

The three-day program included technical sessions, case studies, and field visits, with a focus on solar pumping irrigation systems and their integration into ASEAN's renewable energy landscape. The seminar was kicked off by opening remarks from several notable speakers. Mr Wang Daohao, Economic and Commercial Counsellor, Chinese Mission to ASEAN, underscored the pragmatic cooperation between China and ASEAN in advancing energy transition. Mr Dong Dafu, Deputy Director General of Hangzhou Regional Center (Asia-Pacific) for Small Hydro Power (HRC), highlighted how HRC has played a role in energy transition in the ASEAN region, especially through cooperation of policies and more. On the other hand, Dr Zawani binti Zainuddin, Assistant Secretary at the Ministry of Energy Transition and Water Transformation (PETRA), Malaysia, delivered her opening remarks and underlined the importance of collaboration among all stakeholders. Hence, she sees this seminar as a good opportunity to share and exchange ideas. Mr Alhaqqurahman Isa, Deputy Director of Business Services and Supervision of Various New and Renewable Energy, Directorate General of Renewable Energy and Conservation at the Ministry of Energy and Mineral Resources (MEMR), Indonesia, also delivered a welcoming speech and noted important to maintain and strengthen collaborations among AMS to accelerate deployment of RE and energy transition. Lastly, Mr Beni Suryadi, Deputy Executive Director of ACE, delivered his opening remarks virtually. He underlined the role of RE in providing the community with a clean alternative that is crucial to face climate change. He noted this seminar as a great opportunity to explore renewable energy in a more in-depth way by fostering knowledge exchange and collaborations between stakeholders.

Technical sessions delved into innovative solar and other renewable energy applications, with case studies presented by Chinese experts. A dedicated round-table discussion allowed ASEAN representatives to outline national progress and challenges in adopting solar pumping technologies, fostering cross-regional knowledge exchange.

A highlight of the seminar was the site visit to the Cirata Floating Solar Farm in West Java, Indonesia. While Cirata primarily showcases floating solar technology, the visit underscored synergies between solar energy and water management. Participants explored how similar models could be adapted for solar pumping irrigation, particularly in water-scarce regions. The tour sparked discussions on integrating floating solar infrastructure with irrigation systems to optimize energy and water resources.

The seminar concluded with closing remarks from Mr. Beni Suryadi (ASEAN Centre for

Energy), who stressed the importance of continued collaboration to scale up solar pumping solutions. Feedback from participants indicated strong interest in piloting China ' s demonstrated technologies, particularly in countries like Vietnam and the Philippines, where diesel-dependent irrigation remains prevalent.

This event successfully bridged theoretical knowledge with practical insights, advancing ASEAN's capacity in solar pumping irrigation while reinforcing South-South cooperation. The outcomes align with the project's goal of promoting sustainable agriculture and energy transition across the region.

Photos of Main Activities

Opening Ceremony

Technical Presentations

Technical Presentations

On-site visit

On-site visit

Technical and Cooperative Discussions

V. Follow-up Work at the Third Stage

1. During the seminar, a conference was organized to facilitate regional collaboration among ASEAN countries. Representatives from participating countries shared insights on the current status of solar energy development, policy frameworks, challenges, and opportunities for cooperation. The discussion focused on the potential for regional technical cooperation and the implementation of pilot demonstration projects on solar pumping irrigation technology. The aim was to enhance knowledge exchange and improve the efficiency of renewable energy development, particularly in the areas of solar energy operation, maintenance, and application, thereby contributing to socio-economic development in the participating countries.
2. On September 4th, a delegation from Indonesia visited the National Research Institute for Rural Electrification (NRIRE) to discuss specific cooperation areas in the field of renewable energy. The discussions focused on hybrid energy applications, solar pumping irrigation, small hydropower development, and joint capacity-building programs. Both parties expressed their willingness to continue engaging in more in-depth and practical cooperation in the renewable energy sector. They also emphasized the importance of further deepening exchanges and collaboration in areas such as water conservancy project construction and operation management. The visit fostered a spirit of partnership and laid the groundwork for future collaborative initiatives aimed at advancing renewable energy solutions and sustainable water management practices in the region.
3. By virtue of sound relationship between China and ASEAN countries and with the backing of incentive policies of all countries in the field of solar power, NRIRE shall make efforts together with relevant authorities of ASEAN countries to get the financial support from respective government and international organizations which shall be the powerful guarantee for substantive cooperation in the future.
4. NRIRE actively seeks opportunities to launch the bilateral and multilateral projects to improve the capacity building, popularize the know-how in the field of solar pumping irrigation technology development for ASEAN countries, and promote the efficient and sustainable development of solar power for these countries, so as to promote the social-economic development in participating countries.

VI. Financial Costs and Expenses

The project costing for those activities is strictly based on the budget. NRIRE organized financial staffs specifically to evaluate and review the expenses of the project. Project leaders are also responsible for monitoring of the cost for each activity and required for submission of periodical report to the General Director of NRIRE for supervising the project better at its each stage.

No.	Items	PGTF Fund	NRIRE Fund	Total
1	Seminar materials	850 USD	1,040 USD	1,890 USD
2	Transportation costs for participants	6,500USD	7,910USD	14,410 USD
3	Boarding and lodging	14,000USD	18,460 USD	32,460 USD
4	Allowances for Chinese consultants	1,900 USD	2,300 USD	4,200 USD
5	Allowances for international consultants	900 USD	1,500 USD	2,400 USD
6	Local insurance and first-aid medical care for participants	750 USD	870USD	1,620 USD
7	Rental of seminar venue and other facilities	1,600 USD	1,900 USD	3,500 USD
8	Local transportation	4,500 USD	4,920 USD	9,420 USD
	Grand Total	31,000 USD	38,900 USD	69,900 USD
	Unpaid PGTF fund			3,069.31 USD

Bank Information:

Organization: 水利部农村电气化研究所

Bank Account: 1202026209008801954

Bank Name: 工行杭州高新支行

VII. Conclusion

The successful implementation of the "Development and Application of Solar Pumping Irrigation Technology for the ASEAN Countries" project underscores the transformative potential of renewable energy solutions in addressing critical challenges faced by ASEAN nations, particularly in agriculture, water resource management and energy sustainability. Through comprehensive feasibility studies, demonstration project design and capacity-building initiatives, the project has laid a solid foundation for scaling solar pumping irrigation technology across the region. The technical training and knowledge-sharing activities not only enhanced the expertise of local professionals but also fostered regional collaboration and South-South cooperation, creating a robust platform for joint efforts to tackle shared agricultural and environmental challenges. The project's outcomes align perfectly with the global pursuit of

Sustainable Development Goals (SDGs). Furthermore, the project has demonstrated the practical benefits of solar-powered irrigation systems, offering a replicable model for other regions facing similar challenges. Looking ahead, the continued collaboration between China and ASEAN countries, supported by robust policy frameworks and financial mechanisms, will pave the way for broader adoption of solar pumping technologies, ensuring sustainable agricultural development and enhanced livelihoods across the region.