SHP NEWS

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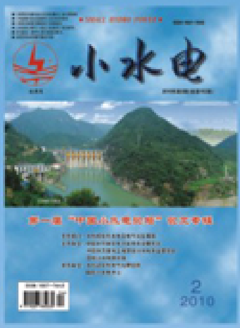

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SHP IN CHINA

SHP WORLDWIDE

HRC NEWS

In 2019, Under the leadership of MWR of China and NHRI and according to the Implementation Plan on Cooperation of Energy and Rural Electrification for Countries Involved in the Belt and Road Initiative (BRI), HRC followed the Initiative and actively organized foreign-aid trainings, implemented international scientific and technological cooperation, consolidated the 4 overseas technology transfer centers, and fully promoted the international capacity cooperation, so the work on foreign affairs scored fruitful results.

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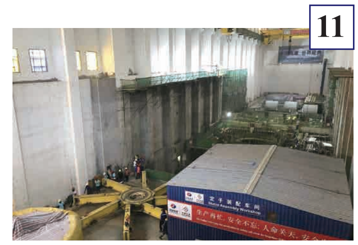

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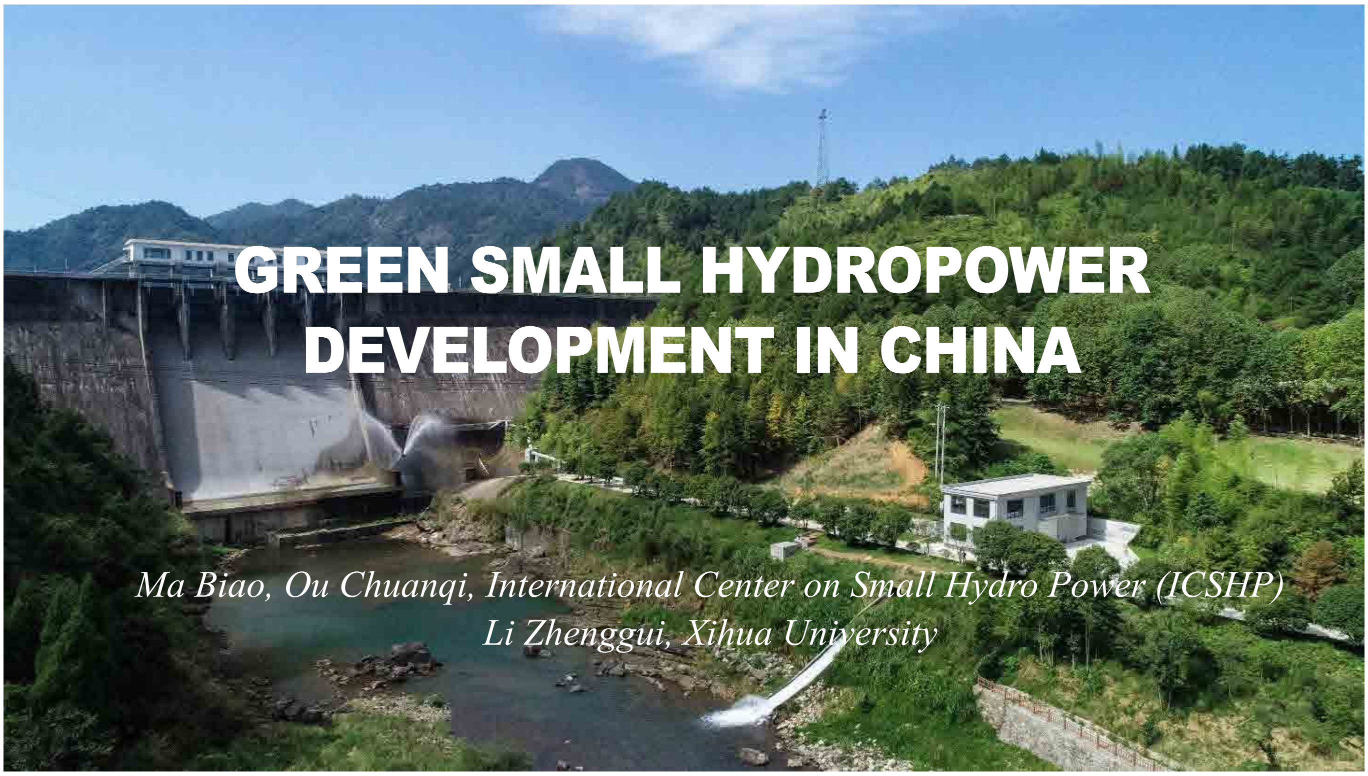

GREEN SMALL HYDROPOWER DEVELOPMENT IN CHINA

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China's small hydropower development process

China's first small hydropower plant (SHP), the Shilongba SHP in Yunnan Province, started generating electricity in 1912 with an initial installed capacity of 480 kW. Since then the country has gone through the following four main stages of SHP development:

• In the initial stage, from 1949 to 1980, the speed of SHP development was slow and the scale small, though it played an important role in solving the issue of no power supply in mountainous and rural areas.

• During the slow development stage, from 1980 to 2000, the Central Government encouraged the local governments and farmers to set up SHP projects themselves to aid in rural electrification.

• The rapid development stage, from 2001 to 2010, driven by the reform of the national investment system and electric power system, saw the growth of social capital and all-round development of the rural economy and society.

• From 2011, SHP development has entered the environmental reform stage. Restricted by resources and environmental factors, the recent focus is to improve SHP quality and increase efficiency. This will promote people-orientated, safe, green and harmonious SHP construction and development.

'The recent focus is to improve SHP quality and increase efficiency, while vigorously promoting peopleorientated, safe, green and harmonious SHP construction and development.'

By the end of 2017, China had built over 47,000 SHPs, with the total installed hydropower capacity exceeding 340 GW. Of this figure, SHP exceeds 79 GW and accounts for 23 per cent of China's total hydropower generation. Over 62 per cent of China's SHP potential has been exploited, rising to a development rate of 82 per cent in some central and eastern provinces.

China's commitment to green SHP

In recent years, the Government's attitude towards SHP has changed from vigorous advocacy to strict regulation. However, there remains a strong commitment to "green hydropower", defined by the Chinese Ministry of Water Resources as "environmentally friendly, socially harmonious, with standardized management and meeting economic rationality criteria".

With increasing hydropower development in China, the environmental impact of the sector has become more prominent including the change in the hydrological features of the rivers. Partial river channels have dried up, river ecosystems and the downstream water for living and production have been affected, and gate-dams have reduced river connectivity. Also, the natural environment of migratory fish and other aquatic organisms are affected.

Presently, China's new rural hydropower resources are mainly located in remote areas, where the environmental conditions are fragile and the demand for electricity is low.

Further, some of China's older SHPs are considered unsafe for the environment and their electromechanical equipment is either ageing or obsolete. Units with obsolete design and manufacturing standards often compete for water with the rivers' ecosystems. In this light, green SHP development is a significant step towards maintaining China's environmental safety. It offers a strategy to maintain harmony between human water usage and the promotion of aquatic ecology, while helping to rapidly transform the SHP development approach by improving quality and increasing efficiency.

Green SHP research and practice

Academic research and seminars underpin China's development of green SHP. For example, in 2012, ICHSP conducted research on the influence of green ydropower on the environment of river systems in the south-western, south-eastern, north-eastern and north-western regions of China. It also analysed major influencing factors, screened key elements to evaluate green hydropower development and convened academic seminars to assess the effects of SHP projects on the environment.

The Standard for Evaluation of Green Small Hydropower, which stipulates the definition and construction standards of green SHP, was formulated based on this research. Moreover, ICSHP is currently formulating "Guidelines for Control Techniques for Downstream Flow Reduction of Small Hydropower Stations" to help standardize the construction requirements for newly built or refurbished SHPs. Similarly in 2016, the Ministry of Water Resources released Guidelines for Promoting the Development of Green Small Hydropower. The current aim is to establish a standard management system for green SHP, develop incentive policies, and build a batch of green SHPs before the end of 2020. It is envisaged that the green SHP concept will be fully embraced by 2030.

The guidelines identified seven key tasks to promote green SHP, namely, strengthening planning constraints and optimizing the layout of development; scientifically designing, constructing and advocating for green development; implementing, upgrading and transforming, and promoting ecological operation; perfecting the monitoring network, safeguarding the demand of ecological water and promoting cascade cooperation; improving technical standards and playing a good leadership role; and accelerating technological breakthroughs and promoting technological innovation.

In 2017, the Ministry issued the Notice on the Establishment of Green Small Hydropower Stations, detailing the certification process and procedures, which require all SHPs to abide by the laws and regulations, meet the requirements of downstream water, have no water disputes and have basic conditions of Standard for Evaluation of Green Small Hydropower.

ICSHP has also led the development of the Green Hydropower Management Information System, with a view of improving the efficiency of green hydropower management and information collection, to standardize work procedures, improve overall management of green hydropower departments, and increase publicity and transparency. The system integrates digital technology with green hydropower and promotes smart management to help the system become the "Internet+" of green hydropower.

In 2017, following voluntary application, preliminary validation, verification and publication, 44 SHPs passed the assessment and were accredited as the first batch of green SHPs in China. Over 400 hydropower stations were registered and applied in 2018, of which 121 were accredited as green SHPs.

Implementing measures for green hydropower

Box 1. Changes and stages in solar hydropower plant in China

Changes in investment mechanisms

The power consumption of Chinese society soared in the 1990s following economic reforms and the opening-up of the Chinese economy. Realizing the great potential of SHP development, the Chinese Government took the lead in changing the SHP investment mechanism and led a reform of feed-in tariffs, while encouraging private-sector investment in the SHP industry, greatly alleviating power supply problems. Subsequent investment in SHP via shareholding mechanism thrived, bringing considerable income to investors. During this period, the proprietary rights of SHP moved from the state and collective ownership to private (or share) ownership.

Changes in benefit distribution

The advantages of developing via shareholding mechanisms stimulated the rapid exploitation of China's SHP resources, enriching specific groups and individuals. The 1990s saw intensive development, and good-quality SHP resources were concentrated with vested interests. Overall, the SHP profits were distributed to the shareholders rather than to the general public.

Changes in energy structure status

Since the 1990s, China has undergone 30 years of rapid development and based on this growth, various other energy technologies were developed including wind, solar and nuclear power. Other alternative energy construction projects were initiated too. In fact, the installed capacity of China's wind and solar power constructed over the past 10 years exceeds the installed SHP capacity, which was developed over the last 60 years. Meanwhile, SHP proportion of China's energy structure is decreasing with every passing year.

Changes in demand

The high-speed development of China's society and economy has continuously improved the living standards and production levels, and the basic demands of people have been transformed from simply wanting a resolution of power supply issues to water resource utilization at a higher level. For example, people around SHPs expect to share the economic benefits of generated power. Moreover, people's demand for water resources has changed too. Earlier, water was primarily used as a tool for generating electricity, whereas now, drinking, environmental protection, and tourism are being prioritized.

Changes in the Government's attitude towards SHP

The Government has established many environmental protection zones, natural reserves, biosphere reserves, soil and water conservation areas, and even conservation areas for drinking water. An increasing number of SHPs, established early in China's SHP development cycle, find themselves located in various reserves. Additionally, environmental issues related to their operation are increasingly visible. The Government has refurbished, used either punitive measures or shut down such SHPs in an attempt to address environmental issues. Overall, the Government's attitude towards SHP has changed from vigorous advocacy to strict regulation.

The requirements for development layout, development scale, development method, construction and operation of hydropower resources must be clarified through planning, and spatial control should be carried out in the development stage. SHP development is strictly prohibited in ecologically fragile and important eco-functional areas, while areas with higher development level must be optimized for development. Development planning should be continually evaluated.

In the design and construction stage, full use should be made of existing topography and landforms to arrange SHP facilities so as to minimize disturbances to river morphology and ecosystems. Moreover, green SHP projects should keep away from sensitive development areas such as nature reserves, national key scenic areas, centralized drinking water sources, and reduce the impact on land vegetation and soil disturbance. Green SHP should also avoid river canalization, which changes the boundary conditions of rivers, adversely affecting the upstream, downstream and both banks of the river. Further, the ecological flow of the river must be scientifically verified and the discharge measures should be identified. The ecosystems' demand for river water should be guaranteed, and the impact on the hydrological situation should be minimized.

As far as renovation and refurbishment measures are concerned, ecological flow features prominently in green SHP development, focusing on eight specific areas (Box 2). One potential measure to be considered is the use of a weir. If the river, on which a hydropower station is located, is wide, shallow and flows slowly, a fixed or movable weir can be built. It should be located at an appropriate part of a dried-up river section that has little impact on flood control for upstream villages. This will allow the section to maintain a certain water depth and meet the requirements of longitudinal connectivity of the river.

Further, sluices can be built at appropriate points in the driedup river section if there is a need for flood-and-erosion control during the rainy season. A typical sluice used for this purpose is a flap gate at the bottom foundation that has discharge holes. At the lowest water level, the flow discharge capacity of the discharge holes shall not be less than the minimum discharge flow. Floodgates can be opened to release flood water at high water level during the flood season.

It should be noted that if the main river channel where a hydropower station is located is stable, the inflow is low during the dry season, the river is wider and the evaporation capacity is larger. Given that certain fish and other aquatic organisms may have certain water depth requirements, it may be necessary to build a longitudinal deep pool at an appropriate point on the dried-up river section to restore water.

In terms of operation and management measures, for hydropower stations that have a significant influence on the hydrological situation of rivers during low water periods, the generation-dispatching mode should be changed. Along with that, seasonally restricted operations should be implemented, which will allow water to flow directly back to the river during the low water period.

It is also recommended to coordinate the operation of cascade hydropower plants using a centralized control system. Such a system should utilize the hydrological survey information and water situation forecast results of the basin to guarantee the continuous discharge of water for improving river ecology.

Another operational measure is to establish an ecological flow monitoring network. This involves establishing monitoring sites at each discharge outlet of hydropower stations in the basin to monitor the discharge. Alternatively, river sections near the downstream part of the dam site of a hydropower station can be selected for installing flowmeasuring devices.

The ecological flow monitoring technology should match with the conditions of the monitoring section, flow characteristics and discharge method. It is mainly based on real-time online monitoring and supplemented by other artificial comparison measurement so as to reflect the discharge flow objectively and accurately. Common measurement methods include traditional flow meter, Doppler (ADCP) flow measurement, real-time radar wave flow measurement, electromagnetic flow meter measurement, water meter measurement and hydraulic structure measurement.

Construction of green hydropower demonstration zone in Zhejiang

Target

The main aim is to undertake a comprehensive restoration of hydropower systems based on basins and regions, aiming to eliminate or alleviate environmental problems, such as drying-up of water or water reduction in river courses caused by hydropower stations. This is achieved through both engineering and non-engineering measures designed to maintain and improve the ecological condition of rivers, optimize the allocation of water resources and scientifically utilize hydropower resources.

Activities

For some old diversion-type hydropower stations, especially those diverting water across the basins, water discharge facilities should be increased through technical refurbishment to maintain the ecological flow of the channels downstream of the hydropower stations.[1] Ecological weirs, rolling dams and landscape weirs should be built in dried-up or water-reduced river sections affected by hydropower dams and cascade hydropower stations. In this way, both the water supply for production and domestic use in the downstream can be safeguarded, and the water landscape of the river can be improved.

Moreover, the minimum ecological flow and control principle of a hydropower station shall be identified according to the characteristics of different rivers in different basins, while ecological flow monitoring facilities must be installed to dynamically manage the ecological flow.

Box 2. Ecological flow release

Use water diversion system

• For hydropower stations that adopt channel diversion, build a side weir by leaving an opening or bury drainage pipes in an appropriate place after the channel passes the dam to discharge the flow into the river channel.

• For hydropower stations that adopt tunnel diversion, utilize the original constructed adit tunnel near the dam to retrofit or excavate a new drainage tunnel. In this case, drainage pipes can be used to discharge the flow into the downstream river channel.

• For technically and economically feasible projects, "ecological generator units" can be installed in the outlet of drainage pipes.

Use spillway sluices with small opening

• For a gate-dam (sluice-dam) hydropower station, a one-hole or multiple-hole sluice gate can be closed incompletely, allowing for the control of discharge into the downstream river channel. After calculating and determining the sluice gate discharge opening using the sluice hole discharge formula, it can be controlled via a sluice gate stroke controller or by setting a limit pier (cement pier) on sluice floor slab.

Use spillway sluice

• According to the actual situation of the layout of a hydropower station, the operating gate (service gate) of spillway can be renovated. The middle gate or flap gate can be set and a hoist can be added to discharge the flow downstream.

Use dam-emptying facilities

• Utilize the original bottom outlets of the dam (such as the diversion bottom outlet, sediment orifice, reservoir emptying hole, flood discharging tunnel, spillway tunnel), add sluice gate control system, adjust dispatching and operation mode.

Set ecological base load or use reverse regulation

• For a dam-type hydropower station, which can meet the ecological flow requirements via electricity generation, it is unnecessary to set up special discharge facilities. According to the upstream water inflow condition, adjust the capacity of the reservoir and the characteristics of the generating unit of the hydropower station, optimize the dispatch and operation of the reservoir, and ensure continuous operation of at least one generating unit. Dispatch discharge flow through base load or reverse regulation and try to reduce the amplitude of variation of the downstream channel in one day as far as possible.

Install an ecological generating unit

• Besides the large generating unit, install the ecological generating unit, which can be set up separately, run for a long term and undertake the task of ecological discharge.

Release discharge by using bypass pipe of generating unit

• Open holes on the bypass pipe of water inlet valve of the generator unit and connect the drainage pipes, and discharge flow downstream after transformation by making use of the original water diversion facilities of the hydropower station.

Add dam water release facilities

• Add inverted siphon, water pumping system, spillway and other facilities at appropriate locations in the dam area to continuously take water from the upstream of the reservoir. After that, get water to pass through the dam and then release it into the downstream channel of the dam to meet ecological flow requirements.

Starting with the actual condition of hydropower stations, an ecological operation mode will be established, the operation and scheduling will be improved, and the optimal scheduling of water resources in the reservoir will be strengthened. In addition, the downstream flow in dry seasons should be effectively improved by accumulating stored water during the rainy season.

Depending on the level of local economic and social development, hydropower stations will be multifunctional, not only generating electricity but also facilitating water supply and flood control. Hydropower stations deemed unsafe, not environment-friendly and uneconomical will be gradually abandoned and dismantled.

Promoting process

Runoff investigation and evaluation were conducted between the powerhouse and the dam. Moreover, an evaluation was done of the water-reduced and dried-up sections of 849 SHPs in Zhejiang Province, which had an installed capacity of above 500 kW. An assessment was made of the water environment and ecological degradation caused by water-reducing and dried-up river sections. Other processpromoting activities include:

• Active implementation of pilot projects in green hydropower demonstration zones in Lin'an, Anji and Kaihua. The total investment was over US$ 3 million; 8 green hydropower demonstration zones and 15 ecological restoration hydropower stations were built; and 5 hydropower stations were dismantled. The demonstration effect and ecological benefits were outstanding.

• Compilation of Technical Guidelines for Ecological Hydropower Construction. Further clarification of technical requirements and methods for green hydropower construction, as well as technical measures for ensuring the ecological flow of downstream of hydropower stations, environmental protection, restoration of dried-up sections and the continuous environment improvement of hydropower stations.

• Compilation of the implementation plan for green hydropower construction during the 13th Five-Year Plan period (2016–2020). Organization and compilation of the implementation plan for the construction of green hydropower demonstration zones in Zhejiang (2016–2020), and integration of the content of green hydropower construction into the 13th Five-Year Plan for water conservancy development in Zhejiang Province. During the period, Zhejiang Province plans to build 50 green hydropower demonstration zones in 39 counties (cities, districts) and complete the restoration of 300 hydropower stations.

Guarantee measures

The rules for the construction and management of green hydropower demonstration zones in Zhejiang Province were established. These rules cover the definition, content, procedures, implementation of the procedures, and project applications of the green hydropower demonstration zone. They also delineate responsibilities for different levels of water administrative departments and project owners.

The management regulations for existing hydropower stations were issued. More specifically, in June 2015, the Province issued the Compensation Principles for Dismantling Existing SHPs in Anji County, which can implement the compensation process according to the dismantling of hydropower stations and restoration of the environment.

The construction of a green hydropower demonstration area was included into the project segmentation contact system, the daily supervision and inspection system and the monthly work notification and report systems. It was also included in the "one thousand people and ten thousand hydraulic projects" on-site guidance and the service work and provincial assessment on "treating sewage and flood control water and drainage, ensuring water supply and grasping water saving".

Construction funds were raised through multiple channels including the Central Government, Provincial Government, the Global Environment Facility, private funds and bank loans. The fundraising channels for the project construction in the demonstration area were broadened to ensure the smooth implementation of the project. Moreover, the power generation loss was also measured and classified for the reimbursement in Jinhua and other cities (regions).

In terms of raising public awareness, a consensus on the

[1] If condition allows, small ecological units can be added.

Box 3. The green SHP certification mechanism

Institution building

In terms of future development, a key aim is to set up a certification institution for green hydropower. This institution will gain policy supports in relevant laws and regulations, finance, price and other fields, set scientific certification standards and adopt transparent certification procedures. Scientific research institutes and industry associations can participate or provide appropriate technical support and consultation.

Green power certificate for SHP

SHPs that have passed the green hydropower certification shall be awarded certificates by the competent department of hydropower resources. Enterprises of power generation and sales can voluntarily purchase the green power certificates. Megawatts hour of power generated is equivalent to a green certificate, which is marked with the type, serial number, production date and other information of the eligible renewable power. The green power certificate supports the quota system of SHP generation, that is to say, it is compulsory to stipulate a certain proportion of green SHP power output from power generation enterprises or power grid.

Green power tariffs

Power supply companies shall set green tariffs separately for the power companies with a green certificate, and consumers shall be free to choose a suitable proportion of green power according to their electricity consumption. A certain additional price is charged per kilowatt hour to make up for the higher cost of green power.

Green certificate market

A new competitive market, which allows the trade of green SHP electricity and has a different pricing system from that of the conventional power market, shall be created. This is called the green certificate market. The trading mechanism of green certificate not only opens up a sales channel for green power, but also ensures its optimized allocation and reasonable supply.

promotion of the green hydropower demonstration area was gradually built from the higher level of government to grassroots hydropower stations through publicity, training and guidance.

Achievements in numbers

Overall, a total of 24 green hydropower demonstration areas have been identified, 53 hydropower stations have been refurbished, 24 rivers have been restored, 25 km of driedup river sections have been restored, 3 discharge sluice holes ensuring ecological flow have been newly built and reconstructed and 37 weirs for maintaining ecological flow have been newly built.

Lessons for future SHP development

Lesson 1: Strengthen publicity, training and technological knowledge.

Lesson 2: Conduct basic investigation and clarify problems and working conditions.

Lesson 3: Set requirements, identify objectives clearly and formulate scientific layouts.

Lesson 4: Formulate standards and issue guidelines for promotion.

Lesson 5: Implement pilot projects, typical models, accumulate experiences and promote best practice.

Lesson 6: Conduct research on supporting policies, establish and improve incentive and guarantee mechanisms.

(Source:WSHPDR 2019)■

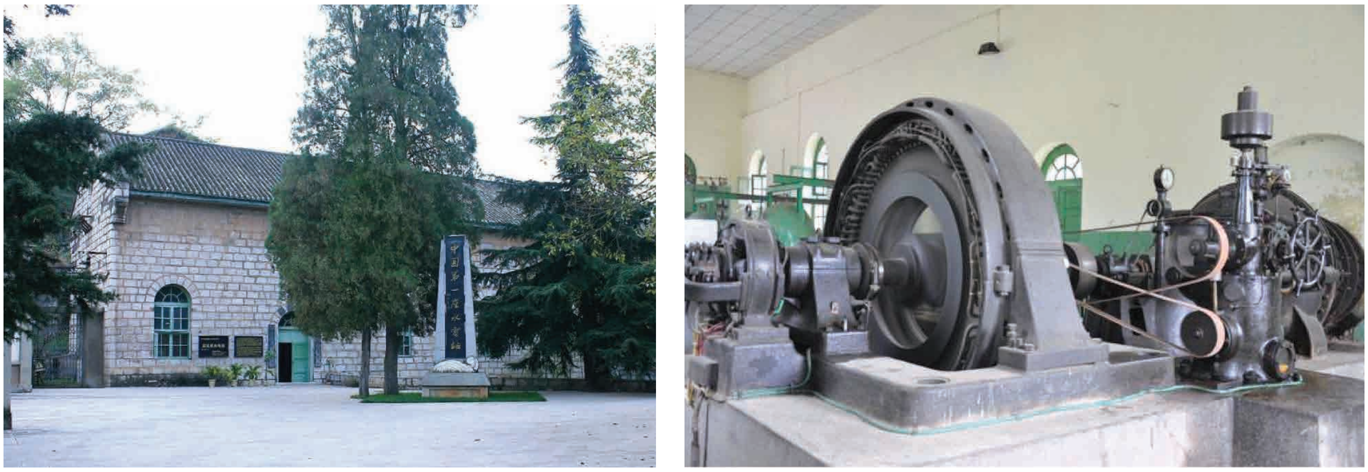

Figure 1. Shilongba SHP in Kunming, Yunnan Province

Note: China's first SHP, with installed capacity of 240 kW, is still operating.

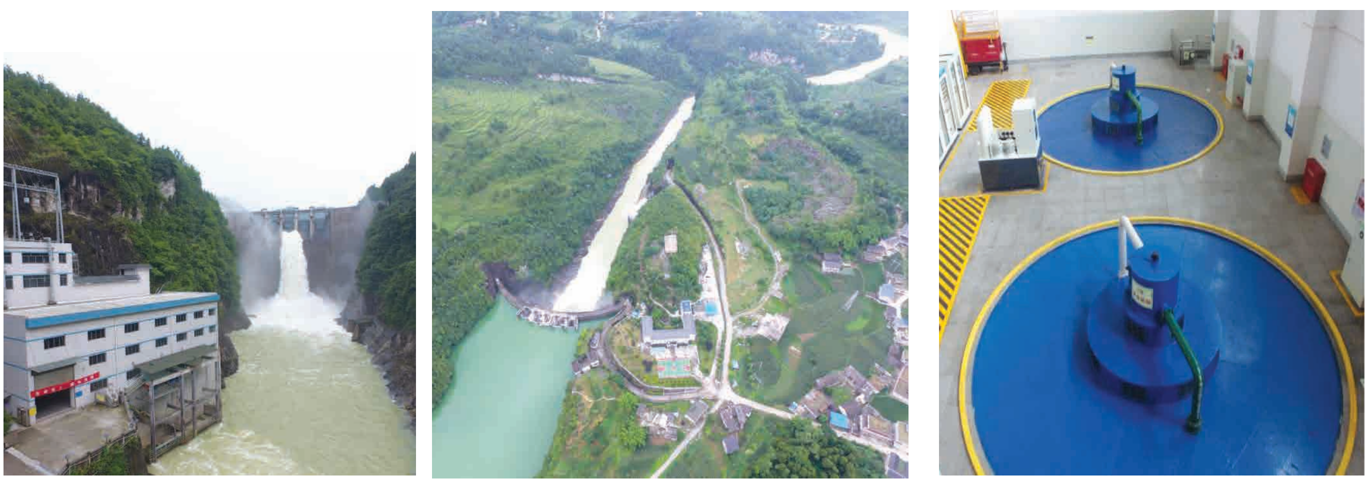

Figure 2. Qingxi SHP in Guizhou

Figure 3. Jinkeng Ling SHP in Zhejiang (1,250 kW)

Figure 4. Hengjin First Cascade in Zhejiang Province (9,750 kW)

Figure 5. Anming First Cascade in Songyang, Zhejiang Province

Note: Total capacity is 2 × 6.3 MW, reservoir storage capacity is 3.32 million m^3, an 80 cm pipe was installed at the bottom of the reservoir for ecological flow discharge.

■

China demolishing hydro dams to protect endangered giant salamanders

Central China's Hunan Province has stopped operation of 34 hydropower plants and demolished 10 dams in the past two years in a key reserve of giant salamanders.

Municipal officials of Zhangjiajie, a popular tourist destination, said they planned to demolish most of the 88 hydropower plants, mainly small ones built before the establishment of the National Giant Salamander Nature Reserve.

There are 3,000 kilometers of rivers in the reserve, which was established in 1995 as a provincial level one but upgraded to national level in 1996.

"More and most of the dams will be demolished," said Hu Shenghu, head of the city's water conservancy bureau. "Only those that have flood control, irrigation and water supply functions will be retained."

Officials and conservationists have blamed the hydropower plants for blocking and fragmenting rivers and hindering fish migration, reducing prey and habitats for the rare amphibians.

"We plan to dismantle all dams that only had power-generating functions in the nature reserve before the end of 2020 and reevaluate the functions of the rest," Hu said.

Ecologists have hailed the decision to close the hydro projects as a milestone for habitat restoration of giant salamanders, which date back 350 million years to the age of the dinosaurs. **(Source:Xinhua)**■

An Overview of Hydropower Development in Zambia

National Research Institute for Rural Electrification (NRIRE)
Hangzhou Regional Center (Asia-Pacific) for Small Hydro Power (HRC)

LIN Ning, ZHAO Jianda, SHI Jin, ZHANG Hua

Geography: *Zambia is a land linked country, lies in the watershed between DR Congo and Zambezi river systems. Zambia covers area of 752,618 km^2.Woodland cover about 600,000 m^2. A coverage of 9,220m^2 are water. The terrain of Zambia is mostly high plateau. The highest point–Mafinga Hills (2,339m asl),Lowest point–Zambezi River (329m asl),Longest River–Zambezi River (2,650 km).*

Climate: *Sub-Tropical climate due to altitude. Two Seasons (Rainy and Dry Seasons).Temperature range is 6°C–35°C.Prevailing winds are generally moderate. In the rainy season, winds are localized with thunderstorms. Whirlwinds are very common but not usually destructive. The country does not suffer tornadoes or cyclones. It's considered vulnerable to climate change.*

Population: *Zambia has a population of 16 million (2018/9 estimate). Ethnically diverse, with a total of 73 ethnic tribes. Zambia is one of the most highly urbanized countries in sub-Saharan Africa. 44% of the population urban areas. Rural areas are sparsely populated.*

I. Water resources

The Water Resources Management Authority (WARMA) is an autonomous body established by the Water Resources Management Act, No.21 of 2011. WARMA exercises control over all water resources in Zambia as envisioned in the Water Resources Management Act. Zambezi River Authority manages Zambezi river which is used for power generation for Zambia and Zimbabwe. The amount of Water Resources has a total coverage of 9,220 km^2 with 104.8 billion m^2 of renewable freshwater resources. Per Capita amount of Water Resources is 6,464 m^3/year as of 2014 data but expected to go up as the resource is being further exploited. Utilization of Water Resources is less than 5% of the available resource.

The Ministry of Mines, Energy and Water Development is in charge of the water and energy sector. The Water Resources Management Authority, under the Ministry of Mines, Energy&Water Development, deals with general water resources development, while domestic water supply is handled by local authorities at district and provincial levels.

Approximately, 90 per cent of the urban population has access to a drinking water supply, and about 41 per cent of the rural population. The average per capita consumption is about 163 l/day.

There are three large dams in the country, according to ICOLD's definition. The total water storage of all dams in the country is about 188 km^3.

Construction is nearing completion at the Kafue Gorge Lower RCC dam on the Kafue river; it will be 139.0 m high. It is scheduled for completion in 2020, and will have a 750 MW powerplant. Construction was recently (2019) completed at the 24 m-high Mwomboshi irrigation dam,and impounding is to begin shortly.

Dams planned to go ahead within the next five years are:

• Batoka Gorge, an RCC dam on the Zambezi river which will be 175 m high,

The Dam of Kariba, Nov 2019 *(Photo by LIN Ning)*

and will have a 2,400 MW powerplant (to be shared with Zimbabwe); it is scheduled for implementation by 2026.

• Mambilima Ⅴ dam on the Luapula river; it will be 50 m high and will have a 372 MW hydro plant.

• Mambilima Ⅱ dam on the Luapula river; it will be 44 m high and will have a 190 MW hydro plant.

• Mambilima Ⅰ dam on the Luapula river; it will be 30 m high and will have a 136 MW hydro plant.

• Mombututo M dam on the Luapula river; it will be 30 m high and will have a 190 MW hydro plant.

• Mombututo CX dam on the Luapula river; it will be 70.5 m high and will have a 300 MW hydro plant.

Refurbishment work is continuing at Kariba dam, on the border with Zimbabwe. The World Bank, African Development Bank and the Government of Sweden contributed funds for this work, to restore the safety of the dam.

II. Power sector

The Ministry of Mines, Energy and Water Development is in charge of the energy sector. The Energy Regulation Board within the Ministry is in charge of energy regulation, while the Office for Promoting Private Power Investment (OPPPI) deals with private power investment in the country. Privatization of energy is under way through the OPPPI, and emphasis is on both private and public-private partnership investments. The major power utility in the country, ZESCO Ltd, has been commercialized.

The total installed capacity of power plants of all types in operation, in 2019, is 2,959 MW. About 3 per cent of the total capacity is privately owned. Of the total capacity, 2,750.5 MW about (86 per cent) is contributed by hydropower,

Installed Capacity[2]

No	Plant Name	Owner	Installed Capacity (MW)	Plant Type
1	Kafue Gorge	ZESCO	990	Big Hydro
2	Kariba North Bank	ZESCO	1,050	ditto
3	Itezhi - Tezhi	ZESCO	120	ditto
4	Victoria Falls	ZESCO	108	ditto
5	Lunzua	ZESCO	14.8	Small Hydro
6	Lusiwasi	ZESCO	12	ditto
7	Chishimba Falls	ZESCO	6	ditto
8	Musonda Falls	ZESCO	5	ditto
9	Shiwa Ng'andu	ZESCO	1	ditto
10	Lunsemfwa	Lunsemfwa Hydro Power Ltd	31	ditto
11	Mulungushi	Lunsemfwa Hydro Power Ltd	25	ditto
12	Zengamina	Rea	0.7	micro
	Total		**2,363.6**	

410 MW (14 per cent) by thermal plant, and 4.2 MW (0.1 per cent)by diesel.

Total electricity production in 2018 was 15,499 GWh, of which 87 per cent (13,693.2 GWh) was from hydro, and the remainder was from thermal power. About 4.6 per cent of electricity was produced from imported fuels.

About 30 per cent of the population has access to an electricity supply.

Peak demand on the main grid in 2018 was 2,194 MW.

Electricity Tariff Structure:

Tier Level	Units	Price (Kwacha /kWh)
Tier I	First 200 kWh	0.31
Tier II	201 kWh–400 kWh	0.50
Tier III	More than 401 kWh	1.50

III. Hydropower development

Classification of Hydro Power Plant

Large Hydro Power Plant has capacity above 500 MW;

Medium Hydro Power Plant has capacity from 10 MW-below 500 MW;

Small Hydro Power Plant has capacity below 10 MW:

- Mini Hydro: 0.5MW-10MW
- Micro Hydro: 0.01MW-0.5MW
- Pico Hydro: is below 0.01MW

The remaining technically feasible hydro potential of Zambia has been estimated at 6,000 MW of capacity (evaluated in 2,000), equivalent to about 55,000 GWh/year, and the economically feasible potential is estimated to be 1,260 MW, equivalent to about 20,000 GWh/year. About 30 per cent of the country's technically feasible hydro potential has been developed. The Ministry of Energy,

The 139.0m-high RCC Dam under Construction, Nov 2019 (*Photo by ZHAO Jianda*)

Kafue Gorge Lower Hydropower Station(KGLHS), on the Kafue River in the southern Chikankata district, located 90 km south away from Lusaka, the capital and largest city of Zambia, is being built by Sino Hydro Corporation, at a cost of over US$2 billion.

The project includes the construction of a 139.0 m high RCC dam with a crest width between 8m and 10 m and a length of approximately 364.5 m. A surface powerhouse with a width of 44.5 m, height of 58 m and length of 127 m and housing five 150 MW generator units, will be constructed.

The power station will have an environmental release outlet channel, a spillway on the left bank with an overall width of 64 m and maximum discharge capacity of 6,210 m^3/s. The right bank will have a flood release tunnel with a maximum capacity of 1,018 m^3/s and a 4.4 km long power tunnel.

The dam will also have a floodgate with five 400 m long penstocks. The left bank will feature a 980 m long diversion tunnel with a horse-shoe cross section of 10m×14m.

KGLHS, the biggest of its kind in 40 years, it has an installed capacity of 750 MW and is expected to increase Zambia's power supply by 38 percent, which is sufficient to meet the country's electricity demand for the next five to 10 years upon its completion in 2020.

The successful completion of KGLHS will add 750 MW to the over 2,000 MW locally-produced power. Government, in the Seventh National Development Plan, states that it will promote infrastructure development to enhance the supply of electricity for economic development. The idea is to expand and improve electricity generation, transmission and distribution, as well as encourage the development of small and mini hydropower stations.

Since the start of its construction in November 2015, the project has greatly benefited the local economy by creating jobs for those under-paid. KGLHS has created nearly 10,000 jobs for Zambia and generated 1 billion yuan (157 million U.S. dollars) worth of tax revenue for the Zambian government It currently employs more than 3,500 local workers.

ZESCO is currently working on the KGL project. The project will make Zambians appreciate the efforts Government is putting towards the electricity sector, the company has also built a school at the Lower Gorge as part of social responsibility investment. The project will complement the main Kafue Gorge which will boost in power generation.

Pipeline Hydropower Projects/ Opportunities Below 50MW[2]

No	Project Name	Capacity (MW)	River	Stage	Developer
1	Kabompo Gorge	40	Kabompo	Pre-Construction	CEC
2	Chavuma Falls	14	Zambezi	Feasibility/IA negotiations	SINOHYDRO
3	Chanda Falls	1	Kashiji	Feasibility/IA negotiations	SINOHYDRO
4	Ngonye Falls	40	Zambezi	Feasibility/IA signed	WESTERN POWER LTD
5	Luchenene	34	Luchenene	Pre-feasibility	POWER MIN ZAMBIA LTD
6	Mutinondo	43	Mutinondo	Pre-feasibility	POWER MIN ZAMBIA LTD

Pipeline Hydropower Projects/ Opportunities Above 50MW[2]

No	Project Name	Capacity(MW)	River	Stage	Developer
1	Mulembo/Lelya	330	Mulembo	Prefeasibility	MCHIMADZI LTD
2	Mwambwa	85	Mwambwa	Pre-feasibility	Electra
3	Mambilima Falls I	126	Luapula	IGMOU/Feasibility	GRZ/DRC
4	Mambilima Falls I I	202	Luapula	IGMOU/Feasibility	GRZ/DRC
5	Mambilima Falls V	372	Luapula	IGMOU/Feasibility	GRZ/DRC
6	Mumbotuta Falls	490	Luapula	IGMOU/Feasibility	GRZ/DRC
7	Batoka Gorge	1,600 (2,400)	Zambezi	Feasibility	ZRA
8	Devil's Gorge	1,000	Zambezi	Pre-feasibility	ZRA
9	Mpata Gorge	543	Zambezi	Pre-feasibility	ZRA
10	Kafue Gorge Lower	750	Kafue	Construction	ZESCO
11	Kabwelume Falls	96	Kalungwishi	Implementation Agreement (IA) signed	LUNZUA POWER AUTHORITY
12	Kundabwika Falls	151	Kalungwishi	IA signed	LUNZUA POWER AUTHORITY
13	Muchinga	230	Lunsemfwa	Feasibility	LHPC
14	Lufubu	163 (326)	Lufubu	Feasibility/IA negotiations	LUFUBU POWER LTD

OPPPI and ZESCO manage a national database of operational and potential hydro plants.

Hydro generation in 2018 was 13,693.2 GWh, which was 87 per cent of total generation.

There is 2,750.5 MW of hydropower in operation, and a further 775 MW under construction[1].

Currently under construction are: the Kafue Gorge Lower (KGL, 750 MW), the Lusiwasi Upper scheme (15 MW), and a 10 MW uprating scheme at Musonda.

The 2,400 MW Batoka Gorge hydro plant is to be implemented jointly with Zimbabwe on the border between the two countries (the capacity is to be shared equally). At a meeting in February this year, the Zambezi River Authority announced a shortlist of bidders for construction of the Batoka Gorge scheme.

Zambia has a further 1,162 MW of hydropower planned for implementation at six other mayor dams which are scheduled to go ahead in the next five years.

Studies have been done for the Ngonye Falls hydro scheme, which could have a capacity of 180 MW.

In addition to these, it was last year(2018) by Zambia's Finance Minister that the 210 MW Kalungwishi hydro plant could be implemented by the private sector, in the Northern Province. It is planned that a transmission link would be established with Tanzania.

An invitation was issued early this year for companies to pre-register for Zambia'S GET FiT initiative, which supports the development of small and medium hydro schemes, up to 20 MW. The tender is to develop, finance construct and operate schemes which could total up to 100 MW of new capacity.

IV. Small hydro

There is a small hydro potential of 97.6 GWh/year. There are five small hydro plants in operation, totalling 25 MW. A 10 MW extension is under way at Musonda Falls.

The Mujila mini hydro plant is at the feasibility study stage.

There are also several small schemes planned, notably at West Lunga, and the Chikata scheme in northwestern Zambia. A total of 50 MW of small hydro is at the prefeasibility study stage.

V. Other renewables

The country is planning to develop other renewables by 2022 in addition to small and large hydro. These plans include 200MW of solar PV. Zambia has engaged in the World Bank's Scaling Solar initiative, supported by IFC. This facilitates the rapid development of privately owned solar PV plants.The country has also initiated the Global Energy Transfer Feed-In Tariff(GET FiT) programme to implement the REFiT strategy. As part of Round 1 of GetFit, a 100 MW solar plant was launched last year(2018).

Other planned renewable schemes include 150 MW of wind power, and 50 MW of geothermal.

ZESCO is also planning a 100 MW solar plant at the Kafue Gorge Lower hydro plant, to operate conjunctively during the day, to conserve water in the reservoir in the daytime. This is at the prefeasibility stage.

A small amount of biomass is also planned, and wind data collection is currently under way.

The Powerhouse under Construction, Nov 2019*(Photo by ZHAO Jianda)*

The Hydropower Training Course and Field Visit to KGL Conducted by HRC, Nov 2019 *(Photo by ZHANG Hua)*

VI. Climate resilience

Evidence has shown that Zambia has, over the past years, experienced a number of climate related hazards including droughts and dry spells, seasonal and flash floods, and extreme temperatures. Therefore, long-term interventions have been put in place to minimize the potential future impacts of climate change. One example is the recent launch of the National Policy on Climate Change by the Government. The Vision of the National Policy on Climate Change is "*A prosperous and climate resilient economy by 2030*". The overall objective of the Policy is to provide a framework for coordinating climate change programmes to ensure climate resilient and low carbon development pathways for sustainable development towards the attainment of Zambia's Vision 2030.

Some specific mitigation and adaptation measures being taken are: spreading the hydrological risk by focusing on the development and expansion of hydro plants in the north of the country, where rainfall is high and reliable; making efficient use of water by developing cascade hydro schemes on the to same river, for example on the Zambezi; and, protecting the headwaters of the Zambezi and Lunzua rivers by planting trees in the upper catchment areas.

VII. Environment and public awareness

The Government introduced Strategic Environmental Assessment(SEA) in the 2011 Environmental Management Act to enhance environmental protection. Water resources and hydropower infrastructure require impact studies, and the approval of the Zambia Environmental Management Agenc(ZEMA). Typically around 10 per cent of the project costs are allocated to social and environmental programmes. There have been no changes since last year in environmental legislation.

The country adheres to several pertinent legislations, regulations and standards to ensure environmental and social compliance in all its projects and operations.

Zambia also complies with the World Bank Safeguard Policies and IFC's Performance Standards in its Environment and Social Impact Assessment Studies, to manage environmental and social risk.

Community-based awareness campaigns in the form of project briefs and open public community hearings during the EIA studies are the main steps taken to increase public awareness about the benefits of dams and hydro plants. Local representation is encouraged in decision making.

VIII. Future outlook

The Government plans to focus on more hydropower development, especially in the north of the country, where the rainfall pattern is favourable. Small hydro and solar plants are also going ahead with the support of international organizations, as part of the move to develop more renewable energy.

The country is encouraging private investment in hydropower development.

As part of its national policy, the Zambian Government aims to make Zambia a "prosperous and climate resilient economy by 2030".

Reference

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2.Amos and Fabian Banda. *Zambia Country Report*—2018 Seminar on Water Resources Management & Small Hydropower Development for Countries Along the Belt and Road,HRC/ Hangzhou China, 15 May—4 June 2018.

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Status of Hydropower Development in Rwanda

National Research Institute for Rural Electrification (NRIRE)
Hangzhou Regional Center (Asia-Pacific) for Small Hydro Power (HRC)

ZHAO Jianda, LIN Ning, SHI Jin, Tang Yanqiu

Rwanda is small and landlocked, hilly and fertile with a densely packed population of about 12.5 million people (2018). Rwanda has an area of 26,338 km² and of about 472.6 per km² population density. It borders the far larger and richer Democratic Republic of Congo, as well as its closest East African neighbors, Tanzania, Uganda, and Burundi.

***Geography:** The country is known as a Thousand hills Country due to its geographical features dominated by hills and mountains (4,507m highest elevation). It is located in the east-central Africa.*

***Capital city:** Kigali.*

***Government type:** Presidential Republic.*

***Climate:** The climate is tropical characterized with moderate rain and sun. Seasons: Short (Jan-Mid March) and long dry season (June-Mid Sept.), and short (Mid Sept-Dec) and long rainy seasons(Mid March-End May). Temperature varies between 24.6°C–27.6°C.*

***Economy:** Based on the services, tourism, export of mineral, coffee and tea, and agro-processing industries; Currency: FRW; Growth:6.7%; GDP/Capita:$2,100. The target of the Government of Rwanda(GoR) is to transform the country from low-income agriculture–based economy to a knowledge-based, serviced-oriented economy with a middle income status by 2024.*

I. Water resources

Average precipitation varies between 800 mm/year in the eastern plains to 2,000 mm/year in the northwest. Per capita domestic water consumption is 43 litres/day in urban areas and 14 litres/day in rural areas with small communities.

The Nyabarongo Ⅰ concrete gravity dam was recently completed for a 29 MW hydro plant, and there is one small dam with a storage capacity of 1× 106 m³ at the Shyogwe water production station in Gitarama province.

A 48 m-high concrete gravity dam is now to be built for the 43.5 MW Nyabarongo Ⅱ hydro plant.

A 38 m-high dam is also planned for the first phase of the Muvumba multipurpose scheme, for flood control, irrigation and drinking water supply. A 29 MW hydro scheme will also be developed.

II. Power sector

Within the Ministry of Infrastructure of Rwanda, the Energy Division is responsible for the energy and water sectors.

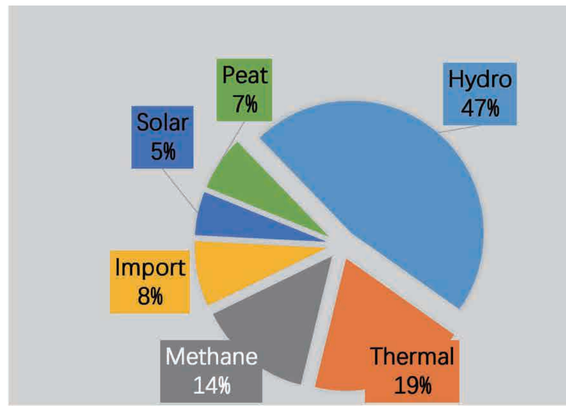
The GoR envisages transitioning from a developing country to a middle-income country, and to achieve this goal, aims to achieve 100 per cent electricity access by 2024. Rwanda has developed the Electricity Sector Strategic Plan (ESSP) associated with the National Strategic Transformation (NST1) which sets out how to achieve the 2024 goal. The National Electrification Plan 2018-2024(NEP) developed by EDCL guides investments in electrification and determines the access targets within the framework defined by

NST1 and ESSP.

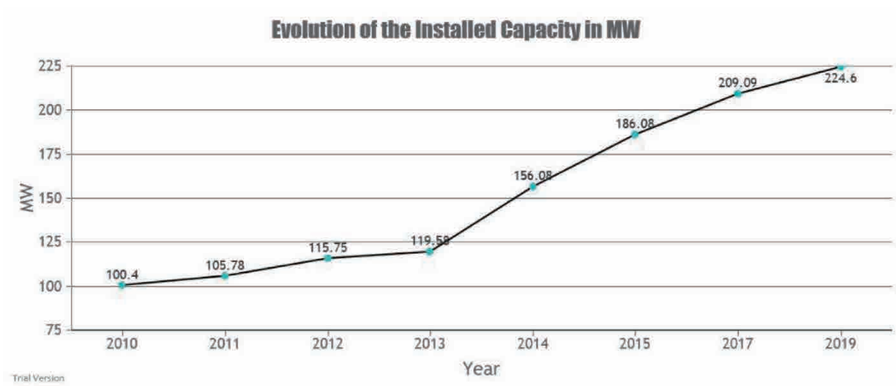
In support of the sector reform, the Government has launched a number of legal, regulatory, and private sector development initiatives that seem to be moving on the right track. Several laws have been approved that together define the emerging sector structure and institutional framework, including the government's clear policy to increase private sector investments primarily in generation and off-grid electricity distribution.

Within the holding company, REG Ltd there are two companies: Electricity Utility Company Ltd(EUCL) and Energy Development Company Ltd(EDCL). The companies are 100 percent government owned, but operate on corporate principles to implement government policy and the Government Strategic Plan for the Energy and Water Sectors. They operate as commercial entities to improve performance and financial sustainability.

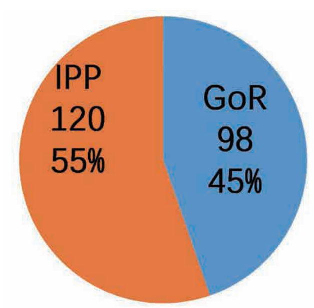
The current installed capacity is 221.9 MW; there has been an increase from 88 MW in 2010 to 221 MW in early 2019.In the fiscal year 2019/2020, an increase from 221.9 MW to 305 MW will be achieved, following commissioning of 80 MW at the Hakan peat plant and 3 MW from the Rukarara Ⅴ hydropower plant.



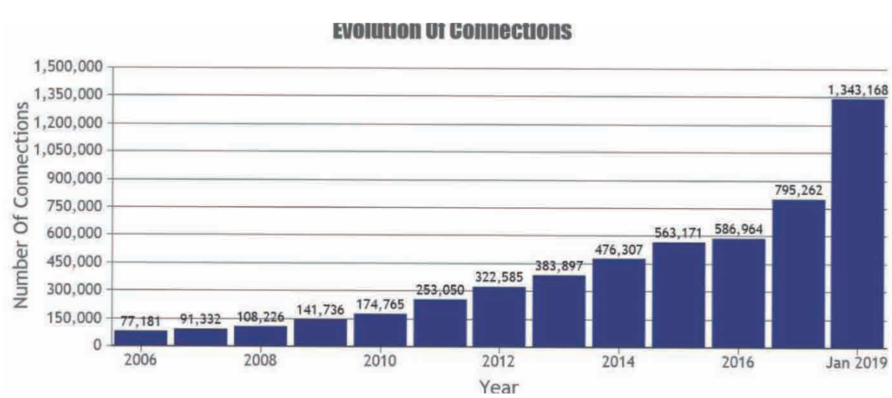
Installed capacity as of Nov 2019 (224.6MW)



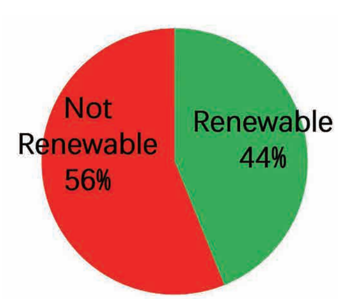
Source: *LCPDP REPORT, June 2019*



Ownership in 2018 (MW and percent)



Source: *LCPDP REPORT, June 2019*



Renewable Energy in 2019

End-user Tariff in Rwanda

S.N.	Type of Consumer	Consumption(kWh)	Tariff(USD, cents)
1	Residential	0-15	12
		15-50	25
		＞50	26
2	Non-Residential	0-100	25.9
		＞100	26.3
3	Small industries including Water treatment plants, Water pumping stations and Telecom towers	126	17
	Medium industries	0.4 kV-15 kV	12 Plus charges of Q
	Large industries	15 kV-33 kV	11 Plus charges of Q

To meet the HLTOs(High-Level Target Objectives)of the Government, in terms of increasing generation capacity to ensure the demand with 15 per cent reserve margin, the Government, through MININFRA and REG, has initiated the following public and public private partnership projects which are now under development: the Symbion methane project(50MW), the Nyabarongo hydro project (43.5 MW), the Rusumo Falls hydro scheme (80 MW to be shared between Rwanda, Burundi and Tanzania)and Ruzizi Ⅲ hydro project(147 MW to be shared between Rwanda, Burundi and DR Congo).

Installed capacity is expected to have increased to 556 MW by 2024-2025.

Per capita consumption is about 42 kWh/year per capita, compared with 478 kWh/year in sub-Saharan Africa and 1200 kWh for developing countries as a whole. Although Rwanda's densely distributed population should facilitate network expansion and access to electricity, at present only about 30 per cent of Rwanda's households are connected to the grid: 12 per cent in rural areas, 72 per cent in urban areas, and about 60 per cent in the capital, Kigali. The Government has launched a programme to increase access to the electricity services by all sectors of the economy and all consumer categories. The aim is to have 52 per cent of households grid-connected and 48 per cent off grid connected by the end of 2024.

About 26 per cent of generation is thermal-based, leading to high costs and tariffs. The dependence on diesel fuels led to the need to subsidize the electricity tariff significantly.

In recent years, the Government has put in place measures to ensure effective routine maintenance.

Feed-in Tariff

• Energy System Frequency: 50 Hz.

• Level of Voltage: High Voltage: 110 kV & 220 kV); Medium Voltage: 15 kV & 30 kV; Distribution/Low Voltage: 220 V/1ph & 380/3ph.

Established by Regulatory Authority (RURA) in consultation with all the stake holders. It varies depending the technology and the installed capacity

III. Hydropower development

Over the last decade, Rwanda's hydropower has been quadrupled. The first Hydropower Plant in Rwanda commissioned in 1957. Hydropower contribute to about 50% of the total installed capacity (2019).Hydropower Atlas Available with 333 sites (to be upgraded) .Hydropower potentials est. to more than 1,000 MW.

Rwanda has a technically feasible hydro capacity of about 400-500 MW. The total installed hydro capacity is 72.75 MW, and the available hydro capacity is 36.72 MW. Two hydro plants, Ntaruka and Mukungwa, have a combined capacity of 23.5 MW. For some years degradation of the watershed let to these plants operating at only about 25 per cent of their capacity. Following restoration measures, they are now operating at full capacity.

On Nov 2019, the hydropower installed capacity is 104.5 MW, that is 47% of the total country installed capacity.

Hydro plants generate 33 per

cent of national electricity, with the remainder being provided by thermal plants, peat to power plant, solar energy and methane gas. About 17 per cent of the population in urban areas and 5 per cent in rural areas has access to an electricity supply.

The 29 MW Nyabarongo Ⅰ hydro scheme is in operation, and construction is now beginning at the 43.5 MW Nyabarongo Ⅱ scheme, by SinoHydro of China, with an EPC contract.

Between 2019 and 2025, Rwanda is expecting to gain an additional 221.9 MW from hydro plants(Nyabarongo Ⅱ, Rusumo Falls and Ruzizi Ⅲ) as well as thermal, peat to power plant and methane gas plants.

Energie des Grands Lacs(EGL) belongs to three countries(Burundi, Rwanda and DRC). This organization was created in 1976 and is an energy planning organization which plans and implements regional power projects.

EGL,CEPGL States and a consortium of IPS and SN Power(a private investor/developer) have signed the Ruzizi Ⅲ project agreements in Kinshasa, DRC, to develop, construct and operate Ruzizi Ⅲ(147 to 230 MW) as a 25-year concession. Through its utility company REG Ltd, Rwanda will import one-third of the total capacity of Ruzizi Ⅲ and will sign a power purchase agreement with the Ruzizi Ⅲ Project Company. Ruzizi Ⅲ is now(2019)moving ahead in the development phase towards financing closure. The developer will begin activities such as the mobilization of funds, selection of the EPC contractor and implementation of the RAP and ESMP.

Meanwhile, a prefeasibility study is available for Ruzizi Ⅳ which will be built between Ruzizi Ⅱ and Ⅲ; this scheme is planned to have a

Powerhouse Construction Works, Rusumo Falls Hydroelectric Project, Nov 2019

Formwork and Preparations to Cast Concrete for Unit 3 Draft Tube, Rusumo Falls Hydroelectric Project, Nov 2019

Regional Rusumo hydroelectric project is a hydropower plant, is under developing at the Rusumo Falls on River Kagera located at the common border of the Republic of Rwanda and United Republic of Tanzania.

The Republic of Burundi, the Republic of Rwanda and the United Republic of Tanzania are jointly developing the 80 MW hydropower project under an agreement signed in February 2012. A new company named Rusumo Power Company Limited (RPCL) has been formed to develop the plant. Each of the three countries owns an equal share in RPCL.

The power plant features a run-of-river design, thereby eliminating the need for constructing a reservoir, and minimising social and environmental impacts. It will include a concrete gated dam with a height of 12 m and a spillway structure with three water passages. The passages will be equipped with three radial gates, each measuring 9 m-wide and 9.5 m-high. A two-lane road will be built on top of the dam.

The water intake and headrace tunnel of the plant will be 11m-wide and 14 m-high and feature a shotcrete and rock bolts support system. A concrete-lined vertical surge shaft with a diameter of 8 m and a surge chamber with a diameter of 41m will also be part of the plant.

The power house of the plant will include three vertical axis Kaplan turbines and three 30 MW generators with 12 kV output voltage. It will be located on the southern side of the Kagera River bank in Tanzania.

The plant will include a 260 m-long diversion canal with a width of 17 m and a 250 m long tailrace canal with a width of 40 m. A 220 kV substation switchyard is also part of the plant and will be located on the northern side of the Kagera River bank in Rwanda.

capacity of 287 MW. Based on the positive results of negotiations for the Ruzizi Ⅲ project, a public private partnership will also finance the implementation stage of Ruzizi Ⅳ hydro plant. The EU has mobilized funds for further project preparation studies for the scheme in collaboration with AFDB.

The 28.5 MW Ruzizi Ⅰ plant, operated by Societe Nationale d Electricite (SNEL) of DRC, and the

Existing Hydropower Generation Plants in Rwanda

No	Plant Name	Installed Capacity (MW)	Capacity factor (%)	Available Capacity (MW)	Owner	COD
1	Ntaruka	11.25	23	2.5875	GoR	1959
2	Mukungwa Ⅰ	12.00	50	6	GoR	1982
3	Nyabarongo Ⅰ	29.00	48	13.44	GoR	2014
4	Gisenyi	1.20	65	0.78	Prime Energy	1957
5	Gihira	1.80	70	1.26	RMT	1984
6	Murunda	0.1	45	0.045	Repro	2010
7	Rukarara Ⅰ	9.5	40	3.8	Ngali Energy	2010
8	Rugezi	2.6	50	1.3	RMT	2011
9	Keya	2.2	50	1.1	Adre Hydro&Energicotel	2011
10	Nyamyotsi Ⅰ	0.1	60	0.06	Adre Hydro&Energicotel	2011
11	Nyamyotsi Ⅱ	0.1	60	0.06	Adre Hydro&Energicotel	2011
12	Agatobwe	0.2	35	0.07	Carera-Ederer	2010
13	Mutobo	0.2	45	0.09	Repro	2009
14	Nkora	0.68	50	0.34	Adre Hydro&Energicotel	2011
15	Cyimbili	0.3	50	0.15	Adre Hydro&Energicotel	2011
16	Gaseke	0.582	90	0.5238	Novel Energy	2017
17	Mazimeru	0.5	49	0.245	Carera-Ederer	2012
18	Janja	0.2	80	0.16	RGE Energy UK ltd	2012
19	Gashasi	0.2	40	0.08	Prime Energy	2013
20	Nyabahanga Ⅰ	0.2	55	0.11	GoR	2012
21	Nshili Ⅰ	0.4	60	0.24	GoR	2012
22	Rwaza Muko	2.6	60	1.56	Rwaza HydroPower Ltd	2018
23	Musarara	0.45	49	0.2205	Amahoro Energy	2013
24	Mukungwa Ⅱ	2.5	73	1.825	Prime Energy	2013
25	Rukarara Ⅱ	2.2	52.5	1.155	Prime Energy	2013
26	Nyirabuhombohombo	0.5	35	0.175	RGE Energy UK ltd	2013
27	Giciye Ⅰ	4	40	1.6	RMT	2013
28	Giciye Ⅱ	4	40	1.6	RMT	2016
29	Ruzizi Ⅱ	12.00	89	10.68	GoR	1984
	Total	**104.16**		**51.26**		

Source: *LCPDP REPORT, June 2019. COD: commercial operation date.*

Kavumu SHPP (0.334 MW) Powerhouse and Penstock under Construction, Nov 2019 (*Photo by ZHAO Jianda*)

36 MW Ruzizi Ⅱ plant operated by SINELAC, have been in operation on the Ruzizi river cascade since 1958 and 1989,respectively.

EGL was the promoter of the Ruzizi Ⅱ project and this is one of the significant achievements in energy cooperation between the Great Lakes countries. This plant, which supplies electricity to DRC and Burundi as well as Rwanda, is to be refurbished. The refurbishment study is being undertaken by the consultant Ingerop International, and institutional reforms are ongoing by the legal company Nodalis. The rehabilitation works is being funded by AFD/EIB/KfW donors.

A further 26.6 MW of hydro capacity will be available from Rusumo Falls, which is being constructed on the border of Rwanda and Tanzania as part of the Nile Basin Iniative. (The total capacity will be 80 MW, to be shared between the three countries). Work began on the project in 2017, and it is progressing well.

Hydropower Projects(>50 MW) to be Constructed & Rehabilitated

Under Construction: GoR—Rusumo, 80/3 MW. IPPs—Rwaza-Muko:2.6 MW;Nyundo:4.5 MW;Rukarara V & Mushishito: 5 MW;Kavumu: 0.334 MW;Kigasa: 0.195 MW.

Planned: GoR—Nyabarongo II: 43.5 MW;Butamwa PSP: 40 MW; Juru PSP: 40 MW; Rusizi III: 147/3 MW.

IPPs—BaseI &2: 5.8 MW; Ngororero: 2.4 MW; Ntaruka A: 2 MW; Rwondo: 2.6 MW; Rukara VI: 9.7 MW; Mpenge I & II: 0.951 MW; Nyirahindwe I&II: 1.268 MW; Nyirantaruko: 1.263 MW; Muhembe: 0.323 MW.

To be Rehabilitated: GoR—Ntaruka HP: 11.2 MW. IPPs—Mukungwa II: 2.5 MW;Rugezi:2.2 MW;Keya:2.2 MW;Nkora:0.680 MW;NBBO:0.500 MW.

IV. Small hydro

Definition

- Pico: <50 kW.
- Mini: 50–500 kW.
- SHP: 500–10,000 kW.
- Big: >10,000 kW.

There are four small hydro plants in operation, with a total installed capacity of about 10 MW.

The US Trade and Development Agency (USTDA) has provided grand financing to Amahoro Energy for the phased development of 12 MW of run-of-river capacity;a new 5 MW scheme is to be built, and five existing small hydro schemes will be upgraded. Technical assistance will also be extended to DC HydroPower of Rwanda by USTDA for two run-of-river hydro plants with a combined capacity of 3.5 MW.

Meanwhile the Rwandan renewable energy company Ngali Energy began work in 2016 on the 2 MW Ntaruka hydro scheme in the south of the country.

The 2.6 MW Rwaza scheme on the Mukungwa river has been under construction since 2017. DC Hydropower plans to develop the 1.1 MW Rwaza 2 scheme.

Other small schemes in the pipeline are Ruhondo(2.4 MW) and Ngororero(2.6 MW).

A total of 333 micro hydro sites have been identified in the country, which would have a combined capacity of 96 MW. Twenty eight of these are now under construction, which total 20 MW of capacity.

Ten of the schemes, totalling about 10 MW, are being developed by Cooperation Technique Belge and the private power producer Energy of Nyaruguru. These are likely to have individual capacities of up to 500 kW.

List of Ongoing Hydropower Projects in 2019

No	Name of Projects	Capacity(MW)
1	Nyabarongo II	43.5
2	Kigasa	0.195
3	Rukarara VI	6.7
4	Rusumo Falls	80 (shared)
5	Rusizi III	147 (shared)
6	Giciye III	7.2
7	Nyundo	4.5
8	Ntaruka A	2
9	Nyirantaruko	1. 2
10	Base II	2.9
11	Rwondo	2.6
12	Ngororero	2.4
13	Base I	2.9
14	Nyirahindwe I	0.909
15	Nyirahindwe II	0.359
16	Muhembe	0.325
17	Kavumu	0.334
18	Rukarara-Mushishito	5
	Total ongoing hydro	**158.72**

Kavumu SHPP (0.334 MW) Channel under Construction, Nov 2019

(Photo by ZHAO Jianda)

V. Barriers in Water Resource Management

• Over-exploitation of water resources (water demand keeps increasing for agriculture, domestic & industrial uses).

• Land use practices (erosion to wetlands (sedimentation in rivers & lakes).

• Pollution(untreated waste, use of chemical fertilizers, etc).

• Invasive species for lakes & rivers (Water hyacinth, aquatic weeds).

• Climate change (prolonged droughts & floods).

• Insufficient water resources especial in western and south provinces.

• Way forward: Policies have been put in place to mitigate the above mentioned barriers.

VI. Main Challenges in Hydropower Generation

• Sedimentation due to geographical features of the country. Silt in rivers catchments.

• Great reduction in flowing water during dry season.

• Cascaded Hydropower Plant.

• Human activities.

• Lack of adequate investment for IPPs project implementation.

• Lack of integrated planning among water users.

• Lack of technological know-how skills.

• High Generation cost (limited inhouse expertise, a land-locked country which increase the importation cost).

• Gap available in Meteorological data available.

VII. Future outlook

Public and private investments in the long-term rehabilitation and expansion of the electricity and water supply system will contribute to the future economic growth and social stability of the country.

The importance of integrated watershed management is well recognized, since restoration measures were required to restore the Ntaruka scheme to its full capacity.

The Government has set a goal of supplying 70 per cent of the population with electricity by 2018. Hydropower will remain an important part of the national energy mix, providing about half the national capacity.

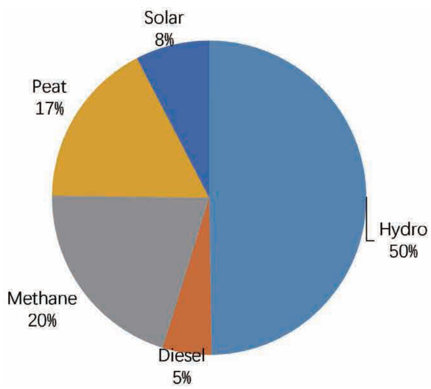
Rwanda's geothermal resources are not yet fully proven, but studies undertaken to date indicate a likelihood to discover a commercially viable resource with about 700 MW of capacity.

A pilot plant has demonstrated the commercial and technical feasibility of extracting methane gas from Lake Kivu. This could also provide about 700 MW of capacity. About 200 MW of capacity could be provided by peat resources, and the private sector has demonstrated interest in developing this resource.

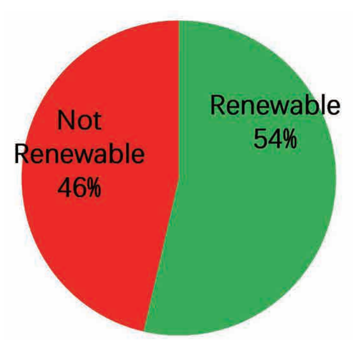
Future developments will include commissioning of the 30 MW thermal LFO plant, development of the 80 MW Hakan peat power plant in Gisagara, the 50 MW Symbion and 75 MW Kivuwatt Ⅱ methane plants, as well as various micro hydro plants(totalling 40 MW), and further imports of electricity from Kenya(30 MW).

Currently, many other projects are in the pipeline, including peat, methane gas, hydropower and solar, which are being developed by independent power producers who are giving support to the Government of Rwanda to help meet its power generation and electrification targets.

Total generation by 2024: 556 MW.



Energy Mix 2024



Renewable energy 2024

By 2024, Methane and Peat share will increase. Hydro-power will be half of the power mix. Diesel power plants will be reduced to a status of emergency sources, restricted to only 5%.

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5 Trends in Hydropower for 2019

By Elizabeth Ingram

The end of the year is the perfect opportunity to look back, to reflect on what has passed, before the new year when we naturally focus on the future.

As I reflect on the news and issues we've covered on Hydro Review over the past year, I can identify five big trends I've noticed for the global hydroelectric power industry in 2019. They are:

A stronger focus on climate change, and solutions

Climate issues were huge this year, and not just because of Greta Thunberg. The hydropower industry has been keeping a weather eye on changing climate patterns for decades. But this year, many companies decided to step up and make significant commitments to changing their practices to help deal with some concerning trends.

Just two recent examples of this focus are Icelandic utility Landsvirkjun and technology company Voith. Landsvirkjun recently announced a plan to become carbon neutral by 2025, five years sooner than it originally proposed. Landsvirkjun operates 18 power stations and generates three-fourths of this energy form hydroelectric power, geothermal energy and wind. And Voith – the parent company of Voith Hydro – said that from 2022 onwards, none of its locations around the world will leave a carbon footprint. Voith is switching to purchasing carbon-neutral electricity in the near future and offsetting unavoidable carbon emissions with compensation measures.

More investment in hydro

This trend combines banks providing financing for hydro and companies buying hydropower assets worldwide.

The European Investment Bank (EIB) very recently approved €8.1 billion (US$9 billion) in financing for climate action, sustainable development, health and education investment across Europe and around the world. This includes support for renewable energy projects, such as hydro. Additionally, the Inter-American Development Bank has placed the planned modernization of the 300-MW Francisco Morazan (also known as El Cajon) hydroelectric complex in its pipeline for possible financing.

And Nexif Energy has acquired 94% of the equity of the Song Giang Hydropower JSC, a company that owns two cascading run-of-river hydropower projects with a total capacity of 49 MW in the Khanh Hoa province of Vietnam. In the U.S., H2O Power and TCorp have completed a transaction in which TCorp will acquire an interest in H2O Power's eight Canadian hydroelectric generating assets.

Small hydro

This is definitely an ongoing trend, rather than a new one for 2019.

In the first half of December alone, we reported on financial completion for a 15 MW hydro plant in the

Solomon Islands, opening of a small hydro plant in Lao PDR, and a permit issued to study development of a new small hydro project in the U.S.

This activity is just the tip of the iceberg, with many countries – such as Ecuador and Ghana — looking into the development of multiple small hydro projects. And Latin America and the Caribbean has a goal of reaching at least 70% of renewable energy, which includes small hydro, in electricity by 2030.

Technology innovations

This has been a fun year, learning about so many new and unique technologies or fun applications of existing technologies to hydropower. Just last week, I reported on a $40 million funding opportunity from the U.S. Department of Energy that includes innovation and technology transfer, with a focus on small businesses. And earlier this month I learned about research at NASA that revealed using data from satellites can save emergency responders an average of 9 minutes per emergency response, with this technology tested using the 2018 failure of the Xepian-Xe Nam Noy dam in Laos.

The above two example are just the tip of the iceberg. Check out the Technology/Equipment tab on Hydro Review for even more. And keep your eyes open on HydroEvent.com, and on this page, for information about the exciting Initiate! program we will be unveiling at HYDROVISION International 2020. Initiate! is a program where startup companies are chosen by a committee to come pitch their solution/product to a panel of experts. Think Shark Tank. More details to come.

Dam and powerhouse rehab

Seismic issues around dams continue to be a concern, but that's not the only type of rehabilitation work happening in the industry, with many utilities rehabilitating their powerplant equipment.

Keeping dams safe is never going to lessen in importance, and infrastructure is aging. Knowing this, the U.S. Bureau of Reclamation and the California Department of Water Resources announced plans to upgrade the B.F. Sisk Dam for seismic safety. In the Pacific Northwest of the U.S., Nicholson Construction recently was named general contractor by Grant County Public Utility District for remedial foundation drain work on its Priest Rapids and Wanapum dams. Nicholson will recondition foundation drains on both dams, which may be experiencing reduced flows or blocking by unknown materials or foreign objects, including calcium carbonate deposits.

Recent powerplant rehabilitation work announced includes Copel's plan to upgrade its 1,240 MW Governador José Richa hydropower plant in the state of Paraná in Brazil and a recent agreement to modernize aging equipment and improve power generation capacity at the 180 MW Uch-Kurgan hydropower plant in the Kyrgyz Republic. The latter will increase the plant's generating capacity by 20%

What trends have you noticed? Is there something I've missed that we should be covering? Email me at elizabeth.ingram@clarionevents.com.

(Source:HRW)■

Bui Power Authority Completes 45 kW Small Hydro Station in Ghana

The Bui Power Authority announces it has completed work on the 45 kW Tsatsadu Generating Station, which it calls Ghana's first micro hydropower plant.

The plant, on the Tsatsadu Waterfalls in the Hohoe District of the Volta Region, has the possibility of adding another 45 kW turbine in the future, BPA says. Construction of the facility was completed under the Ministry of Energy's renewable energy initiative.

The run-of-river Tsatsadu project consists of a concrete diversion weir, an intake structure, a diversion channel, a forebay, a steel penstock, a powerhouse and a transmission line to tie the electricity generated into the national distribution grid. The weir diverts part of the river flow through an intake channel into the diversion channel. The diverted water goes through a 300 mm diameter penstock to the base of the hill where the powerhouse is located. The water returns to the river downstream from the waterfall.

In 2005, the Ministry of Energy entered into a memorandum of understanding with the United Nations Industrial Development Organization (UNIDO) and International Network on Small Hydro Power of China (IN-SHP) to undertake studies to develop the existing small hydro power potential in the country. The Tsatsadu Waterfalls site was selected to be developed as a pilot project. UNIDO donated a 30 kW Turgo turbine and associated electromechanical equipment for the project. The Ministry of Energy appointed BPA in 2016 to develop the Tsatsadu Micro Hydropower Project on its behalf. BPA then reviewed all available information on the project, including site assessment surveys, detailed topographical surveys and the development of engineering drawings for the project.

The project was upgraded from a 30 kW stand-alone system to a 45 kW grid connection system, and new equipment was procured to accomplish this, BPA says.

The Ministry of Energy directed BPA to constitute a technical committee to implement the project. The committee comprised representatives of the Renewable and Alternate Energy Directorate of the Ministry of Energy, Energy Commission, United Nations Development Program – Renewable Energy Technology Transfer (UNDP-RETT) Project Implementation Unit and Electricity Company of Ghana (ECG).

(Source:UNIDO)■

Miljacka—A Century-Old Beauty Still at Full Power

By Marijo Kraljevic

The 24 MW Miljacka hydroelectric project in Croatia has operated continuously since 1906, originally to provide electricity for a carbide factory. For its historic significance, Miljacka was inducted into the Hydro Hall of Fame in 2018.

The hydropower plant now called Miljacka (formerly named Manojlovac until the 1990s, after the waterfall at which it was built) has an installed capacity of 24 MW and is located on the Krka River in Croatia. It is one of the biggest hydropower plants on this river and has been constantly in operation since 1906.

Another thing that makes Miljacka special is the fact that it is located in the beautiful Krka National Park, famous for numerous wonderful waterfalls. In its operation, Miljacka complies with strict norms for protecting the environment and nature, as required by the status of the national park.

A noteworthy feature of the hydropower plant's micro-location is the cave Miljacka 2, which is about 100 m downstream from the Miljacka waterfall on the right bank of the Krka River. It is home to many endemic and protected underground animals. The most attractive among them are an olm, a strictly protected and endangered species, and a long-fingered bat, whose colony with more than 4,000 individuals is one of the biggest in Europe.

Construction and first years of operation

The beginnings of Miljacka are connected to the company SUFID from Trieste, which bought the concession for the Manojlovac waterfall — about 15 km downstream from the town of Knin — at the turn of the 20th century from Girgio d'Andrea Galatti et comp, also from Trieste. Then it expanded its concession to the waterfalls of Brljan, Rosnjak and Miljacka, which together with Manojlovac have a 106-meter fall.

These waterways were used to form Brljan Lake above the waterfalls during the construction of the dam and power plant. From the lake, water is led to the turbines through a gravitational tunnel, which is 1,620 m long and has a diameter of 10.7 m.

The high-pressure derivation plant was built between 1903 and 1906 and it represented one of the biggest technological achievements of the Austro-Hungarian Empire. The project was designed by a famous engineer, Otto Titus Blathy, one of the leading men of Ganz and Co. from Budapest.

Because of its location, the entire

hydropower plant was built manually, and electromechanical parts were delivered from the Ganz factory in Budapest by train to Trieste, then by steamboat to Sibenik and finally by narrow-gauge railway and horse-drawn carriage to the construction site. It is especially fascinating that the gravitational tunnel was dug manually. The installation of the electromechanical parts of the power plant was carried out by experts from the Ganz factory.

Because of its construction complexity, the tunnel was built first. It was followed by an input device, surge tank and engine room in the end. Because of the intensive works and rather short construction deadlines, about 1,000 workers were constantly present at the construction site. They were confronted with unexpected problems, varying from dissatisfaction from the local peasants related to digging holes for the power line to conflicts with local authorities related to cutting down trees at the construction site.

The first generator at the site started working in 1906 and the remaining three in 1907, when the hydropower plant commenced with full operation. In the engine room were four aggregates with Francis turbines, each with a maximum power of 6,000 hp. But because of a special river regime (very low water level in summer), the plant's power was optimized at 15,000 hp. In that work regime, the aggregates were in operation until the 1950s without major repairs.

During its early days, Manojlovac was one of the biggest hydropower plants in Europe and a technological miracle of its kind. Namely, Manojlovac was then the only power plant in Europe from which generators were directly connected to a 30,000-volt power line, which is amazing even by today's technological standards. Such an approach didn't allow the slightest mistake because any inaccuracy in construction at such high voltage would lead to generator breakthrough. The insulation of the generator winding was subject to factory testing at 55,000 V, and it was able to endure a two-minute short-circuit!

A 35-km-long power line was used to transmit electricity generated in the first years of operation to the plant's only customer – SUFID's factory of calcium carbide and cyanamide (chemical fertilizer) in Sibenik, which was one of the biggest in the world by production until 1925. The hydropower plant did not have the possibility of consuming electricity for its own needs, so they used gas lamps to light the plant. It wasn't until before World War II that a small transformer of 30/0.4 kV and an aggregate with a 40-kW Pelton turbine were installed for the hydro plant's own electricity consumption.

The first employees at Manojlovac were people from the surrounding areas who mostly drew their knowledge on managing a hydropower plant from Giuseppe Franzotti, the Ganz engineer, who worked on the hydropower plant construction and became its first "head of plant." Because of its location, Manojlovac had employees of specific occupations in its first years. One example is a job called power line keeper, probably because of conflicts with local peasants, over whose parcels the power line passed.

Interestingly, the first description of this hydropower plant published was in an article by engineer Hugo Tenzer in the journal Elektrotechnik und Maschinenbau – Vienna, published in 1908.

Connection of Manojlovac and the carbide factory

Manojlovac's fate was closely connected to the carbide factory in Sibenik and the business of its first owner, SUFID. Thus, Manojlovac

Exterior of the powerhouse for the Miljacka hydropower plant

The Miljacka powerhouse contained four turbine-generator units when at full capacity

had a direct influence on the industrialization of Sibenik and that part of Croatia. The factory's operation was relatively intact during World War I (instead of mobilized men, women were employed for the first time), so generation continued successfully.

The first problems arose with the economic crisis in 1929. The Kingdom of Yugoslavia did not prolong the concession for the use of water to the SUFID factory, which made the Italian owners sell the shares to the French company La Dalmatienne.

The carbide factory worked at full capacity by 1939, which positively affected the development of that part of Dalmatia. Immediately before the start of World War II, Yugoslavia nationalized the factory, but the war stopped its planned further development. During the occupation by Italy, the factory and Manojlovac were in operation but with problems connected to the shortage of raw materials and more frequent outages caused by partisan diversions. Two original generators from that time are still in the hydropower plant, whereas the remaining two were taken to Sibenik for reconstruction during World War II by its Italian owners. One aggregate was cut and thrown onto the scrap heap, and the other was taken to Italy and never brought back.

From World War II to today

As World War II ended, the operators of Manojlovac began with preparations for the connection into a wider electricity grid, which was supposed to enable a more effective use of the power plant and the transmission of electricity for longer distances, which would lead to abandoning the autonomous (isolated) system of customer supply. The hydropower plants Jaruga on the Krka River and Kraljevac on the Cetina River were included in the wider electricity grid.

The first parallel operation of Manojlovac and Jaruga was achieved by the construction of the Lozovac substation in 1947. Manojlovac was included in the central Dalmatian electric power system in 1948 (together with Jaruga and Kraljevac). That was when it was finally enabled for the plant to be lit by electricity from the grid.

The first significant reconstruction of Manojlovac occurred between 1952 and 1956, when only one original aggregate remained in operation. At that time, the other three units were replaced by new ones (with 6.7 MW turbines). The modernized hydropower plant could, in the most difficult period, cover daily consumption peaks because the other two power plants constructed by then, Kraljevac and Jaruga, were in operation as run-of-river plants. During the 1960s and 1970s, Manojlovac was in operation without bigger overhauls and repairs. Then, during the 1980s, restoration of the power plant was conducted, as it was affected by the ravages of time.

During the Homeland War, Miljacka was on a temporarily occupied territory between 1991 and 1995. But in spite of bad maintenance in war conditions, it never completely stopped its generation.

Miljacka was renovated by 1997, and the new processor-based management and automation system was installed in it as one of the first hydropower plants in Croatia. Today, Miljacka with its four aggregates and the total capacity of 24 MW annually generates about 80 GWh of electricity on average.

The experience gained on Miljacka was precious for the development of the power industry in Europe, so that numerous others hydropower plants in Europe were built according to its principles.

Mario Kraljevic is an engineer with HEP Proizvodnja d.o.o., which owns the Miljacka facility.

(Source:HRW)■

UNIDO Release Small Hydropower Technical Guidelines

Vienna, 4 December 2019 - The United Nation Industrial Development Organization (UNIDO) has published Technical Guidelines for the Development of Small Hydropower Plants.

Small hydropower (SHP) is increasingly seen as an important renewable energy solution to meet the challenge of the electrification of remote rural areas. However, while most countries in Europe, North and South America, as well as China have high degrees of installed capacity, the potential of SHP in many developing countries remains untapped and is often hindered by the lack of good practices as well as SHP development standards on a global level.

UNIDO, in cooperation with the International Centre on Small Hydro Power (INSHP), decided to write the Technical Guidelines for the Development of Small Hydropower Plants to meet the demand from Member States. The guidelines address the current limitations of the regulations for the development of SHP plants by applying expertise and best practices from across the globe. The intention for countries to utilize these guidelines to support their current policy, technology and ecosystems. Countries that have limited institutional and technical capacities will be able to enhance their knowledge in developing SHP plants, thereby attracting more investment, while at the same time encouraging favourable policies and therefore subsequently assisting in economic development at a national level. The guidelines are a valuable asset for all the countries, especially in sharing the technical know-how and best practices between countries that have limited technical capacities.

The publication has five volumes and 26 parts, which can be taken as the principles and basis for the planning, designing, construction and management of SHP plants up to 30MW.

The Terms and Definitions specify the professional technical terms and definitions commonly used for SHP Plants.

• The Design Guidelines provide guidelines for basic requirements, methodology and procedure in terms of site selection, hydrology, geology, project layout, configurations, energy calculations, hydraulics, electromechanical equipment selection, construction, project cost estimates, economic appraisal, financing, social and environmental assessments—with the ultimate goal of achieving the best design solutions.

• The Units Guidelines specify the technical requirements on SHP turbines, generators, hydro turbine governing systems, excitation systems, main valves as well as monitoring, control, protection and DC power supply systems.

• The Construction Guidelines can be used as the guidance technical document for the construction of SHP projects.

• The Management Guidelines provide technical guidance for the management, operation, maintenance, technical renovation and project acceptance of SHP projects.

• The use of guidelines is highly recommended for training, education and practice in small hydropower development. Suggestions and recommendations for possible updates of the guidelines are very welcome.

(Source:UNIDO)■

Dam Removals: Rivers on the Run

By Richard A. Lovett

As the United States destroys its old dams, species are streaming back into the unfettered rivers.

Just outside the small town of Stabler in Washington, hydrologist Bengt Coffin surveys a mountain river that he helped to revive from a decades-long coma.

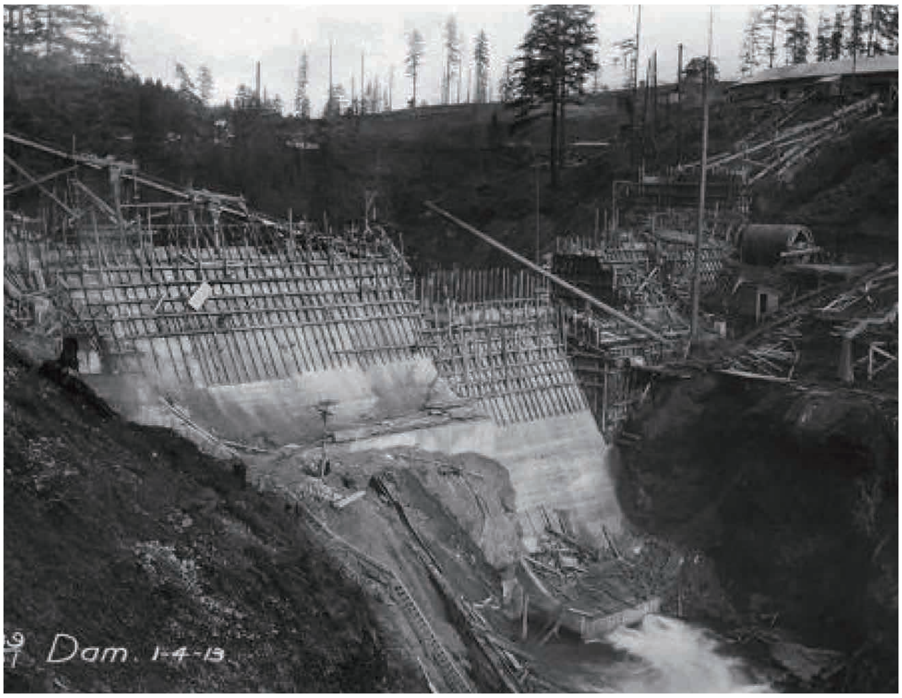
Today, the clear waters of Trout Creek run fast and cool between banks covered in young alder trees. But just five years ago, an 8-metre-high concrete wall blocked the river at this site. The dam and the reservoir behind it had tamed the river and made it difficult for endangered steelhead trout (Oncorhynchus mykiss) to reach their spawning grounds upstream.

In 2009, Coffin led the US Forest Service effort to remove the dam, and Trout Creek has since regained the look of a young river. Vegetation has covered the scars left by the dam and reservoir, and steelhead and other species have started to rebound.

The revival of Trout Creek is part of a growing trend in the United States. About half of the nation's roughly 85,000 known dams no longer serve their intended purposes, and an increasing number are being removed. Around 1,150 have gone so far, mostly in the past 20 years, according to a tabulation by the watchdog group American Rivers in Washington DC. In an era when many countries are still building dams, the United States is taking them out.

“It used to be a crazy idea. Now it's accepted,” says Amy Kober, director of communications for American Rivers.

Most of the demolished structures were lower than 5 metres, but in the past few years, projects in the Pacific Northwest have removed much taller ones. At the top end of the spectrum,



The 38-metre-tall Condit Dam was built on Washington’s White Salmon River in 1913

In 2011, the Condit Dam was destroyed by breaching the base of the structure

the US National Park Service is dismantling the 64-metre-high Glines Canyon Dam, the largest of a pair of big dams on Washington's Elwha River. Many of the larger dams were removed because their operators decided that it was too costly to bring the old structures in line with modern safety and environmental requirements.

The power companies' actions are boons for fish advocates who seek to restore populations of endangered species in the rivers. The dam-elimination trend has also provided an unanticipated research opportunity, because the projects have used diverse approaches to minimize the damage caused by unleashing huge floods of water and decades of accumulated sediment. Some efforts take a slow path, restoring river flow over months or years. Others use explosives and other engineering techniques to drain reservoirs within hours.

Data are still preliminary, but they suggest that both approaches can bring rapid benefits—not just to fish, but also to the habitat on which they depend. The rivers are rebounding at the sites studied so far, says Amy East, a geomorphologist with the US Geological Survey (USGS) in Santa Cruz, California. "We've seen a lot of resilience."

Out of commission

At Trout Creek, Coffin and his colleagues decided to take the cautious route when removing the ageing Hemlock Dam. Built in 1935, the structure provided power and irrigation for a nearby tree nursery that shut down in 1997. It had a fish ladder to allow animals to bypass the dam and swim upstream, but it was poorly built by modern standards and the number of fish using it had steadily declined.

A bigger concern was the reservoir, which had been steadily filling in with silt. By the time the dam was dismantled, the reservoir had become so shallow that it was possible to wade all the way across, says Coffin, waving a hand at mid-thigh level to show the depth of the water. In the midsummer sun, temperatures in the water could reach 26°C—too warm for steelhead, he says.

When the Forest Service decided to remove the dam, it was particularly concerned about the mud, sand and gravel that had built up in the reservoir. Coffin and others worried that flooding the river with all that sediment would harm the steelhead below the dam in Trout Creek. "All of our baby fish are down there," Coffin says. "We didn't want to decimate them."

The solution was to divert the river into a big pipe and then hire a fleet of dumper trucks to carry away the exposed sediment. In the process, the workers rediscovered the creek's original channel through the reservoir bottom and reinforced its banks with logs to stop them from eroding.

All those efforts seem to have worked. When water was first allowed to flow back through the old reservoir bottom, it initially ran muddy. But just seven hours later, Coffin's team documented the first steelhead venturing into the new channel above the old dam site. "It was that clear," he says.

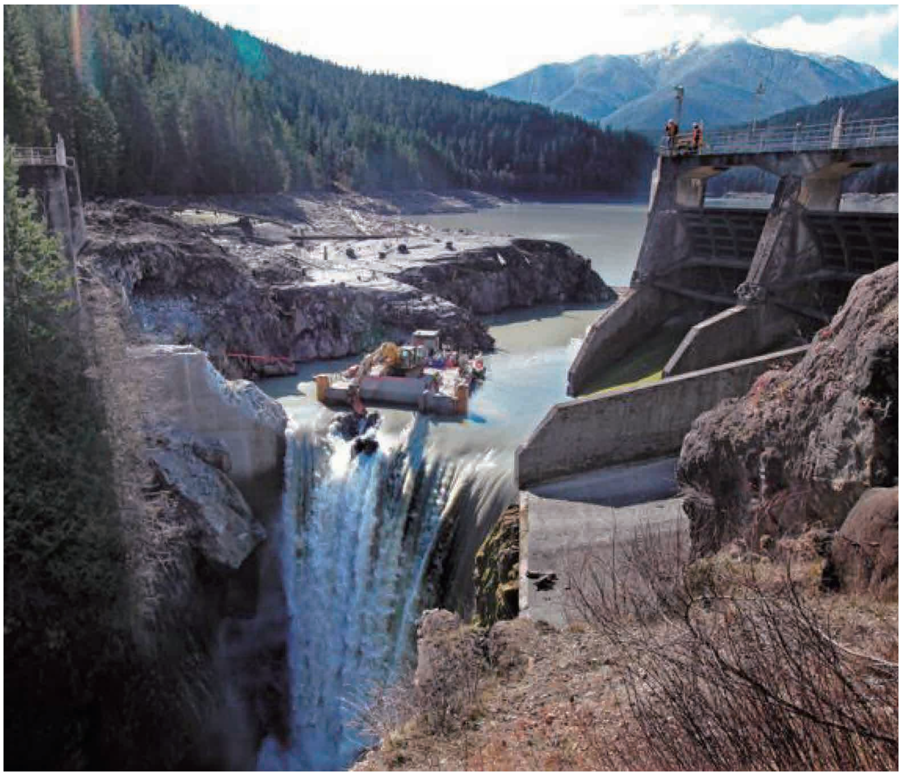
Since then, the number of steelhead in the river and its tributaries has more than doubled, says fisheries biologist Patrick Connelly at the Columbia River Research Laboratory in Cook, Washington, although he notes that fish populations are variable enough that it will take several years to know whether the trend will continue.

Returning steelhead are not the only signs of success. Just above the old dam site, Coffin winds his way through patches of alder trees that were planted after the dam was removed, then crosses a rocky beach to the river. The rounded stones range from the size of potatoes to loaves of bread, and make for tricky footing. But Coffin is thrilled to see them because none of these ankle-breakers was here when the dam was first taken out. “All of this washed in,” he says.

The cobbles provide nesting spots for the trout and a habitat for the insects that the fish eat. “People pay attention to the big animals,” Coffin says, “but the bugs are an important part of the system.” Reaching into the water, he plucks out a couple of rocks, turns them over and points out six types of insect clinging to the underside, including caddisfly larvae and a stonefly. “The year after the dam was removed, these wouldn't have been here,” he says with satisfaction.

Elsewhere in the Pacific Northwest, teams opted for much more extreme measures to remove the 14-metre-tall Marmot Dam on Oregon's Sandy River in 2007 and the 38-metre-tall Condit Dam on Washington's White Salmon River in 2011.

The dams, both nearly a century old, were too big to take the same approach as at Trout Creek, where it had cost nearly US$1 million to cart away 42,000 cubic metres of sediment. Marmot had nearly 20 times more sediment and Condit had double that of Marmot. Because it would be too expensive to dig out that material and carry it away, project managers opted for a more radical approach, colourfully described as “blow and go”, in which the dams were removed quickly, says Gordon Grant, a research hydrologist at the Forest Service's Pacific Northwest Research Station in Corvallis, Oregon.



An excavator chips away at Washington's Glines Canyon Dam in 2012

Steve Ringman/AP/Press Association Images

The results were impressive—but very different at the two sites. At Marmot, the sediment contained an equal mixture of sand and gravel. Once exposed to river action, it eroded out relatively quickly but sedately, with about half of it gone within 8 months. Researchers were surprised to find that the fish seemed little affected—the first curious salmon poked its nose back towards the former dam site within a day.

At Condit, the sediment contained a higher proportion of fine-grained material: 35% mud, 60% sand and just 5% gravel. The result was predictable in retrospect, but nobody anticipated it.

When engineers blew open a hole at the bottom of the dam, a jet of black liquid shot out as if from a giant fire hose. Instead of the expected flood of water, what came out was more like a mudflow, as waterlogged sediment from the reservoir slumped into the rapidly dropping water, then blasted downriver in a slurry that was as much as 28% sediment by volume. The reservoir lost its water and much of its sediment load in three hours. “It was almost like a volcanic event,” says Jon Major, a geomorphologist at the USGS's Cascades Volcano

Observatory in Vancouver, Washington. The 5-kilometre-long stretch of river between the dam and its confluence with the Columbia River temporarily became a muddy wasteland. With this kind of approach, says East, the slug of sediment wipes out everything, but the river can start recovering much sooner.

The National Park Service took a much more conservative approach to removing two large dams on the Elwha River, because the stakes were higher. The upstream portions of the Elwha drain more than 100 kilometres of pristine habitat on the north side of Washington's Olympic National Park. A river that large produces a lot of sediment: an estimated 18 million cubic metres was expected to escape from behind the dams, says Jason Dunham, an aquatic ecologist at the USGS office in Corvallis. That is the equivalent of filling eight typical American-football stadiums. And before the dams cut the number of salmon returning each year to around 10,000, the Elwha supported hundreds of thousands of fish.

“People pay attention to the big animals, but the bugs are an important part of the system.”

Unwilling to risk the blow-and-go approach on both dams, engineers opted for a compromise. They quickly removed the lower, 32-metre-high Elwha Dam, which contained only about one-sixth of the total sediment. But the upstream Glines Canyon Dam, which is twice as big, is coming out in a series of steps that have so far lowered it to a 9-metre stub of its former self. East compares the method to deciding whether to uncover a wound quickly or gradually. The approach on the Elwha, she says, is like “pulling the Band-Aid off slowly, over the course of three years”.

The good news in these giant projects is that scientists have not seen any serious harm from the feared releases of sediment. Instead, the rivers have proved unexpectedly efficient at flushing the worst of the mud downstream towards the sea, rather than letting it accumulate in river-choking mudflats. “It was not the big catastrophe people thought,” East says.

Emily Stanley, a river ecologist at the University of Wisconsin–Madison who has studied dam removals for more than a decade, agrees that it is hard to think of one that had “catastrophically awful” results. (The one exception, she says, was an event in the 1970s, when the demolition of a dam on the Hudson River allowed sediment containing high levels of toxic chemicals called polychlorinated biphenyls (PCBs) to escape from the reservoir and flow downstream.)

Data on the recent dam removals suggest that the fish are now coming back to the unfettered rivers. At Condit, fish were seen returning within weeks of the explosion. Two years later, the total exceeded 5,500, including steelhead and spring Chinook (Oncorhynchus tshawytscha), which had been effectively extirpated from the river, says Jody Lando, a quantitative ecologist with Stillwater Sciences in Portland, Oregon, who reported her results in May at an aquatic-sciences meeting in Portland.

Even on the Elwha, where the Glines Canyon Dam still impedes the river, East says that hundreds of salmon have been seen spawning in the lower dam's former lake bed. “That hasn't happened in over a hundred years,” she says.

In part, these successes may reflect the fact that the Pacific Northwest is a landscape built by geological disturbances—volcanic outbursts, landslides and floods. Local wildlife has had to adapt to such upheavals, and salmon do that by not always returning to the precise stream of their birth. “There's a fair amount that stray,” says East. It is those strays that repopulate any previously inaccessible habitat.

But other parts of the United States have also seen dramatic fish returns. On south-central Wisconsin's Baraboo River, the removal of a string of dams has allowed sturgeon to reach their former spawning grounds. And in New England, the destruction of two dams 7–9 metres high on Maine's Kennebec River and one of its tributaries has allowed Atlantic alewives (Alosa pseudoharengus) to repopulate 100 kilometres of previously blocked-off river. In 1999, before the first dam was taken out, no alewives were recorded in the upper part of the watershed, says Serena McClain, head of river restoration for American Rivers. By 2013, the annual run had rebounded to around 3 million.

Quake concerns

The next big structure destined for retirement is the 32-metre-tall San Clemente Dam on California's Carmel River. The 93-year-old dam, which was originally built to provide

A reconstructed section of Trout Creek in Washington runs through the site of a former reservoir in 2010, a year after Hemlock Dam was removed
Inter-Fluve/USDA Forest Service, Gifford Pinchot National Forest

drinking water, is coming out because of concerns over its safety during an earthquake. And there are expensive homes that could be flooded if even modest amounts of sediment were to escape and raise the stream bed, so the dam-removal plan seeks to avoid that, says East. Instead, the $84-million project will cut a notch in a ridge near the upstream end of the reservoir, then divert the water into a nearby drainage that rejoins the original river downstream of the dam. “It's a major engineering feat,” she says.

Researchers say that the surge in large dam removals in the past ten years has offered valuable insight into how rivers and their ecosystems respond to letting the water flow freely. But because every river and dam is different, it is hard to draw simple lessons that will apply in all situations, says Jim Pizzuto, a fluvial geomorphologist at the University of Delaware in Newark.

Still, the projects have shown that fish are remarkably adept at finding their way back. “If you un-build it, it seems like they will come back,” says Grant.

At least, that is the sense emerging from the limited data so far. Researchers are struggling to get detailed statistics on fish recovery — partly because removal projects tend to be planned according to engineering standards, not ones focused on fish and other river residents. And when fish assessments are done, they tend to be carried out by various state and federal agencies that share data only to a limited degree. “A lot of studies wind up on someone's computer, somewhere,” says McClain.

But that may be changing because ecological considerations are increasingly part of dam-removal projects. A case in point is Maine's Penobscot River, where a $62-million public–private partnership is buying dams and removing them to provide better access for fish to more than 1,600 kilometres of the river and its tributaries.

For a country once so bent on taming rivers, attitudes are quickly evolving. At the site of the former Condit Dam, a couple pulls into the car park and walks to a spot overlooking the water. “I come from a dam-building family,” says the man. “My father used to build things like this down in California — the Feather River, the Rubicon, the Yuba. I helped.”

He pauses.

“A hundred years is a great thing, isn't it? Now we're busily employing people to undo what our ancestors screwed up.” He stares silently for a moment at the ribbon of river, flecked with foam, 40 metres below. “It's a great thing.”

Richard A. Lovett *is a freelance writer in Portland, Oregon.*

(***Source:*** *Nature 511, 521–523 (31 July 2014) doi:10.1038/511521a*)

■

Europe is Demolishing its Dams to Restore Ecosystems

By Quirin Schiermeier

Most scientists welcome the dam-removal trend but some call for research into potential ill effects.

The Yecla de Yeltes Dam in western Spain supplied drinking water to local communities for half a century, until newer projects rendered it obsolete. Its demolition this month is the biggest dam removal project in the European Union so far—and is being hailed by ecologists as a milestone for river restoration efforts in the continent.

Such efforts are ramping up in many European countries—although some, notably those in the Balkan Peninsula, are on a dam-building spree. An initiative has begun to take the first continent-wide census of all dams. And although dam removal is generally welcomed by most scientists, some call for more research into potential ill effects.

Hundreds of thousands of dams and weirs, most small and many no longer in use, fragment Europe's rivers. The structures, some of them thousands of years old, have provided irrigation, energy and other benefits. But their presence also threatens the habitats of endemic fish and wildlife.

"Dams alter the natural characteristics of a river system," says Jeroen van Herk, a project manager with Dam Removal Europe, a group that promotes river restoration in the continent. "Long stretches of rivers, which once flowed freely from source to outlet, become a series of pools, hindering migrating fish from reaching spawning grounds in the upper reaches."

The Yecla de Yeltes is on the Huebra River, a 122-kilometre-long tributary of the Duero, which is one of the Iberian Peninsula's main rivers. Ecologists suspect that the 22-metre-tall dam, built in 1958, is partly responsible for the observed decline of the small freshwater fish called the sarda (Achondrostoma salmantinum), along with that of other endemic species, including otters and black storks (Ciconia nigra), which were once abundant in the area. Scientists in Spain are set to monitor whether the animals come back after the dam is removed.

Across much of Europe, rivers unfettered by artificial barriers are exceedingly rare. However, over the past 20–25 years, at least 5,000 small dams, weirs and culverts have been removed from rivers in France, Sweden, Finland, Spain and the United Kingdom, according to Dam Removal Europe. (There are few reliable records from other countries in Europe.)

Dam removal gained momentum after the EU adopted the Water Framework Directive in 2000. This legislation requires member states to improve the ecological protection of rivers and lakes, but as yet, only about half of rivers in the EU meet its environmental objectives, says Wouter van de Bund, an aquatic ecologist with the European Commission's Joint Research Centre (JRC) in Ispra, Italy.

In the United States, about 1,200 barriers have been dismantled in recent decades, with generally positive effects on local ecosystems, says Laura Wildman, a fisheries engineer with eco-consultants Princeton Hydro in South Glastonbury, Connecticut.

But restoration projects need to be monitored for negative effects, too, experts say. Decommissioning

The Yecla de Yeltes D am in Spain is being demolished in the largest project of its kind ever in Europe. *Credit: Dam Removal Europe*

existing river barriers might mobilize toxic sediment, or affect buildings or bridges downstream. And existing dams could help prevent the spread of invasive species such as the North American signal crayfish (Pacifastacus leniusculu) or the Asian topmouth gudgeon (Pseudorasbora parva). There are also historic dams, such as the Roman-built, 22-metre-high Prosperina Dam near Mérida in Spain, which need to be preserved as cultural heritage.

Dams were built with little regard for the impacts they might have on ecosystems, says Carlos Garcia de Leaniz, an ecologist at Swansea University, UK, who coordinates the US$6.2-million, EU-funded Adaptive Management of Barriers in European Rivers (AMBER) project. “We must not make the same mistake when dams are being removed.”

In collaboration with the JRC, AMBER is managing an exercise to map the location of all registered dams and weirs in 38 countries across the continent, including some that aren’t EU members. The project database currently holds information on 230,000 river barriers in 13 EU countries. Drawing from nine case studies, the project also aims to develop tools to help water authorities assess the costs, benefits and damage potential of dam-removal projects.

Inventories are important for planners and policymakers to understand the scale of issues caused by river fragmentation, says Wildman.

A number of small dams in the Netherlands, Denmark and Spain are scheduled for removal later this year. And starting in 2019, French scientists plan to systematically monitor the impacts of a removal project even larger than Yecla de Yeltes: the demolition of two hydropower dams in the Sélune Valley in Normandy, one 35 metres tall and the other 15 metres.

But while old barriers are being removed, new dams are built elsewhere. Some 2,800 hydropower plants are currently being planned across the Balkans — a threat, says van de Bund, to many of the continent’s last untouched rivers.

(***Source:*** *Nature 557, 290-291 (2018) doi: 10.1038/d41586-018-05182-1)*

■

“We Need to Focus on Getting Affordable, Modern Electricity to Everybody in Africa”

In this interview, Dan Klinck, managing director of East African Power, discussed the company’s Rubagabaga Hydropower Limited project in Rwanda, which won the African Power, Energy & Water Industry Award in the category of Small-Scale Sustainable Energy Project. This award was given during African Utility Week and POWERGEN Africa in Cape Town, South Africa, in May 2019.

Klinck also spoke at the East & Central Africa Mining Forum in Kigali in October 2019 as part of a panel discussion during a Power to the mines briefing with the theme “Building a commercially viable energy mix to support mining operations.”

Background on the Rubagabaga project

The Rubagabaga Hydropower Project is a 445 kW grid connected, run-of-river project in the northern province of Rwanda. It has made a very large impact on the local and regional communities by bringing renewable energy, jobs and improved livelihood to thousands of households. The project was developed by East African Power and is the first hydropower project to implement a containerized turbine and generator in East Africa.

Built almost entirely using simple man-power with little mechanical intervention, this project gives credit to the innovative and resourceful nature of the Rwandan people. In addition to the 445 kW delivered to the national grid, Rubagabaga has created more than 1,000 jobs over the span of its life thus far.

The ongoing introduction of energy linked directly to innovative, locally-initiated industries creates a dynamic and diverse economy and a sustainably healthy community with the power to impact Rwanda on a national scale.

With the assistance of the EEP Africa donor fund, East African Power signed a Power Purchase Agreement with the privatized Rwandan utility, Energy Utility Corporation Ltd (EUCL) and a Concession Agreement with the Ministry of Infrastructure in Rwanda.

What is unique about this project in your view?

What’s unique about this project is that it is a public-private-community partnership. It is one thing to build a project that just hooks up the line and adds it to the utility. For us we really focused in on what it would do to the community and its productive use equipment, its industrial park, its community library, its agricultural center of excellence – it wasn’t just power to line up the grid, it was something that really could bring the community together and make a difference and we’re very happy about that.

Congratulations on recently winning the African Power, Energy & Water Industry Award.

We’re very pleased with the award, this is very prestigious, and we are thrilled that Rubagabaga came to fruition. It’s been a lot of hard work, we’ve had 1,500 workers on this project, so this award is really for everybody who participated.

What is your message to the industry?

Focus on the people, in the end it is about fighting poverty through access to electricity. Whether you’re on grid whether you’re off grid, you’re doing what you can where you are with what you have. I think East African Power takes that practical approach to looking at things and I think we need to focus on getting affordable, modern electricity to everybody in Africa. That is what we are very passionate about doing.

This article was previously published on the East & Central Africa Mining Forum website. ■

Hydro Hall of Fame

The Hydro Hall of Fame recognizes extraordinary hydro achievement throughout the world, with a special emphasis on long-lasting facilities.

Hydro Review has been inducting legacy facilities in the Hydro Hall of Fame since 1995, designating plants that have been operating continuously for 100 years or more.

Together, this prestigious group demonstrates the long-lasting and significant contributions of hydroelectric plants, including clean renewable power, emission-free generation and reliability.

New inductees are honored at *HydroVision International*. For more about the event, please visit *HydroEvent.com*.

Qualification Criteria

To be considered for inclusion in the Hydro Hall of Fame, the plant must have been in continuous operation for 100 years or more. In addition, a representative from the plant must be present to accept the award at the opening keynote session of *HYDROVISION International.*

HALL OF FAME PAST INDUCTEES (*As of 2019*)

No.	Plant Name	Capacity (MW)	Owner	State, Country	Year in Service, Inducted
1	Ames	3.6	Xcel Energy	CO, USA	1906, 2013
2	Blewett Falls	24.6	Duke Energy	NC, USA	1912, 2018
3	Borel	11	Southern California Edison	CA, USA	1904, 2011
4	Bridge Mill Power Station	1.7	Blackstone Valley Electric Co.	RI, USA	1896, 1996
5	Byllesby	21.6	American Electric Power	VA, USA	1912, 2018
6	Cabot Station	62	First Light Hydro Generating Co.	MA, USA	1916, 2016
7	Cedar Falls	20	Seattle City Light	WA, USA	1904, 2019
8	Columbia Canal Hydro Plant	10.6	SCANA Corp.	SC, USA	1896, 1996
9	Croton	8.8	Consumers Energy	MI, USA	1907, 2007
10	DeCew Falls No.1 Hydro Plant	22	Ontario Power Generation	ONT, Canada	1898, 1998
11	Dewey Lakes	0.943	Alaska Power & Telephone	AK, USA	1902, 2015
12	Fulton Hydro Station	1.25	Reliant Energy	NY, USA	1884, 1997
13	Grand Rapids	6.7	Wisconsin Public Service Corp.	WI, USA	1910, 2010
14	High Falls	7	Wisconsin Public Service Corp	WI, USA	1910, 2010
15	Holter Dam	48	North Western Energy	MT, USA	19**, 2019
16	Holtwood	107.2	PPL Generation LLC	PA, USA	1910, 2010
17	Horseshoe	14	Trans Alta Corp.	ALB, Canada	1911, 2011
18	Kakabeka	25	Ontario Power Generation	ONT, Canada	1906, 2006
19	Kananaskis	19	Trans Alta Corp.	ALB, Canada	1913, 2013
20	Keokuk	125	Ameren UE	IA, USA	1913, 2013

No.	Plant Name	Capacity (MW)	Owner	State, Country	Year in Service, Inducted
21	LaBarge Dam and Powerhouse	0.85	American Energy Inc.	MI, USA	1901, 2001
22	LaGrande	64	Tacoma Power	WA, USA	1912, 2012
23	Lake Vyrnwy	0.130	Severn Trent Water	Powys, Wales	1903, 2017
24	Lanesboro Electric Power Plant	0.24	City of Lanesboro	MN, USA	1895, 1995
25	Les Cedres	135	Hydro Quebec	QUE, Canada	1914, 2014
26	Manitou Springs	5.54	Colorado Springs Utilities	CO, USA	1905, 2017
27	Miljacka	17.6	Hrvatska Elektroprivreda	Dalmatia, Croatia	1906, 2018
28	Mill Creek No.1	0.8	Southern California Edison	CA, USA	1893, 2002
29	Mio	4.96	Consumers Energy	MI, USA	1916, 2017
30	Miyashiro No.1	0.250	Chubu Electric Power Co.	QNG, Japan	1904, 2016
31	Morgan Falls	16.8	Southern Company	GA, USA	1904, 2004
32	Narrows	108.8	Cube Hydro	NC, USA	1917, 2018
33	Ninety-Nine Islands	18	Duke Energy	SC, USA	1910, 2010
34	Ocoee Dam No.1	22	Tennessee Valley Authority	TN, USA	1912, 2012
35	Pelzer Mills Lower Hydro Project	3.3	CHI Energy Inc.	SC, USA	1895, 1997
36	Petty Harbour	5.3	Newfoundland Power	NEW, Canada	1900, 2003
37	Piercefield Hydro Plant	2.7	Reliant Energy	NY, USA	1899, 2000
38	Pointe du Bois	75	Manitoba Hydro	MB, Canada	1911, 2016
39	Post Falls	14.75	Avista Corp.	WA, USA	1906, 2008
40	Prairie du Sac	31	Alliant Energy	WI, USA	1914, 2015
41	Prospect No.1	3.76	PacifiCorp	OR, USA	1912, 2012
42	River Mill	25	Portland General Electric	OR, USA	1911, 2015
43	Santa Ana River No.1	3.8	Southern California Edison	CA, USA	1899, 1999
44	Shawinigan-2	200	Hydro-Quebec	QUE, Canada	1911, 2011
45	Small Hydro of Texas Inc. Hydroelectric Plant	1.5	Small Hydro of Texas	TX, USA	1898, 1998
46	Snoqualmie Falls No.1	11	Puget Sound Energy	WA, USA	1898, 1998
47	Snoqualmie Falls No.2	41.7	Puget Sound Energy	WA, USA	1910, 2010
48	Stairs Station	1.2	PacifiCorp	UT, USA	1895, 1995
49	Stevens Creek	19	South Carolina Electric & Gas	GA, USA	1914, 2014
50	TW Sullivan Plant	16	Portland General Electric	OR, USA	1895, 1995
51	Upper Bonnington	66	Fortis BC	BC, Canada	1908, 2018
52	Vernon	32.4	TransCanada Hydro Northeast Inc.	NH, USA	1909, 2009
53	Victoria Falls	0.550	Newfoundland Power	NL, Canada	1904, 2017
54	Vulcan Street Hydroelectric Central Station	0.0125	City of Appleton	WI, USA	1882, 1996
55	Ware Shoals	6.2	Enel Green Power North America	SC, USA	1906, 2019
56	William Birch Rankine	74.6	Ontario Fortis, Inc.	ONT, Canada	1905, 2005

(Source:HRW) ■

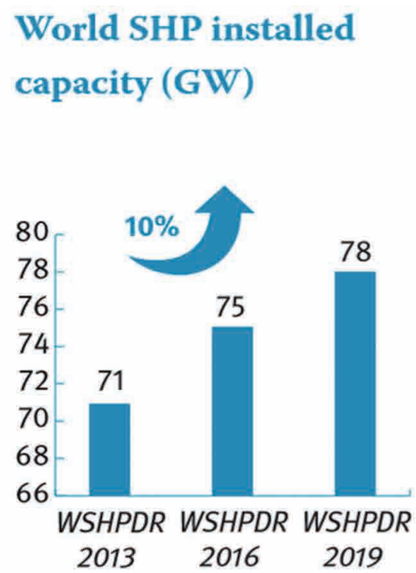
Photo credits: gregbrave -123rf.com

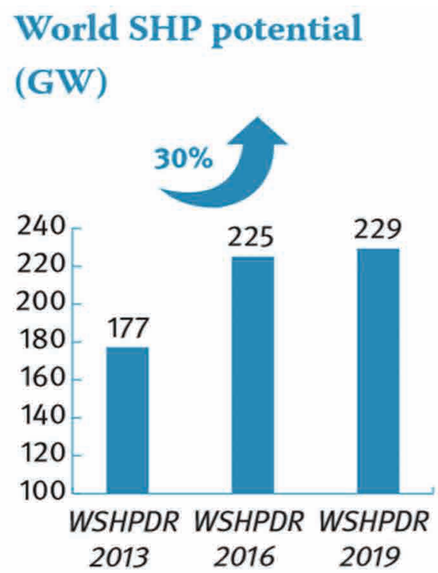
World Small Hydropower Development Report 2019 Released

The *World Small Hydropower Development Report (WSHPDR) 2019* is the result of an enormous collaborative effort between the United Nations Industrial Development Organization (UNIDO), the International Center on Small Hydro Power (ICSHP) and over 230 local and regional small hydropower (SHP) experts, organizations, engineers, academics and government officials across the globe.

Prior to the *World Small Hydropower Development Report (WSHPDR) 2013*, it was clear that a comprehensive reference publication for decision makers, stakeholders and potential investors was needed to promote SHP as a renewable and rural energy source for sustainable development more effectively and to overcome the existing barriers to development. The 2019 edition aims to not only provide an update but also to greatly expand on the 2013 and 2016 edition by providing improvements on data accuracy with enhanced analysis and a more comprehensive overview of the policy landscapes compiled from a larger number of countries.

Energy remains one of the most critical economic, environmental and development issues facing the world today. It is estimated that 1.06 billion people (13 per cent) worldwide, a predominantly rural population, still do not have access to electricity. Access to reliable and affordable electricity has an immediate and transformative impact on quality of life, access to basic services (e.g., health, education) and livelihoods. Small hydropower is a key building block towards the broader development goals associated with environmental sustainability, delivery of public services and poverty





eradication.

Despite the appeal and benefits of small hydropower (SHP) solutions, much of the world's SHP potential remains untapped (66 per cent). The global installed SHP capacity for plants up to 10 MW is estimated at 78 GW according to the *World Small Hydropower Development Report (WSHPDR) 2019*, an increase of approximately 10 per cent compared to data from the *WSHPDR 2013*.

SHP represents only approximately 1.5 per cent of the world's total electricity installed capacity, 4.5 per cent of the total renewable energy capacity and 7.5 per cent (< 10 MW) of the total hydropower capacity. Nonetheless, it plays a major role in improving many lives. This impact is shown in the *WSHPDR 2019* case studies.

The case study section is a new addition to the *WSHPDR*. It is comprised of 18 case studies of successful SHP implementation in a range of communities. The case studies add a more detailed, practical perspective on the transformative potential of SHP and the best practices. Case studies give specific examples of communities that are using SHP for productive purposes to meet their needs and improve quality of life. The purpose of this new section is to provide easy access to the learnings drawn from such experience, thus forming a knowledge base that can benefit communities, decision-makers and developers elsewhere.

■

HRC's Annual Report on Foreign Affairs in 2019 and Work Plan for 2020

Hangzhou Regional Center (Asia - Pacific) for Small Hydro Power (HRC)
National Research Institute for Rural Electrification (NRIRE)

In 2019, HRC earnestly studied and implemented Xi Jinping Thought on Socialism with Chinese Characteristics for the New Era and the Spirit of the 19th CPC National Congress and its third and fourth plenary sessions of the Central Committee. Under the leadership of the Ministry of Water Resources (MWR) of China and Nanjing Hydraulic Research Institute (NHRI) and according to the Implementation Plan on Cooperation of Energy and Rural Electrification for Countries Involved in the Belt and Road Initiative (BRI), HRC followed the Initiative and actively organized foreign-aid trainings, implemented international scientific and technological cooperation, consolidated the 4 overseas technology transfer centers, and fully promoted the international capacity cooperation, so the work on foreign affairs scored fruitful results.

I. International Training

To enhance the foreign-aid human resources development, deepen the South-South Cooperation, and promote exchange and cooperation among developing countries, especially for those along the "Belt and Road" in the fields of clean energy, water resources, small hydropower and rural electrification, and strengthen mutual understanding and enhance traditional friendship, HRC actively implemented foreign-aid trainings for developing countries. 13 trainings, seminars and workshops were held including 10 foreign-aid trainings and seminars entrusted by China International Development Cooperation Agency and the Ministry of Commerce of China and 3 seminars under the special fund for cooperation with neighboring countries. A total of 376 participants attended the trainings, seminars and workshops, who came from 42 countries, inclusive of Cambodia, Laos, Myanmar, Thailand, Vietnam, Indonesia, the Philippines, Malaysia, Mongolia, Sri Lanka, Lesotho, Ethiopia, Sierra Leone, Nigeria, Mexico, Dominica, Nepal, Namibia, Uzbekistan, Rwanda, Zambia, Ghana, South Africa, Comoros, R. Congo, Cote d'Ivoire, Djibouti, Mali, Guinea, Equatorial Guinea, Morocco, Panama, El Salvador, Venezuela, Botswana, Egypt, DPR Korea, Zimbabwe, Cape Verde, D.R. Congo, Grenada and Lebanon.

For the 10 foreign-aid trainings, seminars and workshops for developing countries entrusted by China International Development Cooperation Agency and the Ministry of Commerce of China, the participants came from developing countries of Asia, Africa and Latin America. The training languages included English, French, Russian and Spanish. The training topics covered water resources development & utilization, water resources management, SHP development, medium and small hydropower development & construction, hydropower station operation & management, rural electrification, sustainable development of rural communities, clean energy and so on. Among them, 4 seminars were held for countries along the "Belt and Road" and developing countries, including 1 ministerial workshop and another 3 seminars respectively for francophone African countries and Latin America & Caribbean countries. Training Course on Hydropower Operation and Management for Zambia was held in Lusaka for the first time, Training Course on Small Hydropower Technology for Rwanda was held in the fifth consecutive year, and the tailor-made bilateral training programs were implemented in China for Namibia and Uzbekistan separately.

Furthermore, 3 training courses under special funds for cooperation with neighboring countries were organized by HRC. They were Seminar on Integrated Water Resources Management for Senior Officials of Asian Countries, Training Course on SHP Technology for Lancang-Mekong Countries, and Training Course on Construction & Safety Management of Hydropower and Dam for Lancang-Mekong Countries.

In 2019, HRC maintained close exchanges and communication with many developing countries through foreign-aid trainings, while continuously expanding exchange channels, focusing on high-level visits and exchanges with other countries. Under the recommendation or witness of the governments, Memorandums of Understanding (MOU) were signed with relevant universities and scientific research institutions to further increase mutual political trust and lay a good foundation for practical technology sharing, project demonstration and technical promotion.

II. Exchange of Visits

1. Important Meetings or Conferences

(1) From May 7th to 8th, 2019, Sponsored by Department of International Cooperation, Science and Technology of the Ministry

List of Foreign-aid Training Courses in 2019

No.	Project title	Date/Days	No. of countries	No. of attendants
1	Seminar on Integrated Water Resources Management for Senior Officials of Asian Countries	March 14th –March 27th 14 Days	9	31
2	Training Course on SHP Technology for Lancang-Mekong Countries	May 6th – May 30th 25 Days	5	31
3	Training Course on Construction & Safety Management of Hydropower and Dam for Lancang-Mekong Countries	June 13th – June 26th 14 Days	5	33
4	Seminar on Water Resources Management and Ecological Small Hydropower Development for BRI Countries	July 18th – August 7th 21 Days	4	17
5	Seminar on Small Hydropower and Rural Electrification for the Francophone African Countries	August 7th – August 27th 21 Days	8	18
6	Seminar on Water Resources Development & Utilization and Water Environment Conservation	August 7th – August 27th 21 Days	3	16
7	Seminar on Small Hydropower and Sustainable Development of Rural Communities for Developing Countries	September 5th – September 25th 21 Days	8	19
8	Seminar on Electrification Mode Based on Clean Energy for BRI Countries	September 6th – September 26th 21 Days	6	15
9	Ministerial Workshop on Water Resources Management and Development Planning for BRI Countries	October 18th – October 24th 7 Days	8	17
10	Seminar on Water Resources Development and Utilization for Namibia	October 23rd – November 12th 21 Days	1	21
11	Seminar on Hydropower Development and Medium & Small-sized Hydropower Management for Uzbekistan	October 25th – November 13th 20 Days	1	23
12	Training Course on Hydropower Operation and Management for Zambia	November 11th – December 6th 30 Days	1	90
13	Training Course on Small Hydropower Technology for Rwanda	November 15th – December 5th 25 Days	1	45

of Water Resources (MWR) and co-organized by HRC and Lishui Municipal Government, the International Symposium on Greening and Upgrading Small Hydropower for Eco-environment Restoration, was held in Lishui with success. The symposium was supported by China-Europe Water Platform. It aimed at in-depth exchange and discussion on topics including green standards on SHP, eco-environment restoration and sustainable development of SHP, and sharing the cooperation results between China and Europe regarding SHP policies, standards and technologies with BRI countries. Attendees of the symposium included representatives from BRI countries like Laos, Thailand, Uganda, Guyana, Afghanistan, Pakistan, Nepal, etc., who are working in the field of hydropower and energy and the participants of Training Course on Small Hydropower Technology for Lancang-Mekong Countries. After the symposium, the Chinese and foreign representatives carried out site investigation to Dayang reservoir, Panxi hydropower station and the river ecological management project in Jinyun county, Lishui city.

(2) From June 4th to 5th, 2019, the First Special Meeting of the Joint Working Team of Lancang-Mekong Water Cooperation in 2019 was held in Kunming, Yunnan. As a member of the Chinese delegation, Director General Dr. Xu Jincai attended the meeting. Representatives from the six Lancang-Mekong countries had pragmatic and efficient

communication and exchanges. The parties fully affirmed the positive progress made in the Lancang-Mekong water cooperation and formulated the joint lead plan for six key areas of cooperation in the *Five-year Action Plan for Lancang-Mekong Water Cooperation (2018—2022)*. The 2019 intended application list of Lancang-Mekong cooperation special fund projects and a preliminary plan for the Lancang-Mekong Ministerial Roundtable on water cooperation were discussed and the *Minutes on the First Special Meeting of the Joint Working Team of Lancang-Mekong Water Cooperation* in 2019 and the Memorandum of Understanding on China Providing the Hydrological Information of Lancang River to the Other Five Member States under the Joint Working Team of Lancang-Mekong Water Cooperation had been signed.

(3) On July 18th, 2019, the summary meeting of the first youth backbones training of the project of National Key R&D Program Strategic International Scientific and Technical Innovation Cooperation called "China-Pakistan Joint R&D Center for Key Technologies of SHP and Rural Electrification", was held in HRC. Four Pakistani young engineers have finished their half-year research & study in China and presented the training results. They had exchanges on future training mode and contents, and intended to actively promote the follow-up cooperation with HRC.

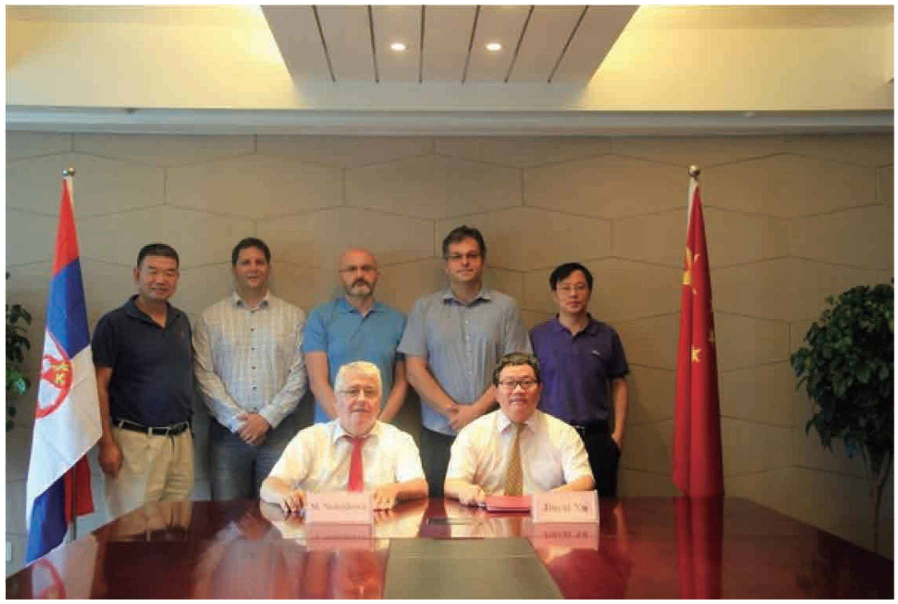
(4) On July 22nd, 2019, Director General Dr. Xu Jincai attended the Symposium Foreign Affairs on Water Resources in Wuhan organized by the Department of International Cooperation, Science and Technology, MWR. The representatives reported the work of foreign affairs in 2019, and proposed the work ideas on how to implement Xi Jinping's diplomatic thoughts, serve the general tone of the water resources reform and development, and serve the overall foreign policy of the country to dock the Belt and Road Initiative.

(5) On September 6th, 2019, Director General Dr. Xu Jincai attended the Workshop on the Belt and Road Joint Laboratory Construction in Beijing organized by China Science and Technology Exchange Center. The topics included the general proposal and arrangement of construction, planning, and development of the joint laboratories, the considerations on the objectives, tasks and mechanisms of construction & operation of the joint laboratories, and the consideration on the construction of the joint laboratories to serve the Belt and Road Initiative. Dr. Xu reported on the construction of the China-Pakistan Joint Laboratory for Small Hydropower under the Belt and Road Initiative.

Moreover, HRC staffs attended the Foreign Affairs Liaison Meeting on Pre-departure Education Material Revision, the 24th Annual Meeting of China South-South Cooperation Network, the Foreign Affairs Liaison Training Course of MWR, the Work Exchanges on Foreign-aid Training for the Yangtze River Delta Area, the Working Symposium on Foreign-aid Training in Zhejiang Province, Training Course on Foreign-aid Financial Settlement for Southern Area of China, China-ASEAN Workshop on Flood Control, Drought Relief and Integrated Water Management, and the Forum on Serving the Belt and Road Initiative and Cultivating International Water Talents, etc.

2. Foreign Guests Visiting HRC

In 2019, HRC received 5 delegations of 23 foreign guests in total, respectively from Vietnam, Pakistan, Serbia, and the Philippines for technical exchange and project cooperation.



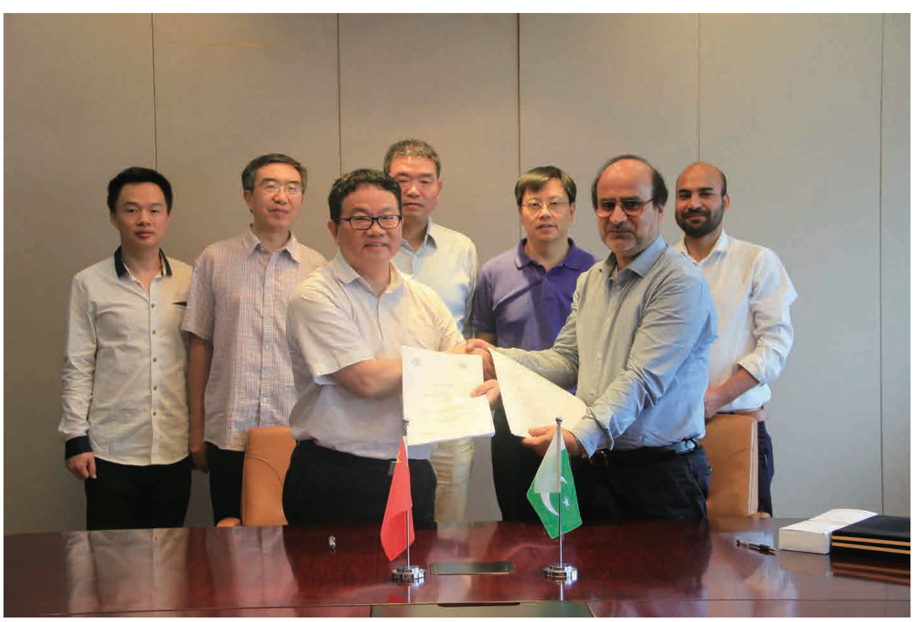
(1) On March 19th, 2019, a delegation headed by Mr. Do Ngoc Anh, Deputy Director of Institute for Hydropower and Renewable Energy (IHR) in Vietnam visited HRC for the exchange on implementing the Lancang-Mekong Cooperation Fund Project called "Technology Sharing and Capacity Building on Hydropower and Dam Safety Management in Lancang-Mekong Countries".

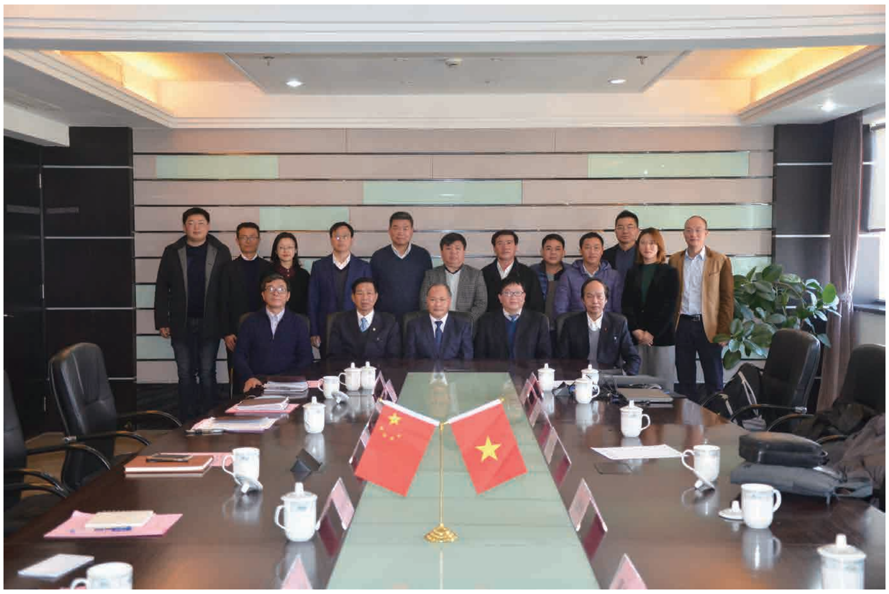
(2) From June 15th to 19th, 2019, a delegation headed by Dr. Raza Baqer, Director General of Pakistan Council of Renewable Energy Technologies (PCRET), visited HRC and HRC's technical innovation and equipment development & experimental base. Both sides had an in-depth discussion about the ongoing key project of international scientific and technical innovation and cooperation, called "China-Pakistan Joint Research & Development Center for Key Technologies of Small Hydropower and Rural Electrification", which reviewed the past achievements. Both sides signed the Memorandum of Understanding which will further promote China-Pakistan small hydropower technology exchange and cooperation.

(3) From July 1st-4th, 2019, a 5-person delegation from the University of Belgrade, Serbia visited HRC and HRC's technical innovation and equipment development & experimental base for renewable energy. Both sides had an in-depth exchange on the ongoing China-Serbia inter-governmental key project for scientific and technological innovation called "Joint Research on the Development Technology of Low-head Run-of-the-river Hydropower". Two sides made a conclusion of the preliminary results of the project and reached consensus on the follow-up work.

(4) From July 9th to 11th, 2019, a 3-member delegation headed by the President of PROCLEAN General Construction & Energy Consultancy and Development Company in the Philippines visited HRC. Both sides discussed the cooperation on the building-up of solar-powered irrigation systems, and the progress and follow-up work of the ongoing China-ASEAN Maritime Cooperation Fund project called "Renewable Energy Assessment and Demonstration for Islands of ASEAN Countries".

(5) From December 26th to 30th, 2019, a 11-member delegation headed by Dr. Hoang Van Thang, Chairman of VNCOLD, Vietnam visited HRC.





Both sides had in-depth exchanges and reached cooperation intention on dam and hydropower station safety, ecological hydropower and solar-powered irrigation device. Accompanied by HRC staffs, the Vietnamese delegation visited the hydropower stations designed by HRC and the equipment R & D and production base of HRC.

3. Outbound Visits of HRC

In 2019, HRC dispatched 4 delegations of 28 staffs respectively to Vietnam, Austria, Serbia, Zambia, and Rwanda for undertaking international cooperation, foreign-aid trainings, etc.

(1) From May 23rd to 24th 2019, at the invitation of ASEAN Centre for Energy, HRC staffs attended 26th Annual Meeting of ASEAN Renewable Energy Network. The HRC representatives introduced the ongoing China-ASEAN Maritime Cooperation Fund project called "Renewable Energy Assessment and Demonstration for Islands of ASEAN Countries" and presented the cooperation activities on renewable energy in Southeast Asia and the follow-up work. Besides, the HRC delegation communicated with the Executive Director of the ASEAN Center for Energy, exchanged views on further promoting the cooperation of ASEAN Maritime Cooperation Fund project, and clarified the work scope and the time line.

(2) From October 27th to November 3rd, 2019, HRC's delegation, headed by DG of HRC Dr. Xu Jincai, visited the University of Natural Resources and Life Sciences of Austria and the University of Belgrade of Serbia, carrying out exchanges on "Sustainable Hydropower Use and Integration in China and Europe (SHUI-CHE)" project under the China-Europe Water Platform(CEWP) and implementing the National Key R&D Program of China called "Joint Research on the Development Technology of Low-head Run-of-the-river Hydropower", an inter-governmental cooperation project between China and Serbia.

In Austria, the delegation paid visits to the Nussdorf low-head small hydropower plant, the channel experiment done by the University of Natural Resources and Life Sciences of Austria, the Freudenau low-head hydropower plant, and exchanged

deeply with the Austrian counterpart. The major topics included the progress of SHUI-CHE project under CEWP, and the assessment of green ecological restoration for small hydropower (SHP) and the policy compensation mechanism under the background of the SHP greening and rehabilitation in China's Yangtze River Economic Belt, etc. The follow-up work plan was also proposed initially between both sides.

In Serbia, the Seminar on Low-head Small Hydropower Technologies was conducted jointly by HRC and University of Belgrade. 32 representatives from Southeast European countries of Serbia, Montenegro, and Macedonia attended. During the seminar, "China-Serbia Joint Research and Training Center for Small Hydropower" was inaugurated. In addition, HRC delegation visited the laboratory of hydraulic machinery in the University and an irrigation channel on Danube in Kajtasovo, and collected relevant data. Then both sides had an in-depth discussion on the low-head hydraulic turbine simulation, the low-head hydropower development on irrigation channels, as well as the adaptability of SHP technology in southeastern Europe, etc., and clarified the respective responsibilities and cooperation contents in the follow-up work.

(3) From November 11th to December 6th, 2019, HRC organized Training Course on Hydropower Operation and Management for Zambia at the Sinohydro KGF (Kafue Gorge Lower) site, 100km away from Lusaka, the capital. 75 local staffs working on the site of KGL and 15 participants from ZESCO limited attended the 30-day training. It's the first time for HRC to organize a training course in Zambia, which is the 118th training workshop and seminar that HRC has organized to this date.

(4) From November 15th to December 5th, 2019, HRC organized Training Course on Small Hydropower Technology for Rwanda in Kigali, the capital. 45 participants from Energy Development Corporation Ltd. (EDCL), University of Rwanda, IPRC KICUKIRO, University of Technology and Arts of Byumba (UTAB), Prime Energy, Rwanda Mountain Tea, etc., attended the 25-day training. It's the fifth training course that HRC has organized in Rwanda, which is the 119th training workshop and seminar that HRC has organized to this date.

(5) From December 2nd to 5th, 2019, a delegation headed by Director General Dr. Xu Jincai went to Thailand to organize and participate in the Seminar on Dam Safety Management for Lancang-Mekong Countries. Dr. Xu presented Hydropower Station Safety and Technology Management, shared the situation of hydropower development and the status quo and management experience of hydropower safety, and organized the discussion on hydropower and dam safety management cooperation for Lancang-Mekong Countries.

In addition, HRC dispatched experts to join the NHRI delegations respectively to Italy, Sweden, Norway, Laos, Vietnam, Thailand, etc., to carry out international scientific and technological cooperation and exchanges.

4. Information Exchange

HRC edited and published *SHP News* in English, which was shared with over 70 countries, including about 40 countries along the Belt and Road. Besides, the database of training alumni has been updated, and the website released more than 100 pieces of news in Chinese and English. Contributions in Chinese and English have been submitted to Zhejiang Foreign Affairs Yearbook, China SSC Network (journal), and the Training Center of Ministry of Commerce.

III. International Sci-tech Cooperation and Technical Transfer

1. HRC submitted the achievement report of the China-Pakistan Joint Research Center on Small Hydropower, one of the sci.-tech. foreign-aid projects, inclusive of the promotion and application of follow-up results; completed the application for the China-Pakistan "Belt and Road" Joint Laboratory of Small Hydropower Technology, which was identified as one of the first 14 "Belt and Road" joint laboratories by the Ministry of Science and Technology; implemented the project of China-Pakistan Joint Research & Development Center on Key Technology of Small Hydropower and Rural Electrification, completed the organization of youth backbones training, the selection of demonstrative site, the visit reception from Pakistan, the arrangement of an interview with Xinhua News Agency on the youth backbones participating in the training, and the conduction of on-site mid-term inspections and annual summary.

2. China-ASEAN Maritime Cooperative Fund Project called "Assessment of Island Renewable Energy and Demonstration of Capacity Cooperation for ASEAN Countries" was carried out. HRC staffs attended the Annual Meeting of ASEAN Renewable Energy Network in Vietnam, introduced the situation of projects cooperation, and had exchanges with ASEAN Energy Center and renewable energy coordinators from ASEAN countries. HRC carried out the selection and confirmation of demonstration site, worked out the technical proposal of demonstration system of Wind-Solar-Water Hybrid Power Generation; completed the project called "China-Indonesia Technology Transfer Center for Rural Electrification Technology Based on Hydropower", which laid the foundation for setting up China-ASEAN Technology Transfer Center on Renewable Energy and Rural Electrification. Meanwhile, HRC participated in the implementation of "Technology Sharing and Capacity Building on Hydropower Station and Dam Safety Management", dispatched experts to Laos and Vietnam for site investigation, and organized in Thailand the Seminar on Dam Safety

Management for Lancang-Mekong Countries.

3. HRC implemented the project called "China-Serbia Joint Research on the Development Technology of Low-head Run-of-the-river Hydropower", gave warm reception to the delegation from Serbia and discussed the follow-up implementation plan on cooperation. HRC staffs visited Serbia, carrying out the technical exchanges and organizing the Seminar on Technology of Low-head Run-of-the-river Hydropower with the participation of professionals from Serbia and its neighboring countries. The "China-Serbia Joint Research and Training Center for Small Hydropower" was set up formally, investigation on the demonstrative site was carried out and technical proposal was worked out.

HRC continued to involve himself in the project called "Sustainable Hydropower Use and Integration in China and EU (SHUI-CHE)" under the framework of China-Europe Water Platform (CEWP), conducted comparative study on China-Europe Standard for Green Hydropower Evaluation, translated and compiled books on river ecological restoration, and conducted technical discussion with BOKU University. All the work laid a foundation for the establishment of SHP Technology & Equipment Development Base for West Asia, East Europe and Caucasian Region.

4. Both Training Course on Small Hydropower Technology in Rwanda and the Training Course on Hydropower Operation and Management in Zambia were held successfully. The number of training participants hit a record high, which further consolidated the foundation for the existing China-Africa Clean Energy & Rural Electrification Technology Transfer, Research and Training Center. HRC actively made the preparation for the establishment of these sub-centers in East Africa, West Africa, Southern Africa and North Africa.

Furthermore, HRC actively carried out strategic research on international cooperation in water and clean energy under the Belt and Road Initiative. Based on the previous research results, the report outlines and specific goals were proposed.

IV. Fully Promoting International Cooperation in Production Capacity

In 2019, HRC further expanded international cooperation of production capacity from point to area.

1. **In Africa:** With Kenya as the center, the international cooperation was radiated to countries and regions such as Ghana, Egypt, and D.R. Congo. Site investigation of Nzoia River Basin in Kenya was completed, the upstream and downstream developable resources were identified, and the feasibility study report of hydropower stations was compiled and submitted. Site inspection and evaluation of the cascade hydropower development in Ghana and three rehabilitation projects of hydropower in D.R. Congo were completed. Inspection and evaluation of the photovoltaic pumped storage power station in Egypt were completed with the joint effort of the partner.

2. **In Asia-Pacific region:** Tara Khola SHP project in Nepal was

accomplished, inclusive of the equipment installation instruction, commissioning and trial operation. Site investigation and negotiation on the potential hydropower projects as well as the bidding for rehabilitation projects were carried out. The design contract for a hydropower plant in Indonesia was signed with the related Indonesian partner. Investigation on the related hydropower projects in the Philippines was conducted and technical proposals were submitted. Three solar pumping projects of the Department of Agriculture of the Philippine were undertaken by HRC and the on-site construction was about to be completed. A Memorandum of Cooperation and an Implementation Agreement for the demonstration projects of solar water-purification system and solar fertigation system were signed by HRC with the Mindanao Development Agency of the Philippines.

In addition, on-site services for 5 hydropower stations in Turkey were completed, and the on-site installation instruction for Sirvan hydropower project was carried out. The on-site and after-sale services for Tara Khola hydropower project in Nepal was completed.

V. Work Plan for Year 2020

In 2020, HRC shall continue to follow the guidance of Xi Jinping Thought on Socialism with Chinese Characteristics for the New Era, and the ideas of water governance of the central government. According to the Belt and Road Initiative and the South-South Cooperation Initiative, HRC shall actively carry out the following work based on its Implementation Plan on Cooperation of Energy and Rural Electrification for Countries along the Belt and Road.

1. To Continue the High-Quality Foreign-Aid Trainings

(1) To carry out foreign-aid trainings/seminars and share technology and experience with 400 governmental officials and engineers from other developing countries by the way of “Bringing in” and “Going Global”. HRC shall focus on the implementation of seminars for BRI countries, as well as seminars in Rwanda, Nigeria, Cape Verde, Zambia, etc., achieving more high-quality training programs.

(2) To pay more attention on the statistical analysis of training questionnaire as well as the sharing of the country report. HRC shall also fully understand the water resources development strategy, management policy, laws and regulations, standard system, and the bottleneck and obstacle in BRI countries. Based on the data collected over years, Small Hydropower and Rural Electrification Development Report for BRI Countries would be compiled.

(3) To organize the workshop for the HRC Alumni from relevant countries in due time with the signing of Memorandums of Understanding, so as to promote the existing and newly applied international cooperation projects.

(4) To cooperate with large state-owned enterprises for making joint efforts in carrying out training for

the staffs of overseas hydropower projects.

2. To Sequentially Execute International Scientific and Technological Cooperation Projects and Forward the Construction of Four Overseas Centers

HRC shall earnestly implement the approved international cooperation projects, actively apply for new projects, and further consolidate the construction of four overseas centers.

(1) The Construction of "China-Pakistan Joint Research & Development Center on Key Technology of Small Hydropower and Rural Electrification".

HRC shall upgrade the existing laboratory of PCRET, make full preparation for the reception of Pakistani scientists to visit China, promote the implementation of demonstrative projects, writing papers, and the database construction in South Asia. HRC shall also complete the construction of "China-Pakistan Joint Research and Development Center on Key Technology of Small Hydropower and Rural Electrification" on time so that the center could be officially put into operation in Pakistan. HRC will promote the construction of China-Pakistan "Belt and Road" Joint Laboratory of Small Hydropower Technology as well as the implementation of subsequent projects. Combined with the construction of China-Pakistan Economic Corridor and Bangladesh-China-India-Myanmar Economic Corridor, HRC shall carry out extensive cooperation on small hydropower and rural electrification with all the south Asian countries.

(2) The Construction of "China-ASEAN Renewable Energy and Rural Electrification Technology Transfer Center".

HRC shall keep close contact with ASEAN Center for Energy, well implement the project of "Renewable Energy Assessment and Demonstration for Islands of ASEAN Countries", promote the China-Indonesia cooperation on seawater desalination demonstration with hybrid power generation of wind & solar energy for islands, and carry out hydropower and dam safety cooperation with Laos, Vietnam, Thailand and other countries along Mekong River, making hydropower and dam safety management a key cooperation area in the "Lancang-Mekong" sub-region. On the basis of the successful implementation of the BRI project in Zhejiang province, HRC shall continue to fully utilize the advantage of being the International Science and Technology Cooperation Base of Zhejiang Province for Renewable Energy and Rural Electrification and shall continuously apply for new international science-technology cooperation projects of Zhejiang province and Ministry of Science and Technology.

(3) To Further Promote the China-Africa Clean Energy and Rural Electrification Technology Transfer, Research and Training Center, and gradually establish the sub-centers in other parts of Africa.

Under the cooperation framework of "China-Africa Clean Energy & Rural Electrification Technology Transfer, Research and Training Center", HRC shall continuously cooperate with Addis Ababa Science and Technology University on disciplinary construction, vocational training and project demonstration. HRC shall also promote the project of South-South Cooperation Fund called "China-Africa Technical Transfer and Capacity Building on Rural Clean Energy", ensure project cooperation

funding and train center operators. At the same time, HRC shall further communicate with relevant cooperative organizations in Rwanda, Cote d'Ivoire, Zimbabwe, Egypt and other countries, sign cooperation agreements, and gradually establish the Sub-centers of Clean Energy & Rural Electrification Technology Transfer, Research and Training in East Africa, West Africa, Southern Africa and North Africa.

(4) Construction of SHP Technology & Equipment Development Base for West Asia, East Europe and Caucasian Region which shall be based on the "China-Serbia Joint Research and Training Center for Small Hydropower".

HRC shall continue to complete the project of "Joint Research on the Development Technology of Low-head Run-of-the-river Hydropower" and carry out international exchanges, seminars and demonstrations, take part in the project of "Sustainable Hydropower Use and Integration in China and Europe (SHUI-CHE)" under the framework of China-Europe Water Platform (CEWP), conduct comparative study on China-Europe Standard for Green Hydropower Evaluation, carry out a comparative study on the evaluation standards of green hydropower in China and Europe, and gradually expand cooperation with Serbia and other European countries. As a result, the "SHP Technology & Equipment Development Base for West Asia, East Europe and Caucasian Region" would be established.

(5) Relying on the "International Science and Technology Cooperation Base of Zhejiang Province for Renewable Energy and Rural Electrification", HRC shall apply for the "BRICS Countries" international cooperative projects, the cooperative projects with developed countries, and apply for the International Science and Technology Cooperation Base of China for Renewable Energy and Rural Electrification.

3. To Expand International Cooperation on Production Capacity

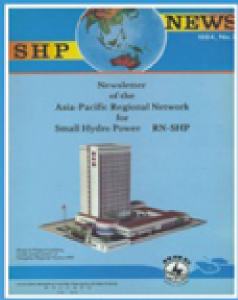
While implementing the existing projects with full success and maintaining the relationship with previous project owners, HRC shall make full use of the advantages of training participants in the water and hydropower industry and the convenient channel to collect and analyze relevant market information for the potential projects, and explore new business opportunities.

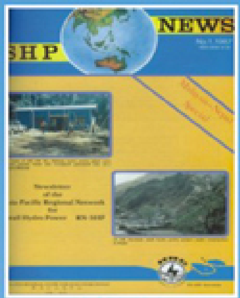
HRC shall focus on projects of hydropower engineering design and electromechanical equipment supply in D.R. Congo, the Philippines, Nepal, Indonesia, Ghana and Egypt and promote more concrete cooperation. HRC shall also cooperate with domestic and foreign competent enterprises to improve the capacity of project operation, and investment and financing capability, and get ready to meet the new diversified business modes in the international market. Besides, HRC shall strengthen the cooperation with EPC companies, and jointly explore overseas hydropower projects. Based on the demonstration of solar-powered irrigation systems in the Philippines, HRC would like to make more contribution to building up more projects of solar-powered irrigation system, water purification system, and fertigation system.

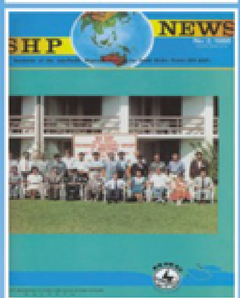
4. To Strengthen the Management of International Cooperation Projects and International Communication

HRC shall further regularize the management of foreign-aid training, international Sci-Tech cooperation, administration on foreign affairs, and reception of foreign guests. HRC shall also constantly improve the construction of policies and systems related to foreign-aid training programs and international cooperation projects. At the same time, HRC shall make full use of the HRC website and two magazines, namely SMALL HYDRO POWER in Chinese and SHP NEWS in English, the Column of the "Belt and Road" Cooperation on HRC website, HRC's Annual Report on Foreign Affairs, foreign-aid magazines, South-South Cooperation Network magazines, and various channels such as essay submissions and exhibitions to make better voices. HRC will strengthen communication with domestic and foreign media, plan publicity activities such as exclusive interviews and news reports; make a promotional video, and set up publicity efforts on international cooperation in the field of small hydropower and rural electrification.

(Source:HRC)■







About the Newsletter

"SHP News" was firstly published on May,1984 by HRC under the sponsorship of UNDP/UN-ESCAP-REDP(Regional Energy Development Program) in association with UNIDO. It was officially permitted for publication with an ISSN No.0256-3118(International Standard Serial Number). The major objective of the journal is for constant exchange of information and experience in the small hydro power(SHP) section among Asian-Pacific countries and/or worldwide. The comprehensive coverage of "SHP News" includes:

1. General information of SHP development in relevant developing countries.
2. State-of-the art and/or new ideas and trends of SHP technology in various countries or worldwide.
3. Technical experience of SHP development, including articles written by experts and staff.
4. Policy, regulations, institutional issues and finance approaches in the SHP section.
5. Market conditions of SHP construction.
6. Opportunities for SHP business, including technical consultations and services, equipment supply, etc..
7. Major events and international activities in the SHP section mainly in developing countries.
8. SHP news

Since 1984, 97 issues of "SHP News" have been edited, published and disseminated to more than 30,000 readers in about 117 countries in the world. Our readers include individual persons and institutional organizations, such as relevant government officials, experts(technicians), professors(teachers), SHP institution or NGO staffs, etc. Organizations may include government sections, universities, research institutes, SHP developers, consultant firms, operations, manufacturers, financial and legal institutions, etc. Our training workshop trainees are special readers and contributors of the journal. As of the end of 2019, There have been 2876 technical persons participated in 120 more training workshops held by HRC during the past 3 decades. Most of them keep contact with us and offer articles and /or information to the journal, forming a vital source of the publication.

We hope to continue obtaining enthusiastic concern, encouragement and support from our readers. Contributions,advertisement and comments made on the journal are warmly welcome.

Please click http://www.hrcshp.org/shp for more and contact our editor……

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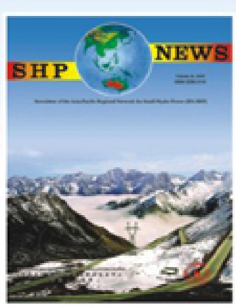

The Fuziling Reservoir Dam, located in Huoshan County, Anhui Province, China, was built in 1952. It is the first reinforced concrete multi-arch buttress dam in China, the first multi-arch buttress dam in Asia and the third in the world. The Chinese engineers designed and constructed this large-scale multi-arch buttress dam with international advanced level at that time.

This hydroelectric engineering project is a multi-purpose development scheme of flood control, irrigation, water supply, generation (7 units with total installed capacity of 42.9 MW), fishing, tourism and recreation.

Photo by: *Mr.Zhang Jiake*