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

(G77 Project)

Final Report

on

Seminar on Small Hydropower Operation and Maintenance for Asian Countries

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

JANUARY 2020, HANGZHOU, CHINA

G77 PGTF Project Final Report

Introduction

The Group of 77 approved the project entitled "Seminar on Small Hydropower Operation and Maintenance for Asian Countries" with the funding source from the Perez-Guerrero Trust Fund (PGTF)-Reference Number INT/18/K07 at the 41st 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 January 2019, and completed in December 2019.

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

I. Project Overview

1. **Project Title**: Seminar on Small Hydropower Operation and Maintenance for Asian Countries

2. **Abstract**: With the rapid development of economy in Asian countries, water resources of numerous rivers are going to be tapped and the significant role of small hydropower is getting more important in promoting the socioeconomic development of this area. However, there is lack of competent expertise which involves not only the know-how of small hydropower operation such as operating principal of power station, hydraulic engineering, hydraulic machine, electrical engineering, automation, power generation, etc., but also the understanding of professional skill such as hydropower operation, safety operation, equipment maintenance, innovation and other related knowledge, which lead to management deficiencies existing in small hydropower operation. The seminar aims to improve the concept awareness and capacity building regarding the operation and management of small hydropower in Asian Region.

3. **Background Analysis**: Energy is an essential stimulator in the socio-economic development of a country and now the world is drawing more and more attention on the sustainable development and utilization of renewable energy resources. Among these renewable energy resources, small hydropower is considered as one of the most cost-effective, more technically & economically variable and environmentally-sound energies for power generation. SHP-related technologies have been proven for many years. Scientific operation and maintenance are the key means and sustainable way to promote the development of small hydropower, which not only targets to produce the remarkable benefit for investment payback, but also takes full advantage of all the resources to ensure a green and sustainable

development. The seminar on small hydropower operation and maintenance shall not only cover the theoretical knowledge, but also the feasible practice and know-how as well the people's mindset about the sustainable development which integrates green hydropower and environmental protection. Overall, this project is going to attract full consideration to small hydropower itself, and economic and social development etc. as well.

Most of Asian countries are rich in water resources and hydropower potential. With the rapid development of economy in the Asian Countries, abundant water resources are being or going to be tapped and the significant role of small hydropower in promoting the socioeconomic development is widely recognized and getting more and more important. In recent years, the development of small hydropower accelerates in Asia and numbers of new small hydropower plants are put into operation. However, along with the rapid development of small hydropower, a series of problems arise, such as lack of competent expertise, no concept of scientific management, negligence of environmental protection and energy saving, which result in low output, poor efficiency and short life span of hydropower plants. How to develop small hydropower in scientific and rational way emerges as the new challenge in Asia.

The problem is actually a regional issue, since most of the Asian countries mainly rely on natural gas or coal which is not sufficiently available there, and the shortage of electric power there is getting serious day by day in the whole region. It is crucial to adopt rational and effective ways to develop new hydropower plants and especially manage the existing hydropower plants, i.e., improve the operation and maintenance of the built hydropower plants, in order to ensure the stable, reliable and efficient power supply for the local people and industries and achieve a sustainable socio-economic development for most of the developing countries in Asia.

In Asia, the issues of social development, natural resources exploitation and environmental protection are prominent, which have seriously hindered the economic development and social stability. To tackle all these issues, the Asian Countries have shown great concern and sincerity, desiring to cooperate to address these common issues. They have initiated a series of multilateral and bilateral cooperation activities for improving the expertise and public consciousness about the scientific operation and maintenance for small hydropower plants since small hydropower is one of the most favorite renewable energies which provide a key to the aforesaid prominent obstacles. However, the know-how of operation and maintenance for small hydropower is not fundamentally eased yet.

II. Implementation

The project is divided into 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

★Department of Energy Management, Ministry of Energy and Mines, Lao P.D.R

★Institute for Hydropower and Renewable Energy, Ministry of Agriculture and Rural Development, Vietnam

•The first phase of the project involved the selection and compilation of training materials, allocation of lecturers and recruitment of participants from Asian Countries for the Seminar.

•The second phase of the project involved the organization of the Seminar on Small Hydropower Operation and Maintenance for Asian Countries in China.

•The third phase of the project involves substantial cooperation and promotion of potential projects on small hydropower and rural electrification.

2. Benefits:

- An in-depth understanding of energy situation and facing problems of most Asian countries
- Awareness of the importance of developing scientific operation and management systems on small hydropower
- Awareness of the great importance of improving capacity-building in the field of small hydropower operation and maintenance within Asian Countries
- Dissemination and sharing of experience, technology and research findings of China and other Asian countries in relevant areas of small hydropower
- Enhancement of understanding, communication and cooperation among relevant governmental authorities of China and other Asian countries
- Establishment of bilateral as well as multilateral relationships and cooperation among Asian Countries in order to exchange knowledge, transfer technologies and carry out R&D on small hydropower development to tackle the common issues and problems faced by the participating countries through the efforts of the institutions and agencies involved

III. Completed Activities at the First Stage

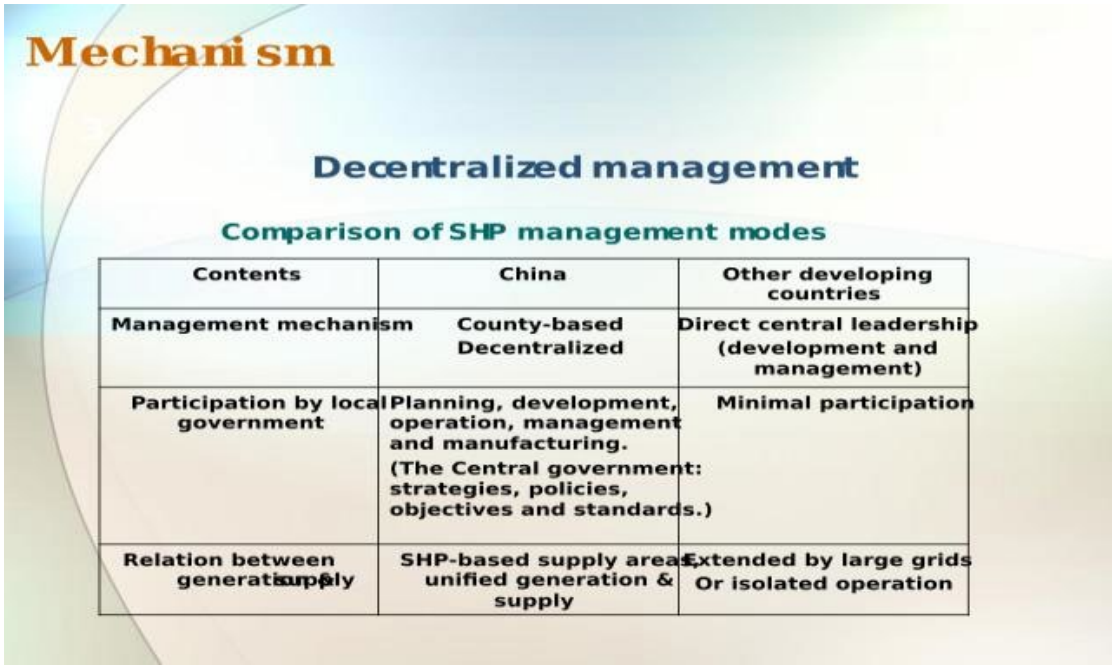
Activity – 1: Selection and compilation of training materials, allocation of lecturers
Time: January – February 2019
Location: China

Participants: NRIRE, Laos Ministry of Energy and Mines, IHR

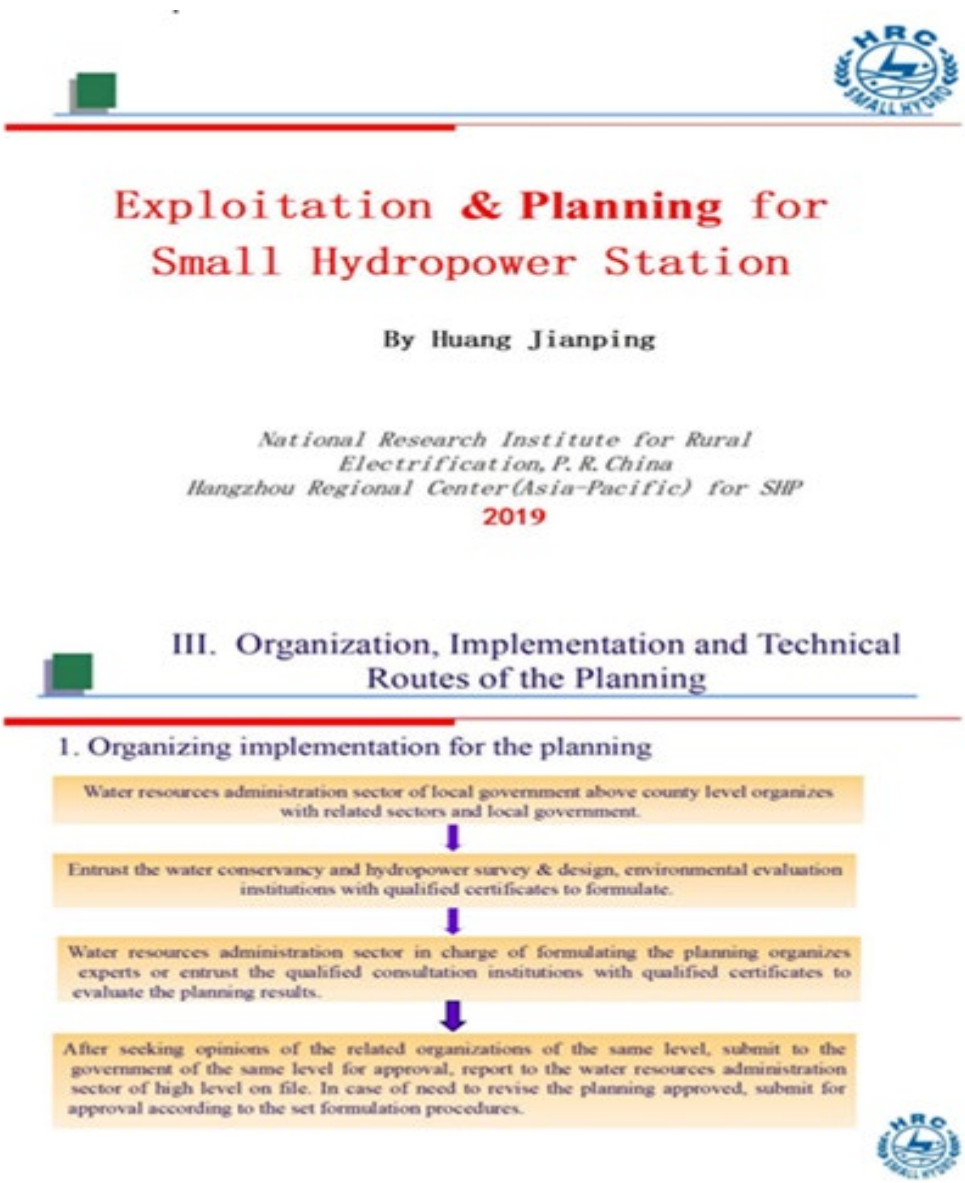
Implementation: Entrusted by Chinese Ministry of Commerce, Ministry of Water Resources, Ministry of Science & Technology, UNDP, UNIDO etc., NRIRE has hosted with success 119 training workshops and seminars for over 3000 participants from 115 countries. Based on the experience in training programs and considering the features of this project, NRIRE appointed four experts who are quite experienced in the field of small hydropower, rural electrification, power management information system, policy research, SCADA system, planning and design, etc. to give the lecture on special topics for the coming Seminar after several discussions. Meanwhile, experts from Ministry of Energy and Mines, Lao P.D.R and IHR 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. The presentations on special topics include,

- A General Survey of SHP&RE in China (by NRIRE)
- Exploitation & Planning for Small Hydropower Station (by NRIRE)
- Green Hydropower and its Evaluation System (by NRIRE)
- Application of SCADA System for Small Hydro Power Station (by NRIRE)

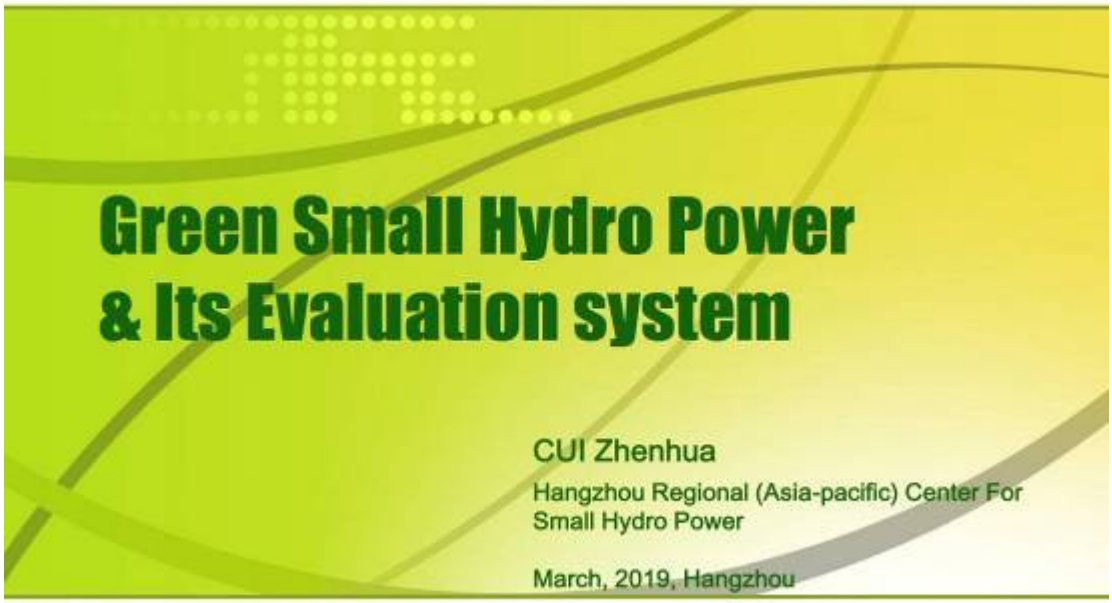
Excerpts of PPT Training Materials



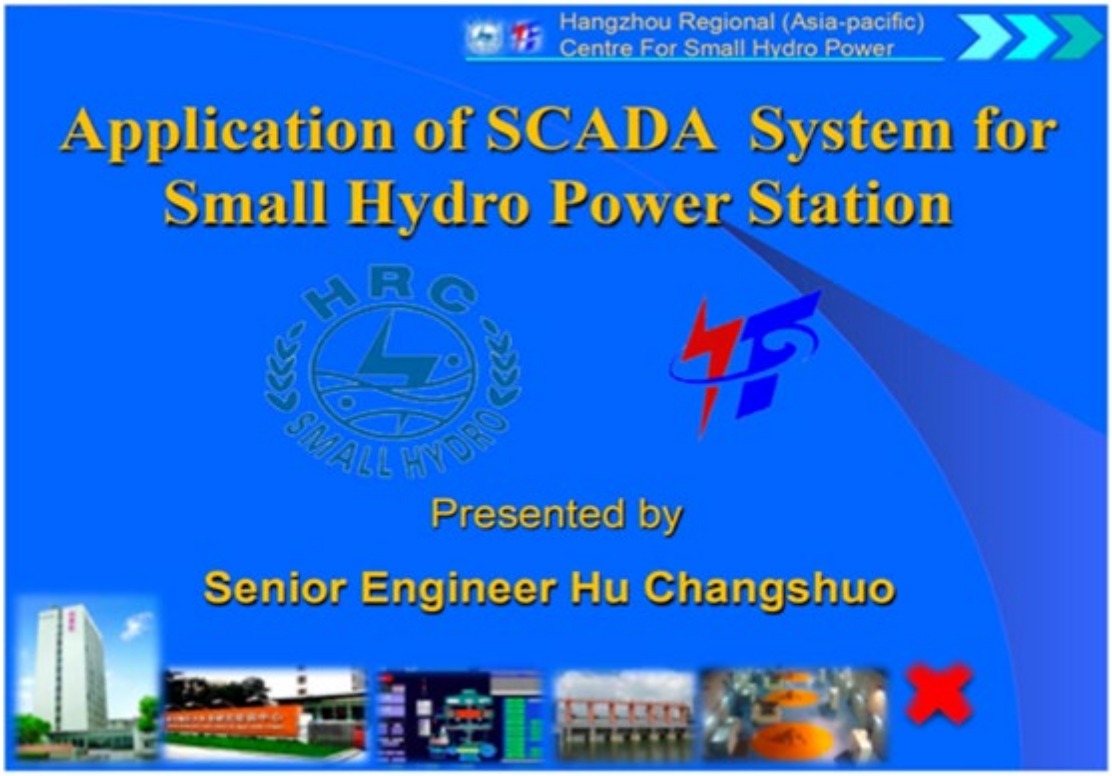
The contents of "A General Survey of Small Hydropower and Rural Electrification in China" include the background of small hydropower, status quo of small hydropower in China, major success of SHP development, SHP mechanism and incentive policies, SHP technical features in China, barriers for SHP sustainable development, outlook for SHP development and so on.

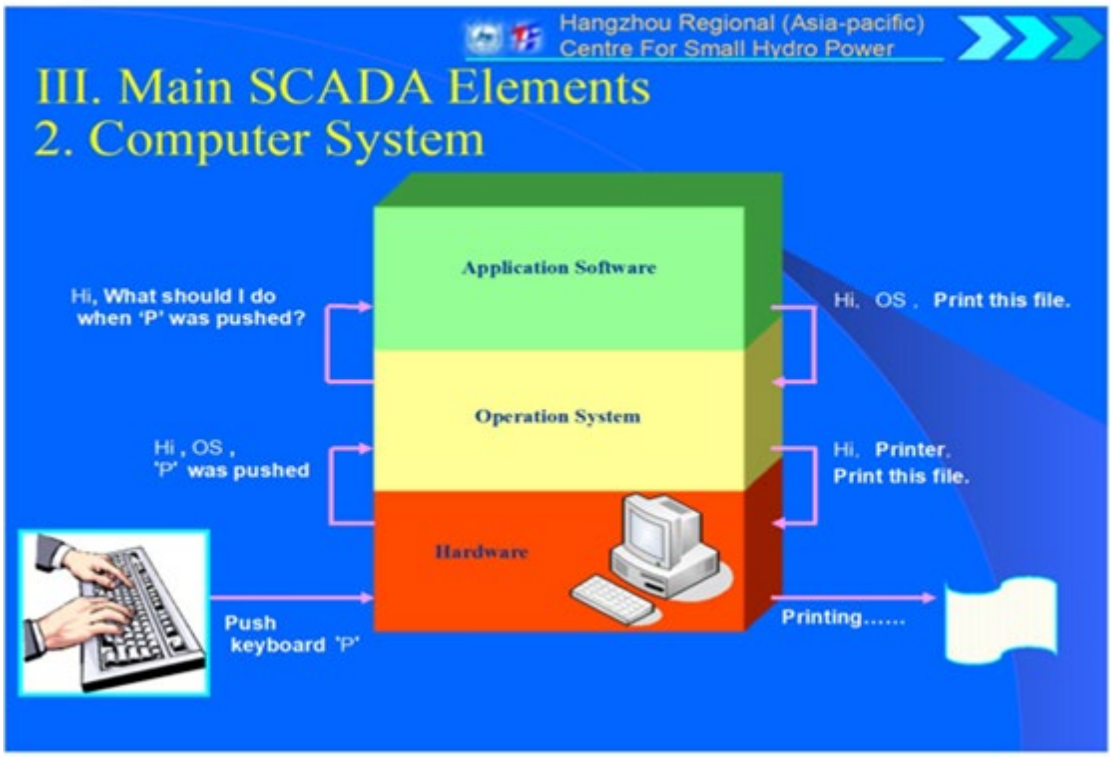


The contents of "Exploitation & Planning for Small Hydropower Station" introduce the exploitation types for SHP and planning for SHP from the aspects of the concept, main contents, organization, implementation and technical routes based on many practical cases.



The contents of "Green Small Hydro Power & Its Evaluation System" covers the background of green small hydropower, environmental and social impacts of small hydropower and the mitigation measures, international practices of green small hydropower, and the comparison of different practices, green small hydropower practice in China, etc.





The contents of "Application of SCADA System for Small Hydro Power Station" include the overview of SCADA system for hydropower plant, equipment under control of the SCADA system, main elements of the SCADA system, communication technology, video surveillance system, centralized control of SHP, etc.

Activity – 2: Recruitment of participants from Asian Countries
Time: February-March 2019
Location: China, Cambodia, Indonesia, Laos, Malaysia, Mongolia, the Philippines, Sri Lanka, Thailand and Vietnam
Participants: NRIRE, Ministry of Water Resource of the People's Republic of China
Implementation: With the great support of Ministry of Water Resource of the People's Republic of China and related institutes and agencies, project information was disseminated to relevant departments of Asian countries. 31 officials from 9 Asian countries are selected to participate in the coming Seminar. After that, NRIRE sent seminar invitation letters to all the selected participants for their visa application or going through the go-abroad formalities to China.

Participants' Information

Seminar on Small Hydropower Operation and Maintenance for Asian Countries

No.	Country	Name	Position	Organization	Tel.	Email
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No.	Country	Name	Position	Organization	Tel.	Email
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IV. Completed Activities at the Second Stage

Activity – 1: Preparations of the Seminar
Time: February-March 2019
Location: China
Participants: NRIRE
Implementation: NRIRE made considerable preparations for the Seminar together, including:

1. Round-trip international air tickets and relevant insurances purchasing for all the participants, lecturers;
2. Establishment of working team for implementing the Seminar and submission of work reports to the related authority on the preparation to launch the project;
3. Selection and determination of the Seminar venue, a hotel to stay, and hydropower projects and laboratory to visit during the Seminar;
4. Arrangement of the necessary meeting facilities, the meals, meeting room decoration, seminar material packages for the participants, gifts, etc.;
5. Arrangement of airport and point-to-point pick-up & see-off services for all the participants, lecturers and the transportation for the site visit;
6. Drafting of the speeches needed during the seminar and translation work for the presentation delivered at the seminar.

Activity – 2： Implementation of the Seminar
Time: March 18th-20th, 2019
Location: Hangzhou, China
Participants: NRIRE
Implementation: From March 18 to March 20, the "Seminar on Small Hydropower Operation and Maintenance for Asian Countries" sponsored by Perez-Guerrero Trust Fund (PGTF) for South-South Cooperation was held by National Research Institute for Rural Electrification (NRIRE), MWR of China (also known as Hangzhou Regional Center (Asia-Pacific) for Small Hydro Power) (HRC) in Hangzhou, China, There were in total 31 participants from 9 Asian countries including Cambodia, Indonesia, Laos, Malaysia, Mongolia, the Philippines, Sri Lanka, Thailand and Vietnam present attending the 3-day seminar. Dr. Xu Jincai, Director General of NRIRE addressed the opening ceremony.

During the seminar, presentations covering the topics on small hydropower operation and maintenance were arranged. Site visits to the world-famous Three Gorges Project, Gezhouba Water Conservancy Project and HRC's Hybrid Power Generation Lab were included in the seminar. Moreover, country reports were presented by participants and in-depth discussion and communication also were made.

Excerpts of Country Reports

VII. Hydropower Development in Cambodia

1. Existing Hydropower

No.	Name of the Project	Install Capa.MW	Company	Country
1	Kirirom 1	12	CETIC	China
2	Kirirom 3	18	CETIC	**China**
3	Kamchay	194.1	Sinohydro	**China**
4	Stung Atay	120	CHD	**China**
5	Lower Stung Russei Chhrum	338	CHDPC	**China**
6	Stung Tatay	246	CTHL	**China**
7	Lower Se San 2*	400	LSS2 Co.,Ltd	**Cambodia/ VN/China**

VII. Hydropower Development in Cambodia

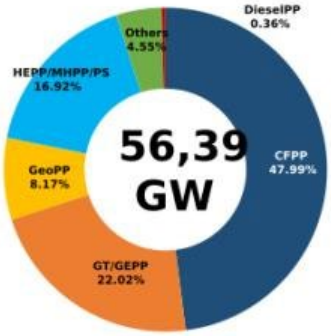
2. Existing Hydropower Under MoU Study

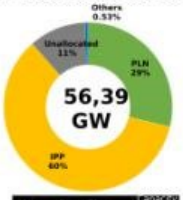
No.	Name of the Project	Install Capa.MW	Company	Country
1	Stung Sala Munthun	70	Power China Ltd	**China**
2	Middle Stung Russie Chhrum	70	CHLSRC	**China**
3	Stung Veal Tmor Kombot	100	CHLSRC	**China**
4	Prek Liang 1/2	70 / 50	Asia Ecopo Nev.Ltd	**China**
5	St. Battambang 2	36	ENEX Joint stock Co.	**Russia**
6	Stung Pursat 1	40	KTC Cable co., Ltd	**Korea**
7	Stung Cheay Areng	108	SCAHP Co.,Ltd	**China**
8	Sambor	2600	China(Cambodia) Rich Investment Co., Ltd	**Cambodia/China**
9	Lower Se San 1/5	96	EVNI	**Viet Nam**

Country Report by Cambodian Delegates

Power Development Plan

Total additional capacity until the year 2028 is about 56,39 GW or 5,6 GW/year





No	PowerPlant	Capacity (MW)
1	CoalFiredPP	27.063
2	GasTurbine/EnginePP	12.416
3	DieselPP	201
4	GeothermalPP	4.607
5	HydroPowerPlant/PSH	8.010
6	SmallHydroPP	1.534
7	Wind/SolarPP	1.763
10	WastePP	259
11	Biomass/BiogasPP	536
12	MarineEnergyPP	7
	Total	56394,2

PowerFacilitiesDevelopmentPlanuntil	
TotalAdditionalCapacity	56,390MW
TotalAdditionalTransmissionLine	57,293kms
TotalAdditionalDistributionLine	472,795kms
TotalAdditionalSubstation	124,341MVA

To attain RE target at 23% in 2025, it will be achieved by adding other RE PP with capacity 14.3 GW.

However, in the plans (RUPTL), the option of Gas PP development is choosen as contigency plan if the RE PP target not achieved

Power Supply Business Plan (RUPTL) by PLN for the period 019-20282

RUPTL issued to serve as a guidance for the development of power infrastructure to meet electricity demand with PLN business areas

RUPTL covers electricity demand load forecasts, generation capacity expansion plans and the development plans related to transmission, substation and distribution

Small Hydropower Operation in Indonesia

SHP in Indonesia is defined as hydropower project upto 10MW, it is similar to international definitio
The potential for small hydropower is more than 2,782MW with about 16% has already operated.

SmallHydropowerDevelopment	
UnderConstruction	375MW
UnderFinalizingProjectFinancing	87MW

Potential Already Studied	202 Existing SHPP, capacity up to 439.8 MW
2,782 MW	

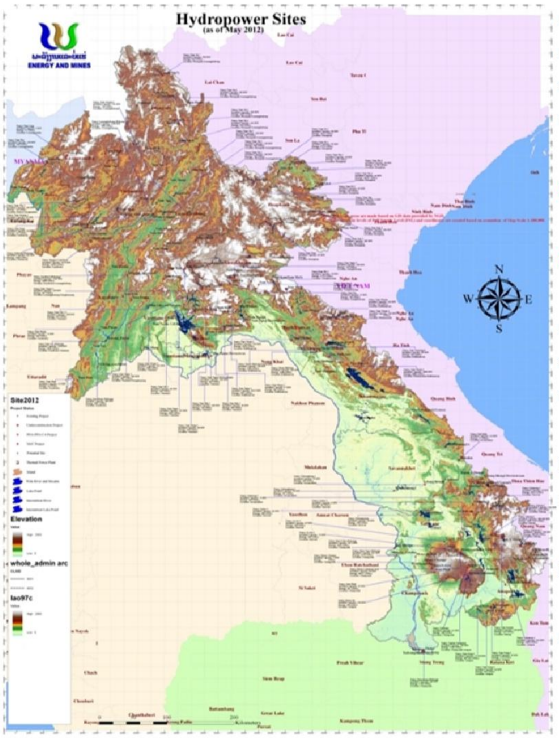
High Idle Capacity
84% of Total Potential SHPP

Some challenges in development new small hydropower in Indonesia are:

1. **Lack of Standardized Technology**:
   Almost every hydropower project is custom engineered, presenting associated high engineering costs because each project is site specific.
1. **Far away from demand**
2. **Low Selling Price**

Country Report by Indonesian Delegates

1. Overview of Lao PDR-Hydropower Development Status



- Land locked country
- Surrounded by the borders of 5 countries
- Population of 6.8 million
- High precipitation in average 1200-3000mm/ann.
- **12 major tributaries to the Mekong river covering 35% of total Mekong river inflow**
- **Abundant hydropower potentials around 30,000 MW**
- **64 Projects in operation: 5,228 MW**
- **56 Projects under construction: 7,100 MW**
- **387 Projects under development and studies : 17,500 MW**
- Highest dam: 210 m (Nam Ngum 3)
- Largest storage capacity: 7 billion cum Nam Ngum 1)
- Largest reservoir area : 450 sq.km(Nam Theun 2)
- Biggest installed capacity: 1285 MW (Xayabury Hydropower Project)

4.3 Status of the Management of Hydropower Development in LaoPDR

- **Management at Central Level: (O:32+C:25+S:95 = 152 Prjs)**

➢ **Large Scale Hydropower Projects have been defined as follows:**

- Electricity law 2018 Installed Capacity > 5 MW (amended)

- **Management at Provincial Level:(O:33+C:31+S:295=356 Prjs)**

➢ **Small scale Hydropower Projects have been defined as follows:**

- Electricity law 2018 Installed Capacity ≤ 5 MW (amended)

- **Management at District level:**

➢ **Micro hydropower Projects have been defined as follows:**

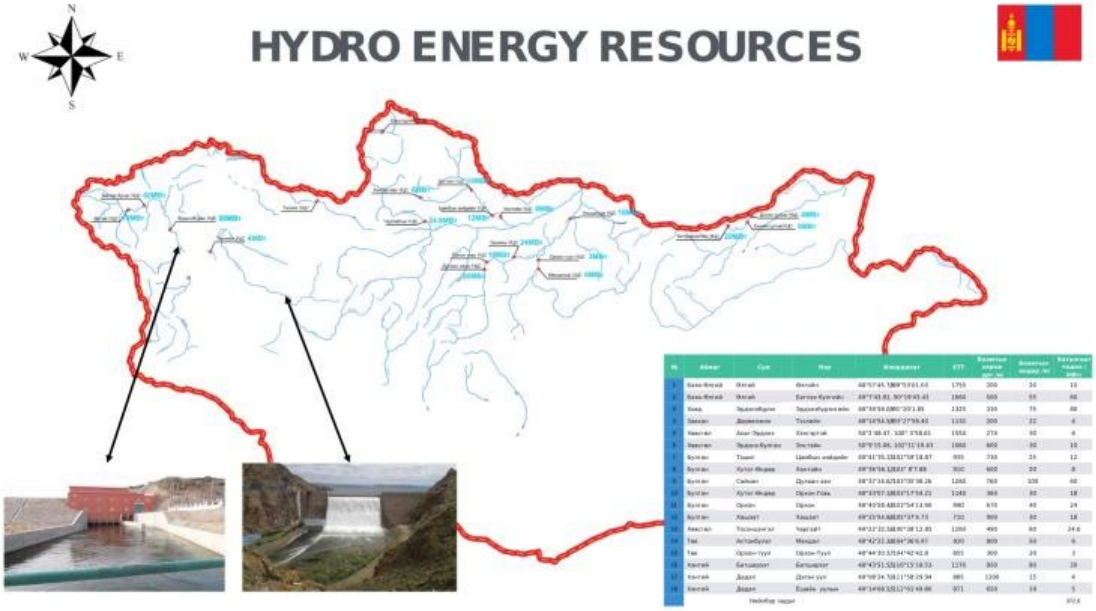
- Installed Capacity of 100 kW according to Electricity law of 1997 as well as it amended versions in 2008,2012 and 2018.

Potential of Hydropower

- Malaysia's hilly topography from south to north, east to west and an abundant number of streams flowing to foothills, Malaysia has considerable small hydropower potential.
- A total of 149 sites for micro hydropower potential have been identified in the country whereas the maximum installed capacity of small hydropower is possible 87.7 MW.
- In separate study, the estimated potential of hydropower resources were registered to be 29,000 MW, whereas for small-hydro it was 500 MW.
- The expected potential of small-hydro by 2020 is 490 MW

Small Hydropower

Country Report by Malaysian Delegates



Country Report by Mongolian Delegates

HYDROPOWER IN THE PHILIPPINES

✓ Hydropower plants are classified based on their capacities:

(i) micro-hydro - 1 to 100 kW

(ii) mini-hydro - 101 kW to 10 MW

(iii) large hydro - more than 10 MW

The total untapped hydropower resource potential of the country is estimated at 13 GW:

85% large and small hydros (11,223 MW)

14% mini-hydros (1,847 MW)

<1% micro-hydros (27 MW)

SOURCE: Department of Energy. www.doe.gov.ph

Energized Hydroelectric Power Plant (Luzon)

Conditions of WRM, hydropower..Cont.

Most small hydro plants disuse as National Grid Expand

Last estate hydro plant supplied by *Gilkes* was imported in 1959

Installed in	*– Udaveria Estate*
Turbine	*– Turgo*
Rated Power	*– 21hp*
Net head	*– 120ft*

** **Revival of small hydropower in the estate again took place around 1980.**

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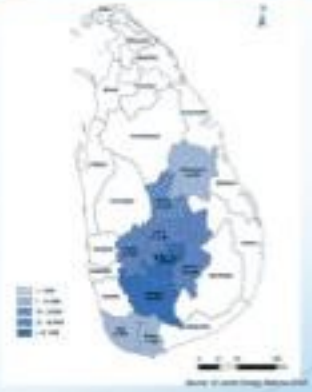
Conditions of WRM, hydropower..Cont.

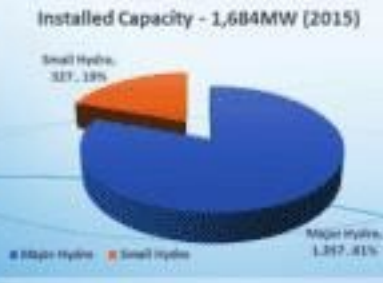
2.3 Conditions of hydropower development

Big/Small Definition

Category	Capacity
Pico	<1kW
Micro	1 kW- 50kW
Mini	50kW – 1MW
Small	1MW – 10MW
Large	> 10MW



Installed Capacity



Major hydro projects underway:
- Uma Oya – 120MW
- Broadlands – 37.5MW

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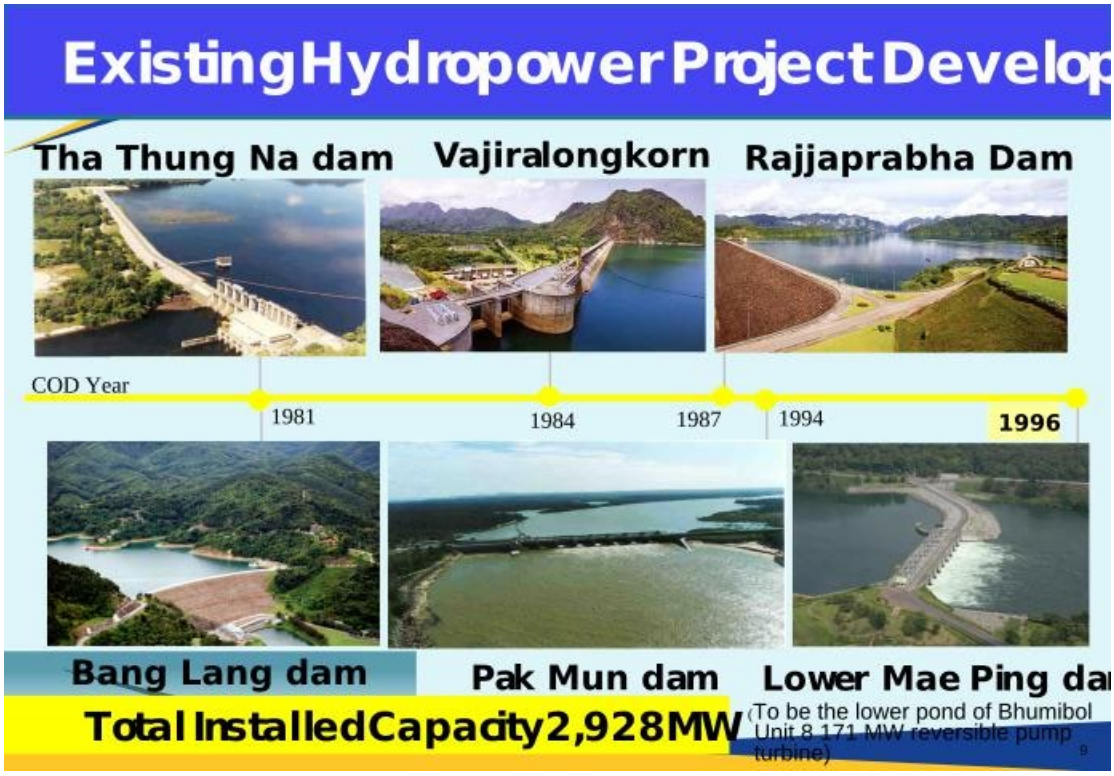
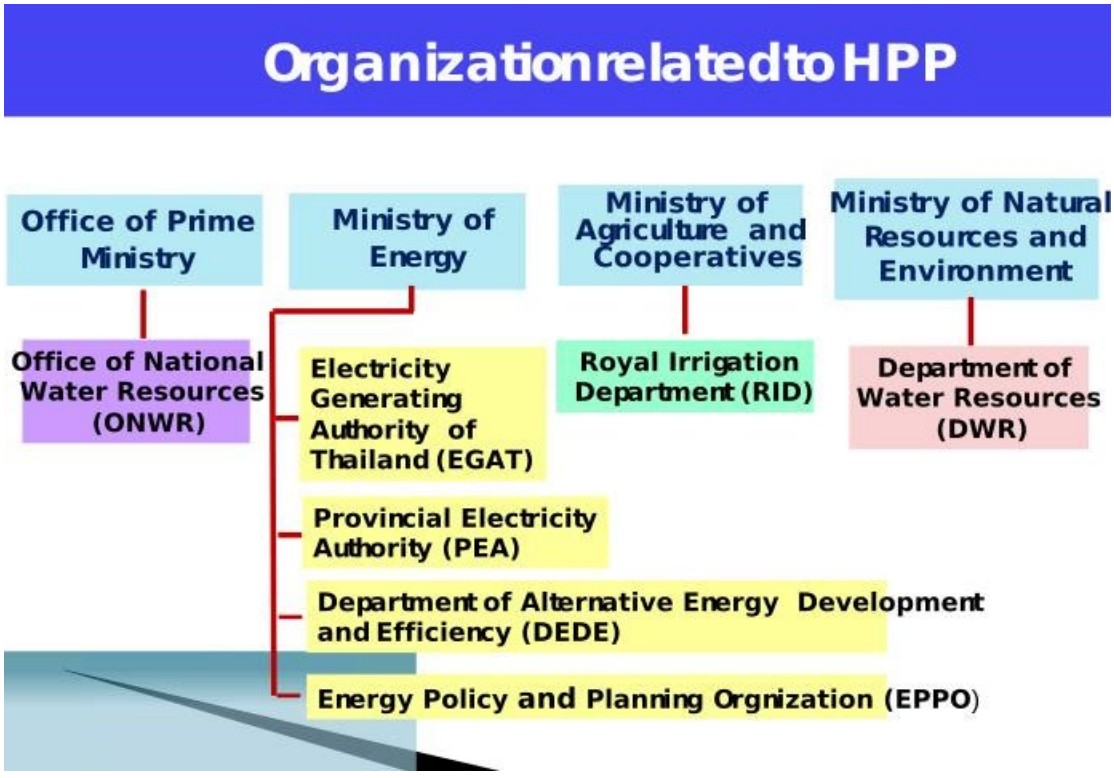
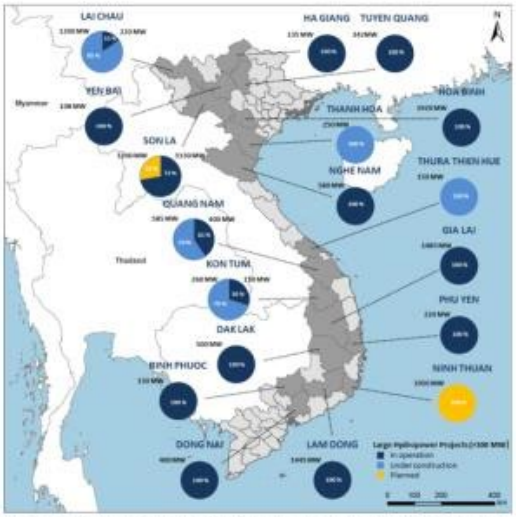
Country Report by Sri Lankan Delegates



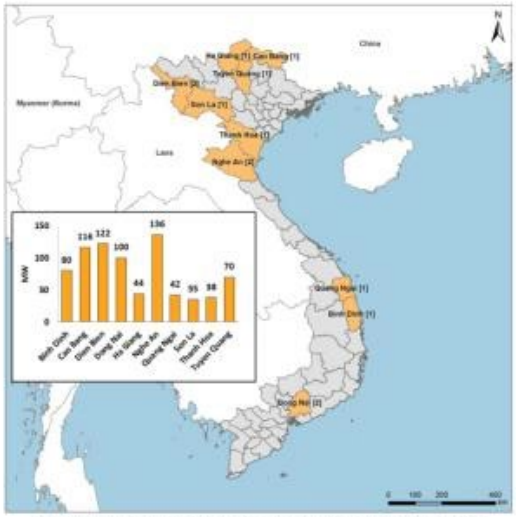


Country Report by Thailand Delegates

IV. Conditions of Hydro power



Current and future situation for LHP (Consultant's processing). Source: MOIT (2014).



MHP preparing for construction status (Consultant's processing). Source: MOIT (2014).

IV. Condition of hydro power

Currently there are more than 120,000 pico and micro hydropower plants installed in off-grid areas in Vietnam. As documented, most of these power projects were funded by the Government or international organizations with the different supporting mechanism. However, only few are currently operating at full capacities mainly because of the technical failures.

Table 10 Scaling Hydropower

Name	Size	Example usage
Pico Hydro	< 5kW	two fluorescent light bulbs & a TV / radio in about 50 off-grid households
Micro Hydro	<100kW	One household (assuming demand growth) or a small community/hamlet.
Mini Hydro	<1000 kW (1MW)	Mini off-grid aim to supply electricity for a group of households, hamlet or village.
Small Hydro	<10MW	Grid connected or mini off-grid supply electricity to village or commune.
Hydropower	>10MW	Grid connected

- ❑ Off-grid power has high potentials but now, conditions of off-grid power system have still limited.
- ❑ Off-grid power system includes: wind, solar and pico, micro & mini hydropower.
  - The pico, micro and mini hydropower has been the most effective technology applied popularly in Vietnam for off-grid areas. The potential stream energy is mainly in the North and Central parts of Vietnam, particularly in Lao Cai, Son La, Thai Nguyen, Nghe An, Thanh Hoa etc.
  - Wind/Solar power can be deployed on islands and suitable areas.

Country Report by Vietnamese Delegates

Photos of Main Activities

Opening Ceremony

Technical Presentations

Technical Presentations

Visit to the Three Gorges Project

Visit to Hybrid Power Generation Lab

Country Reports

	
Technical and Cooperative Discussions	
	
Technical and Cooperative Discussions	

V. Follow-up Work at the Third Stage

1. During the seminar, a conference was held, through which all the participating countries exchanged information on SHP development status, policies and strategies, problems and challenges in SHP development and cooperation opportunities in their countries and conduct in-depth discussions on regional technical cooperation and the possibility of setting up a SHP innovation demonstrative project. It is expected that, based on full communication and exchange of expertise in the field of small hydropower operation, maintenance, etc., efficiency of small hydropower development and technical capability could be improved, so as to promote the social-economic development in participating countries.

2. In September and December, the delegation from the Philippines and Vietnam paid visit to NRIRE respectively, and had in-depth discussion on the potential cooperation in capacity building, R&D, project demonstration, and technical transfer in the field of small hydropower and other renewable energies. They also expressed their willingness to jointly build a demonstration project with NRIRE under the framework of the "Belt and Road" Initiative.

3. By virtue of sound relationship between China and other Asian countries and with the backing of incentive policies of all countries in the field of small hydropower, NRIRE shall make efforts together with relevant authorities of Asian 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 operation and maintenance of small hydropower for Asian countries, and promote the efficient and sustainable development of small hydropower for these 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	1,150 USD	1,330 USD	2,480 USD
2	International travel	13,600 USD	8,650 USD	22,250 USD
3	Boarding and lodging	5,710 USD	20,790 USD	26,500 USD
4	Allowances for Chinese consultants	2,130 USD	1,490 USD	3,620 USD
5	Allowances for international	510 USD	1,110 USD	1,620USD

	consultants			
6	Local insurance	600 USD	630 USD	1,230 USD
7	Rental of seminar venue and other facilities	2,000 USD	2,500 USD	4,500 USD
8	Local transportation	4,300 USD	5,650 USD	9,950 USD
	Grand Total	30,000 USD	42,150 USD	72,150 USD
	Unpaid PGTF fund			3,000 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 project is implemented by National Research Institute for Rural Electrification, Ministry of Water Resources, P.R. China (NRIRE). The rewarding event, designated to provide a platform for China and the other Asian countries to fully discuss and communicate in the field of small hydropower and related technologies in its operation and maintenance, has achieved great success. The officials and experts from different countries shared not only the technology, but also the development methodology and cooperation confidence, which is deemed to make much contribution to economic and technical cooperation on small hydropower among Asian countries. It is expected that the participants, as the direct beneficiaries, can apply the knowledge gained during the seminar and at the same time, transfer the knowledge and technologies to other people in their respective country.