OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

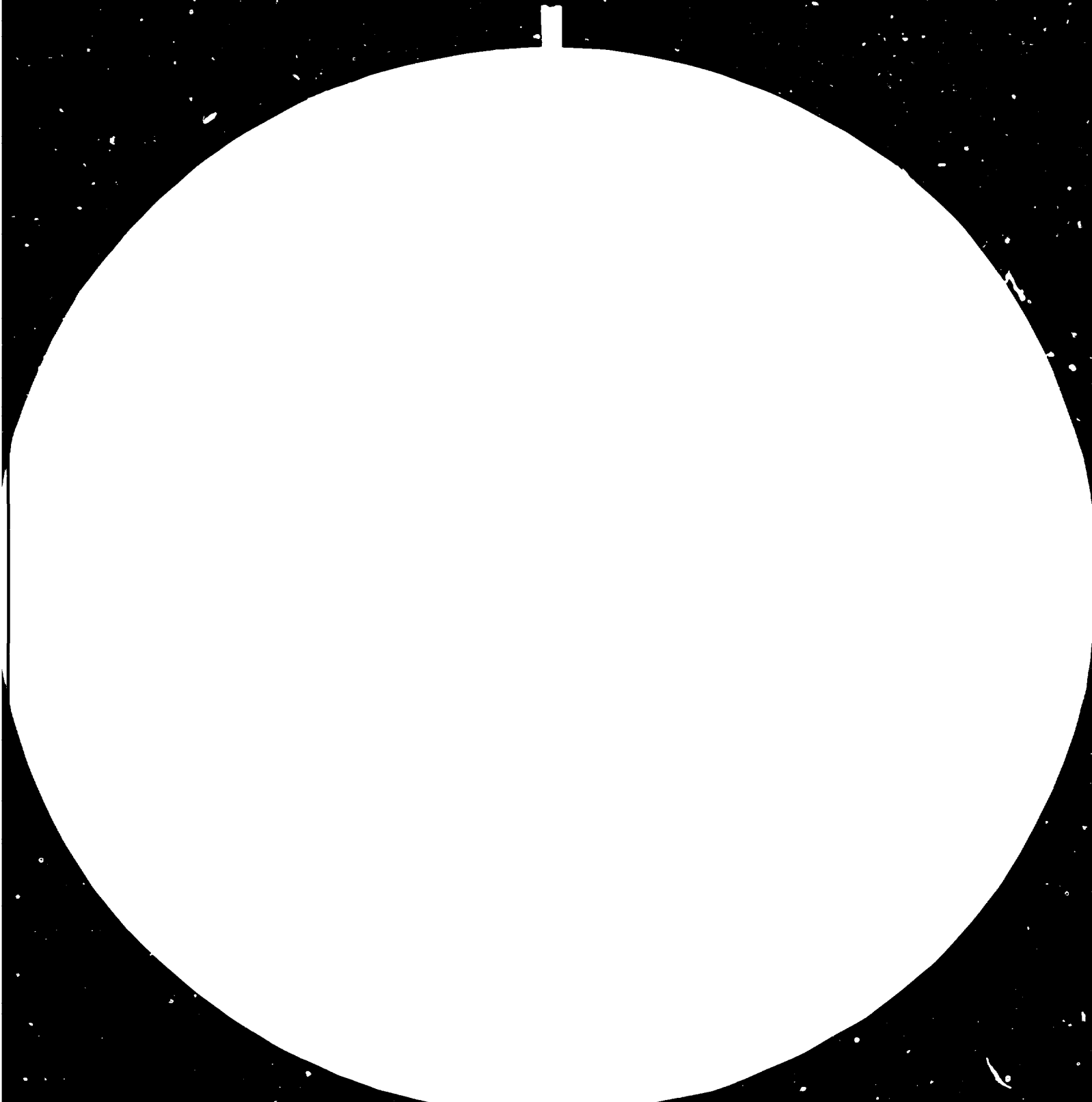
FAIR USE POLICY

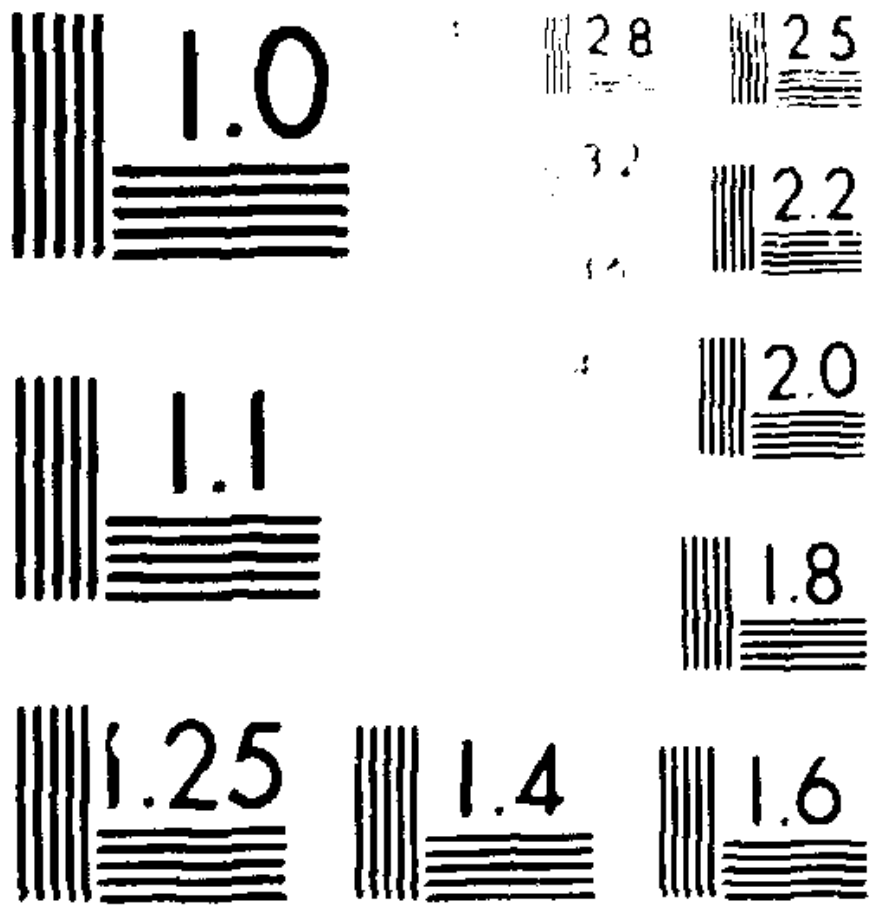
CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org




1.0
2.8
2.5
3.2
2.2
2.0
1.1
1.8
1.25
1.4
1.6

10598

Distr.
LIMITED

ID/WG.329/23
24 July 1981

ENGLISH

United Nations Industrial Development Organization

Second Seminar-Workshop/Study Tour in the
Development and Application of Technology for
Mini-Hydro Power Generation (MHG)

Hangzhou, China, 17 October - 2 November 1980

Manila, Philippines, 3 - 8 November 1980

SMALL HYDROPOWER IN CHINA *

by

Ministry of Water Conservancy **

* The views expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

** People's Republic of China.

V.81-27857

In China, hydropower station with total installed capacity up to 12 mw and each unit below 6 mw as well as small local grids composed mainly of small hydro generations are classified into small hydropower (hereinafter refered to as SHP).

By the end of 1949, there were only 2 mw of SHP throughout the country.

After liberation, under the great importance attached and active initiatives taken by the Chinese government, a rather faster development of SHP has been achieved. The level of development at the end of 1979 is shown in the following:

	No. of stations	Installed capacity Mw	Production in 1979 (Gwh)
Grand total for SHP in whole nation	89,000 (approx.)	6,300 (or more)	11,600
Stations with units less than 500 kw	88,000 (or more)	3,700	5,000
Stations with units larger than 500 kw	964	2,580	6,600

The total capacity of SHP makes up one third of the total of hydropower generations in china.

In addition, about twelve thousand SHP stations are under constructoin with a designing capacity of 3,500 mw.

The construction of SHP in China was initiated on the basis of nationwide movement of agricultural co-operation conducted in the early stages of 1950s.

Followed with the development of industrial and agricultural production in rural areas, and with the growth of national economy and raise up of technical levels, both the developing tempo of SHP grows faster, and the scale of stations becomes larger steadily.

The SHP put into operation in 1979 even overtake 1 million kw. The average capacity of each SHP station in whole nation raised from 32 kw in 1970 to 70 kw in 1979, and is close to 300 kw for stations under construction. If only units of 500 kw and over are accounted, the capacity of each plant has reached 2,670 kw on the average.

Many isolated SHP stations have been integrated step by step into a local grid or even state-run grid which is conducive to the reliability of electric supply.

The direction and path of development of SHP in China is determined by the actual concrete status of the country. An introduction of progress of SHP and main experiences gained in China will be stated in the following.

I. Utilization of decentralized energy potentials in building SHP to meet hastily the rural consumers.

There exists a superiority in hydropower in China. The total hydropower potential all over China is estimated at 680 million kw (an updated figure of 1980) in which 370 million kw is possible to be developed. Nearly 150 million kw is from small and medium scales, about 40-60% of which might be exploited and utilized recently. The resources of hydropower is widespread mostly in southwest and northwest China. Estimated in a rough term, there are 1,100 or more counties with a developable SHP potential exceeding 10 mw (in which, many are in the range of 30-50 mw) which make up 50% of the total counties in whole nation.

The SHP in China has been developed in conjunction with construction of water conservancy. A huge amount of hydraulic engineerings has been implemented in China, including 300 or more reservoirs of large scale, 2 thousands or more of medium scale, 150 large scale irrigation projects each with benefited farmland over than 300 thousand mu and innumerable navigations locks and dams, many of which might be incorporated with power generation at a low cost and quick construction.

China is vast in territory with an area of 9.6 million sq. km and abundant in energy resources. But, on the other hand, it is immense in population, and comparatively backward in economy. Huge amount of electrical energy is necessary for the development of industrial and agricultural production. It would be difficult to match generation with loads of massive rural areas in a short time if electricity were supplied merely by large and medium scale power stations built on the state investment. It is even impossible in the remote rural regions.

Full utilization of decentralized hydropower potential in China and combination of SHP generation to the development of water conservancy, building stations and feeding electricity locally, each station covering a certain stretch and forming an entire area spread with stations somewhat like stars in the sky or men on the chessboard, with less state investment and faster speed of construction, operating in connection with state run grid, could hasitly meet the requirement of electrical energy in decentralized rural areas and has promoted the development of agriculture. Today, there are 70% of 2,000 or more counties in the nation which have erected their own SHP, 720 or more counties obtaining electricity mainly from SHP, and 162 counties each with installed capacity over than 10,000 kw. High voltage transmission lines of 6-35 kv erected with SHP approach to 430 thousand km and low voltage distribution lines of 0.4 kv to 920 thousand km. Through the provision of power both by SHP and state-run grid, there are 100% of counties, 81% of people's communes, 62% of production brigades and 50% of production teams where electricity is available. In quite a few counties comparatively developed in SHP, such as Xianju County of Zhejiang Province, Nanping County which is densely populated with Tibetan Minority in Sichuan Province, Yungchun County of Fujian Province,, Changbai County where Korean minorities accommodated in Jilin Province, Laoding County of Guangdong Province, Tongcheng County of Hubei Province, Hengtong County of Hunan Province, Luchuan County of Guangxi Zhung Autonomous Region, Tengchong County of Yunan Province, etc., 100% of communes, 90% of brigades have been supplied with electricity in different levels and 85% of commune members home have brightened with electric light.

The rapid increase in supply of electricity in rural areas gives steady rise to numeral varieties of consumers of agricultural production and cultural life. At pre-

sent. drainage and irrigation of farmland. thrashing. insect control in agricultural production: milking. shearing, feed processing in animal husbandry: poultry breeding: processing of various agricultural and sideline products: county and comune-run industrial enterprises: rural cultutural life and lighting etc utilize electricity in different levels in different places. The total capacity of nationwide rural electrical facilities approaches to 60.000 mw. in which 26.000 mw are used for electric irrigation and drainage pumping station benefiting 390 million mu of farmland.

The total rural electric consumption in China exceeds 28 Twh or more in 1979, one third of which comes from SHP. Of the total consumption of electricity in rural areas. 43% is for drainage and irrigation. 16% for commune and brigade-run industries. 22% for processing of agricultural and sideline products and 19% for home lighting.

Summing up what stated above. the development of SHP in China has been becoming an inseparable important component in realization o rnization of agriculture.

II. Construction of electric stations relying on local administrations of different levels with less state investment, faster and greater benefit.

The special features of SHP are: small amount of engineering works, short duration of construction. simple technologies required and a small distance of feeding. Therefore, it can be built on reliance of localities in spurring the initiatives of communes and brigades.

As the territory of China is vast, the concrete conditions between north and south, hilly and plain regions, inland and remote areas. agricultural and pastural regions, vary greatly which results in a big margin of variation of capital investment in SHP, with a minimum specific cost of 600-800 yuans (R.M.B.) per kw and a maximum value close to or even over 2000 yuans. In general, the average value all over the country is likely to be 1,000-1,400 yuans per kw. According to informations from 27 engineerings. The specific cost per kw is: 550 yuan as minimum and 2,090 yuan as maximum, and the specific cost per kwh is 0.1 yuan as minimum and 0.48 yuan as maximum.

The breakdown costs of SHP are the following:

Civil engineering	40%~60%
Electro-mechanical	30%~50%

Transmission facilities are not included in all above costs.

Despite the fact that the specific costs of kw and kwh for SHP station are economical indicies of utmost importance in consideration of economic feasibility of that station, however. due to the acute shortage of electric energy in broad rural areas and finite financing from the state. close attention should in the same time be paid to the status it would be secured in the local national economies. (i.e.. the impact which might be brought forth by the SHP on the development of local production) and to the requirement of capital investment from the nation. and the long-term operating cost as well as integral economic benefits should also be considered as a whole.

Financing for the construction of SHP in China is mainly obtained from localities for different levels (including loans from banks). In general. the state investment only makes up one third of the total. and is mostly used for electro-mechanical equipments and principal construction materials.

The state capital investment on the SHP in five years from 1975 to 1979 averaged at 350 yuans kw only.

According to statistics from 23 counties each with installed capacity of over 10 mw in Guangdong Province, the financing for stations of total capacity 311 MW is 335 million yuans in which the capital investment from the state is 76.54 million yuans, averaged at 240 yuans per kw, only about one fourth of the total, with the others solved by counties, communes and brigades themselves or by loans.

While the specific cost of SHP is a little more expensive in comparison with that of large and medium power stations, the total investment to SHP delivered by the nation, however is 50% less than that of large and medium ones. Therefore, in China, to expedite the development of SHP along with the construction of large and medium scales is economically viable at least in the present or near future stages.

The operating cost of SHP is in general 2-3 cents per kwh which is cheaper than any other kinds of energy in rural areas. The sales cost is either as low as 5-6 cents per kwh. The tariff prices for consumers are determined in line with state-set levels. Recently, in place where quick development of SHP is won, a rapid growth of county and commune run industrial and agricultural production would be achieved either. The production costs of industry and agruculture in those counties each with SHP exceeding 10 MW usully approach 30-40 million yuans with some individuals close to 100 million.

The production cost of industry and agriculture brought forth by one kwh of electricity in rural areas is about 2 yuans.

Following is an information of prices of electricity for small thermal power, SHP and feeder making wholesale from national grid in Sichuan Province in 1979:

Alternatives of energy sources	No. of stations	Installed capacity (mw)	Annual utilization hours	Generation cost yuan/Mwh	Sales cost yuan/Mwh
SHP	266	296	3388	17.39	53.84
SThp	11	36		69.6	89.43
Feeders from national grid	31	108			74.24
Integrated	308			27.66	60.43

(Notes: 1. SThP indicates small thermal power.
2. Installed capacity of feeders is in kva.
3. Generation cost is that with feeding not accounted)

It is evident from the table that both generation cost and sales cost of SHP are cheaper than those of SThP and feeders from national grid.

In addition. SHP is a renewable resource. with long life. reliability. simple operation and maintenance. Therefore. development of SHP in China is exceedingly favorable.

III. Formulation of policies guiding the nationwide development of SHP.

In accordance with the state general line and general policy, taking the historical experiences of development of SHP and proceeding from the actual status, the Chinese government and leading department concerned have set up policies and measures for different stages in spurring the initiatives of different levels in constructing power stations and accelerating the development of SHP. The current major policies and measures are the following:

1. Administration at different levels under unified planning. Stations might be implemented by counties. communes and brigades levels either. which should be "owned and managed by and beneficial to those who build and invest". Equal attention should be paid both to construction and management. A substantial results are emphasized.

2. The financing is mainly obtained from different levels of localities themselves. with an appropriate subsidies from the state which give priority to better ones. Recently, low interest loans are delivered to commune and brigade-run stations and medium and short-term loans to county-run stations. A tax free or reduction method is also stipulated by the government for promoting the development of SHP.

3. Manufacturing of equipments on self-reliance.

Units with capacities below 500 kw are mainly produced by localities and utilized locally. Only a certain amount of silicon steel sheet and copper would be subsided by the state. Units over 500 kw are manufactured under unified disposition of the nation and distributed acording to a nation's planning.

4. Due considerations should be paid to planning in order to exploit hydropower potentials reasonably and achieve an integral utilization. Generation is to be incorporated into water conservancy. It is preferred to construct stations according to specific site condition and use local materials. The state-set procedures of capital construction should be strictly executed to ensure the quality of works. The project documents and design drawings of stations with units over 500 kw are to be examined by provincial competent authorities while those of stations with units less than 500 kw may be approved by counties. Construction might be initiated only after being arranged into yearly planning. Designing of SHP is required to achieve technical reliability, economical viability, safety; practical and in line with the spirit of "greater, faster, better, and more economical".

5. Strengthening of administration.

It is advocated to construct and manage SHP under a unified leadership, and to put generation. supplying and utilization under a unified administration. A SHP corporation might be set up in counties numerous in SHP or taking SHP as a main energy source. The corporation is responsible for a unified administration.

6. Making clear the policies of integration of SHP to the grid. SHP is encouraged to combine gradually into a local independent grid as far as possible, which would generate, feed, and be utilized locally. It might further be connected into the national grid in case preconditions are permissible. After integration, both system and right of ownership and right of administration should not be changed. The

problems of load dispatching, balancing of electricity, calculation of energy, prices and settlement of charges of electricity etc., might be solved in accordance with contract between SHP and the grid, which should reflect the spirit of mutual support, equality and benefit.

IV. Manufacture of equipments by self-reliance.

Before liberation, China was not capable of manufacturing hydropower facilities substantially.

After liberation, capability of building hydropower equipments has been raised step by step. At present, there are hundred or more state-run manufacturing plants throughout the country with an annual output of small generator sets over 1,000 mw. In addition, there are numerous prefecture-and county-run factories either, which have produced a certain amount of hydropower machineries according to local demands thus created some preconditions of expediting the development of SHP.

A scheme of seriation of medium and small hydro-generator sets has been formulated in China which is divided into two parts, one for units below 500 kw and the other for 500-10,000 kw. The number of models of turbine runners included in the seriation is 26, with 83 varieties of turbine sets available, and with a suited head ranging in 2.5-400 m.

Types of Turbines	Sets less than 500 kw		Sets of 500-10,000 kw	
	No. of runner model	No. of varieties of turbine sets	No. of runner model	No of turbine sets
1. Axial flow	2	10	4	11
2. Tubular	2	10	3	4
3. Francis	3	12	10	32
4. Impulse	3	10	1	4
Total	8	32	18	51

Trial-manufacturing and application of bulb type turbines are just initiated. Presently, a set of 1,600 kw with diameter 2.70 m is on probation and an another set of 10,000 kw with diameter of 5.5 m is under trial-production.

A series of micro-generating sets have been built in recent years, with capacities from 0.5-75 kw, and available head from 2.5-40 m. The whole set is completely packaged with all auxiliary equipments which can be moved conveniently and is simple in operation and maintenance, thereof suitable for remote hilly regions.

In China, generators adopted in SHP are mostly of synchronous type. Asynchronous generators are rarely used due to shortage of reactive power in rural grid or even in national grid.

The voltage levels of generators are as follows: voltage of generators smaller than 500 kw is usually 400 v. and that of 500-6000 kw is 6300v. A voltage of 3.15 kv had been adopted before but is dismantled later.

Together with provision of main generating sets. manufacturers are responsible for providing auxiliary equipments including governors. excitation facilities and automatic components.

Speed governors used for small turbines have been built in five types of operation, i.e.. manual. electrical. electric hydraulic. electronic-electric and electronic-hydraulic. Total number of types included in the state-set series is 8.

There are many varieties of generator excitation. Numerous types of SCR excitation systems have already been widely produced and utilized. e.g.. in Luoding County. Guangdong Province. over 70% of installed generators are equipped with or being reformed to SCR excitation. Brushless excitation has been applied in Sichuan, Zhejiang and Hunan Provinces. Three types of third harmonic voltage excitation for generators of 630-1250 kw have been exercised and won success in Jiangxi. Gansu and Fujian Provinces. already in operation for several years with good economic and technical results.

For sake of customer's convenience. provision of complete set of main electro-mechanical equipments for SHP has been organized by the state and some provinces. which include transformers, high tension switchgears, various control and protecting panels, cables. cranes. air compressors. pumps. porcelains etc., in addition to the main auxiliary equipments. In Sichuan Province. a "Manufacturing Corporation of Power Plant Equipments" has been set up to incorporate 90 or more manufacturers of power plant facilities under the principle of co-ordination among specializations. Such corporations are being established in Zhejiang and Guangdong Provinces either.

V. Technical Aspects of SHP in China

The natural status of various places in China differ immensely. There are, hence, many varieties in exploitation and designing of SHP. In addition to the types mostly used such as stations at the rear side of dams and stations with conduits, there are many other alternatives like stations on canal drops. implemented navigation locks and dams. by tapping underground water and turbine-pump generating station etc. Cascade development. multi-purpose utilization for generation irrigation and navigation and even diversion of water across neighbouring catchments have been made in many places yet. Tidal power plant is being on probation.

The highest head of SHP in operation is 630 m (Zhunsan Station of Dayun County. Hunan Province) and the lowest about 1 m.

The design. construction of civil engineerings. installation of equipment, coordination and examination as well as operation and management of SHP have been conducted by personnel of localities.

The level of design of SHP is selected according to their scales and geographical site condition as well as state-run specifications.

The procedures of SHP design are usually as follow: Those for stations with units of 500 kw or over are of two stages. i.e.. preliminary design and engineering drawings with comparatively full informations and regular documents; those for units less than 500 kw. however. being implemented by communes and brigades. might also be proceeded with a design. but differ greatly in their deepness.

For typical illustrations of various alternatives of exploration and designing, refer to chapter X "The Experiences of China" in «Manual of Small Hydropower» edited by UNIDO.

Through practice, ranks of technical staffs including planning, exploration, designing, construction, installation, operation and maintenance have already been trainned up in China. The Ministry of Water Conservancy and most provinces have established their own institute (designing bureau) of water conservancy and hydropower as well as bureau or corporation of construction and scientific research institutions which are capable of designing and constructing various sorts of medium and small scale hydropower engineerings. At present, serious considerations are being paid both to the improvement of technical levels and to technical innovation, increasing of reliability of electric supply, decreasing of cost of construction and strengthening of basic works, etc. Following are some technical aspects:

1. Trial of technical innovations in penstocks and surge chamber.

(1) Popularization of prestressed cement penstocks.

Various types of penstocks have been used in China, including steel, concrete, and wooden pipes. In recent years, the prestressed cement penstocks are widely spread with a maximum head and diameter of 168 m and 1.3 m respectively (Shuixia Station of Guangdong Province).

According to the practical experiences of several provinces as Guangdong and Hunan, the advantages of pre-stressed cement penstocks may be summed up as follows:

a) Capable of saving rolled steel for 70%
b) Capable of cost saving for about 60%
c) Better stability
d) Locally available materials can be used
e) Reliable, simple maintanence and lasting longer.

Shortages are: heavier in weight, large volume of transportation and easier to crack in the course if a centralized production took place.

(2) Adoption of regulating valves instead of conventional surge chamber.

There are some stations which have already used this regulating valve in replacing the traditional surge chamber. For instance, in Lungyuan Station, Hunan Province, where 3 sets of turbines each of 1.600 kw with a head of 88 m and a pressure diversion system totalled at 1,957 m in length were erected, it was originally necessary to set up a surge chamber with diameter 7 m and height 45 m costing 400 thousand yuans, according to the calculation of performance of pressure regulation. Later on, 3 regulating valves each with diameter of 400 mm were installed instead, which costs only 40 thousand yuans. This station has been in operation for several years with good results.

Such a regulating valve is designed and manufactured in China, which had won a state prize of third class for science and technology in 1979.

Steel, cement and wood can be spared and duration of construction be reduced in utilizing this regulating valve and it is therefore spread nationwidely.

2. Ensuring quality of electrical energy and improving reliability of electric supply.

The state-set quality indecies of electrical energy for local grid are the following:

Permissible variation of frequency should not be greater than ±1 hz. and that for voltage. +5% and -10%.

Stations with units rated 500 kw and over usually equipped with automatic speed governor and voltage regulator are capable of maintaining frequency and voltage within allowable range under normal condition. The frequency and voltage fluctuations in stations with micro or mini sets. however, are comparatively large when operated isolately due to manual operation of governor and excitation system.

The electrical loads in China have been classified into 3 catagories according to their importance of roles. The rural consumers including county-run industries are mostly of third class. Stations with units larger than 500 kw can fundamently meet the reliability required for electric supply of this class.

Followed with rapid development of SHP. small local grids have been formed in many places which is conducive to the improvement of reliability of electric supply. In general, the capacity of a county-level grid is several thousand to ten or twenty thousand kw.

In some places developed in SHP, such as Luoding county of Guangdong Province, Xianju County of Zhejiang Province, Dayi County of Sichuan Province, Tong Cheng County of Hubei Province, etc., experiences have been summed up through practices which may be briefed in the following:

1) For the sake of improving reliability. a small local grid must be established, which can further be made better when integrated into national grid whenever possible.

2) The installed capacity of a small local grid must be sufficient and a reserved capacity be set up.

3) At least some of the units installed in the grid should be large enough to exert the load impact and remain stable operation. At present level. a unit capacity of 1600-3000 kw would be sufficient.

4) It is necessary to strengthen the load dispatching and allocate different kinds of load to various types of stations.

5) The frame structure of network of electric supply should be improved and the quality of transmission lines be increased.

6) Relay protection has to be made better. It is favourable to establish three-stage protection in the county-brigade-team level in limiting the range of emergency.

7) Communication facilities in the grid should be erected. At present, most of the stations existing outline voltage of 35 kv have been equipped with communication facilities connecting to the county dispatching station.

Besides the reasonable level of designing, ensurance of construction quality, and good maintainence etc. are as a matter of fact. all fundamental factors in improving the reliability of small grid.

3. Constructing dams with locally available materials in reducing engineering costs.

Dams using local available materials are widely adopted. The prevailing dam types in China are as follows:

1) Earth dam, one of the most popular types;

2) Stone masonry dam. a saving of cement at 40-50% than concrete dam is assessed, in which a further classification may be made:

a) Gravity dam with cement pasted stone masonry. being mostly used in stone masonry dams. accounted for about 60%.

b) Arch dam with cement pasted stone masonry (single and multiple arch dams), having been used in Guangxi and Sichuan provinces, saving volume of engineering at 30-50% than gravity dam with stone masonry at same height.

c) Hollow gravity dam.

d) Stone masonary gravity dam with wide joints, having been used in Hunan, saving volme of engineering at 14% than gravity dam with stone masonary.

e) Dry-laid stone masonary dam with histories of several hundred years in many provinces.

3) Rockfill dam with stone masonary casing, having been used in Zhejiang and Guangdong provices .

4) Earth-rock composite dam.

5) Timber-stone dam, often used in mountainous regions with abundant woods and rock.

4. Due considerations be paid to basic works like hydrology and geology.

At present, various kinds of hydro-gauging stations set up in China have reached 17,000 or more, out of which 2,922 are normal standard hydrometric stations being concentrated in the catchment of some main rivers. The metric stations on small rivers and streams only account for 11%. Therefore, it is sometimes insufficient in hydrological informations in planning and designing. The hydrological works of SHP are conducted principally by means of site investigation incorporated with consulting of hydrological manuals compiled by each province or region. In general, a document of analysis of hydrology would be brought out in designing stations with units greater than 500 kw, while in those up to 500 kw no definite analysis of hydrology is made.

In exploration of engineering geology, means of site inspection, digging of test pit (including pit, trenching and horizontal cave) are widely used. Drilling and testing the selected intact rock sample is carried on in larger stations to secure relevant data for designing.

5. Efforts being exerted to raise the generating utilization hours.

At present, the annual utilization hour of small hydropower throughout the country is only 2,000 approximately, in which units below 500 kw capacity accounted for 1,300 hours while that over 500 kw for 2,600 hours.

Stations with units less than 500 kw, being mainly implemented by communes and brigades, are usually both insufficient and inaccurate in hydrological informations. In addition, the load demand hours are rather low in those stations where numerous problems might be occurred in operation. This usually results in a low annual utilization hour.

The designed annual utilization hour for stations with units larger than 500 kw is in general 3,000-5,000, while in actual, it is averaged at less than 3,000. Why does it happen so? According to a primary understanding, the main reasons may be stated in rough term as follows:

a) Due to inaccuracy of hydrological information and certain causes of our works, the installed capacity selected in some stations are on the larger side.

b) The agro-based load varies greatly both in different seasons and in day and night. The maximum demand hours of rural power machineries are as low

as 2.000. whereas the working time of electrical irrigation and drainage which occupy a great percentage in agro-based load is even lower. being only 1.000-1.500 hours and would be further influenced by weather. Therefore. the peak and valley loads of SHP are tremendously unbalanced. Water is usually spilled in stations without regulating reservoir thus resulting in the under-utilization of installed capacity.

c) The designed power factor of SHP generators is mostly 0.8. while the actual average power factor of rural grid in operation is only 0.6-0.7 or even less than 0.5 in some cases. Thereafter. most of generators cannot produce rated active power in line with designed installed capacity. which in turn gives rise to the shortage of output of energy than designed value.

The reason of low power factor in rural area in China is the following. The rural consumers are both numerous in feeding points and extensive in spreading. The low load intensity, thereof, causes a larger capacity of distribution transformer than what is necessary. A large amount of no-load iron loss in transformers increases the reactive power loss which in turn makes the power factor of small grid bad.

d) SHP projects major in irrigation often fail to run uniformly as destined in design. Water discharges in these stations may sometimes happen to exceed the rated flow of normal requirement of irrigation and thus spilling water and loss of energy take place.

e) For safety in flood prevention, the water level of some reservoirs does not retain at a value as it should be, also results in loss of energy.

Of course, various abnormal mal-functioning and emergencies of SHP are also causes of underutilization of installed capacities.

The utilization hours in quite a few places, however, have been being raised through the improvement of administration, adoption of effective measures or implementations of technical innovations. For instance, the designed utilization hour of Guapi station in Yansan County, Guangdong Province is 4.000, which has been steadily increased through adoption of some measures like storing water in canal by pumping under low head and generating power under high head. The annual utilization hour of this station had thus been overtaken 6.000 in successive years from 1972 to 1978.

In the meantime. the overall rate of well-being of facilities in whole Yansan County approached 93% in 1979 on account of improvement in maintanence and management. The annual mean utilization hours of 181 small stations in this county, with total capacities of 14,211 kw, approached 4,000 in the same year.

At present. a struggle for increasing the utilization hour is being conducted in SHP throughout the country.