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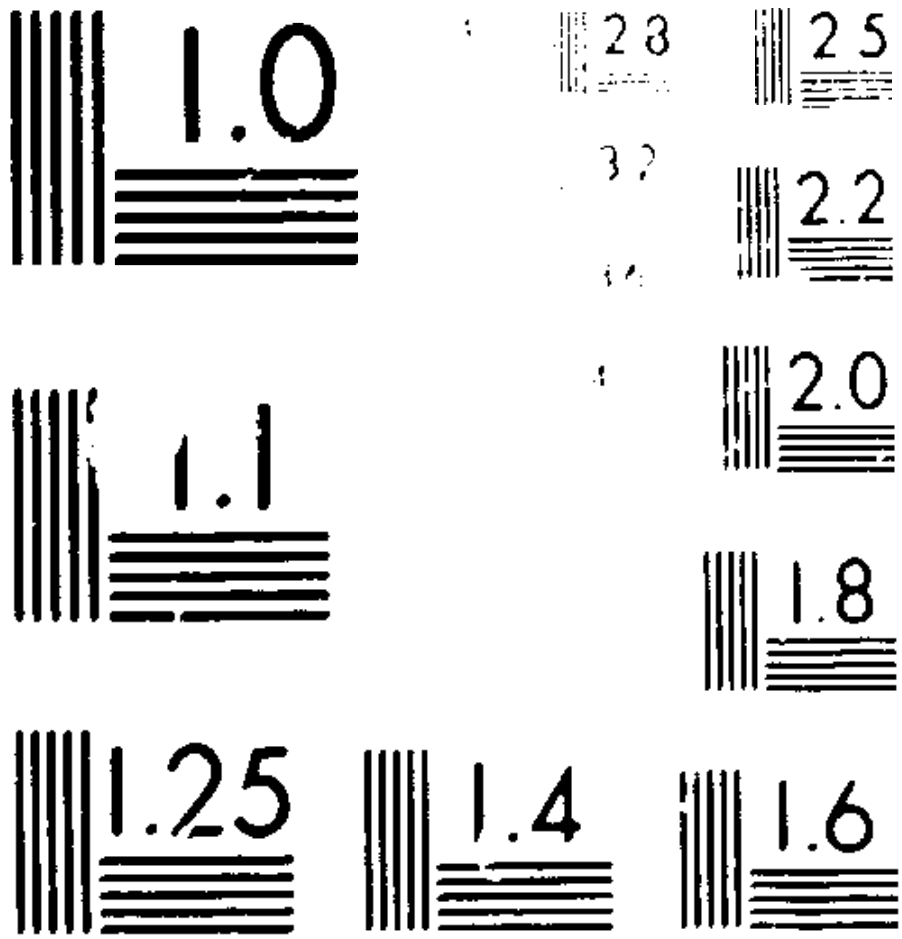
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PLANNING FOR THE SMALL HYDRO-POWER STATION AND NETWORK IN TUNGCHENG COUNTY, HUBEI PROVINCE*

by

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It is a notable feature to utilize the local water resourses as a sort of energy for the modernization of agriculture and for the development of national economy in the southern rural area in China. This article has systematically summarized the experiences of Tungcheng County in running hydro-power in combination with river harness by taking small hydro-power station as a primary and making every little a mickle to form a countywide network and in exercising unification of constrution and management and of power gencration, supply and consumption.

1. Selection & Exploitation of sources of energy for Modernization of Agriculture

Tungcheng County lies in the southern provincial border area of Hubei, where Lushui river, one of the tributaries of the Yangtze, rises. It is a small hilly county with a maximum sea level height of 1600 m. It has a population of 356,000 people and a total area of 1140 km^2 of which 21,300 hectares are farmland. In order to do a good job in modernizing the agriculture, to speed up the development of local economy, and to make the peasants be well off, the energy problem must be solved properly.

We had taken a roundabout course in selection of sources of energy. Before 1972, we tried to solve the energy problem by transporting diesel to generate electric power, but the cost of diesel generating power was as nigh as 0.19 yuan per kwh, and that of coal, 0.14 yuan per kwh, due to the long distance of transprotation. Then we spent 1,350,000 yuan in erecting power transmission lines and bought electric power from the state run grid at the cost of 0.082 yuan per kwh. All of there are not beneficial to the local economy.

From 1973 on, we began to exploit water resourses and to set up small hydropower stations. The construction of small hydro-power stations is a better way to rely on the masses and is simple in technique and easy for mastery by the masses. We have, in close connection with the basic construction of farmland, built up 65 small and medium sized reservoirs with a total storage capacity of 200 million cubic meters, and 145 small hydro-power stations with a total installed capacity of 14,971 kw, thus forming an indepindent small hydro-power network. The power consumers are increasing gradually. By the end of 1979, all industrial and mining enterprises and all of the communes of the county (85% of the brigades, 65% of the production teams, 75% of the peasant households used the power generated by small hydro-power stations. The county's gross output value of industry in 1979 was twice as that in 1973, and the gross output value of the commune-run and

brigade-run enterprises was 5.6 times than that in 1974. Last year the county experienced serious drought, but with the water conservancy projects and the small hydro-power stations in full play, it still gained the best harvest in agricultural production in the history of the county with a specific production of grain of 1100 jings per mu. It is proved by practice, that making full use of local water resourses and setting up small hydro-power stations are a correct way of rural modernization constrution. Water resourse, which is a renewable sourse of energy, being rich in the county, cheaper on cost (0.045 yuan per kwh, about 2.1-3.2 times lower than that of thermal power) and not polluting the enviroment, is well received by the peasants. Therefore, we take the hydro-power as the power sourse for the modernization of agriculture at the present stage.

Table 1 Comparsion of costs

Alternatives of power sourse / Main data	Diesel generated power	Coal generated power	State owned power	local hydro power
Cost (yuan per kwh)	0.190	0.140	0.082	0.045
Terminal voltage (V)	380±20	380±20	360±19	380±20
Tariff (yuan per kwh)	0.110	0.110	0.110	0.110
Profit (yuan per kwh)	-0.080	-0.030	0.028	0.065

Table 2 Exploitation and Utilization of Water Energy Resourses

Name of river	Drainage area km^2	Total exploitable water energy kw	Installed capacity km	Exploitable power per km^2 kw/km^2	Generating power of established stations kw/km^2	Utilization ratio %
Paichangtan	69.7	6836	5476.5	98.08	78.57	80.1
Yunxi	48.3	5000	3669.0	103.50	57.96	73.4
Hunglong	89.0	10000	1596.0	112.30	17.94	16.0
Other Water System	933.7	8200	4229.0	8.78	4.53	51.6
Amount	1140.7	30036	14971.0	26.3	13.12	49.8

It is seen from the table that the mean expolitable power of the county is 26.3 kw per km^2, and the utilization ratio is about 50%.

2. Planning for small hydro-power station

The features of the rivers in the county are short in sourse, less in water, many in rivulet, steep in riverbed slop and high in flood-dry ratio. There are three bigger water systems, namely Paichangtan, Yunxi and Huanglong, which have many tributaries, flowing in the mountain areas with steep slope and have their drops concentrated; over years, the mean annual rainfall of the county is 1500 mm, the hydro-power resources are abundant with total reserves over 30.000 kw.

The general principle for water power planning is to rationally balance the water and soil reourses in the whole county so as to benefit the industrial and agricultural production, the ecologic balance and requirements of water and electricity in people's livelihood. Therefore, in planning hydro-power station, integrated consideration should be given to the issues of flood prevention, irrigation and power generation, and great efforts should be made to utilize the water wherever it exists whether big or small. With this in mind, we have worked out a policy for harnessing rivers, i.e. to build reservoirs in every river, lay emphasis on conservation of water, harness rivers in multi-purpose and develop in cascade, be of benefit to flood prevention and irrigation and to explore the energy potentials fully.

With a view of speeding up the construction of hydrp-power and the development of the commune and brigade enterprises, the hydro-power stations might be owned by four levels, i.e. county, commune, brigade and production team. The county runs big power stations while the commune and brigade run small ones, i.e. to run stations also at four levels. This can not only lighten he burden of the state, but mobilize the initiative of all levels in runing the stations.

The terrain in hilly area is complicated and has great many ups and downs, so the work for water level connection must be done well so that no water head is wasted. In site selection, the water head utilized should suit the local conditions, and be chosed as it should be. Otherwise, it will be difficult to construct and cost very high, and the process of electrification will be affected.

As there are many rivulets, many reservoirs, many steps and many departments concerned in running stations in our county, so the established small hydro-power stations have a feature of being "small, many and dense". Of the existing stations, the maximum single generator capacity is not more than 1000 kw and the minimum only 3 kw, this shows how numerous they are; there is a small hydro-power station, on average, in every 8 km^2. The density of stations is fairly big, in some stepped stations, taking the Taoyuan small cascades of Jianshe Commune for example, the inter-stations distance is not more than 1 km.

The principle of "laying emphasis on conservation of water, concentrating water heads and making an overall plan which is to be implemented by stages" is executed from beginning to the end in developing the small hydro-power stations in Tungcheng County. Of the three bigger water systems, priority of exploitation is given to the river which has larger threats of flood and can provide sufficient water resourses and electric energy once it is harnessed. Proceeding from this point, we took the Paichangtan and Yunxi river systems as the first phase of the projects.

There are now a controlled catchment area of 69.7 km^2, three reservoirs and five power stations with a toatl utilized water head of 345.6 m and a total installa-

tion capacity of 4740 kw in the Paichangtan river system. Of the total utilized water head, station No. 4 in the main course has a total water head of 295.6 m and a total installation capacity of 4340 kw. The generation of one kwh in this station consumes 1.33 m^3 water. The Paichangtan reservoir with a storage capacity of 16.7 million m^3 was built at the up stream of the river. The dammed power station has an installed capacity of 280 kw. The reservoir for No. 1 station has a regulation performance of over years and has created the conditions for the development of stations at the down stream. The tail water of No. 1 station flows through a covered channel of 980 m long to the place where a water head of 157 m is achieved and No. 2 station with an installation capacity of 1600 kw is built. The tail water of No. 2 station goes through a channel of 2800 m long to the place where a water head of 66.5 m is achieved and No. 3 station is built with an installed capacity of 1300 kw. In order to utilize the surface runoff further and to improve the firm power of No. 3 station, the Yangsimiao reservoir with a storage capacity of 4.2 million m^3 and a power station with 400 kw installed capacity was built at the right tributary, consequently, the regulated flow of No. 3 station is increased by 1.3 m^3 per second; in addition, a dam was built at the left lower side of No. 2 station to divert the regional water within 10 km^2 to the channel of No. 3 station. The topography below No. 3 station becomes open gradually and slope of the river course gentle, and is not available for building power station with conduits. In order to control water, prevent farmlands in down stream from being submitted to flood or drought and to make full use of the sectional water, we have built the Shenlungping junction reservoir with a storage capacity of 5.6 million m^3 and the dammed power station with 1160 kw installation capacity.

The main parameters for the stations in the Paichangtan river are listed in Table 3.

The Yunxi water system has a controlled catchment area of 48.3 km^2. The Yunxi reservoir with a storage capacity of 48 million m^3 was built mainly to serve the purpose of irrigation and incorporated with power generation. There are five

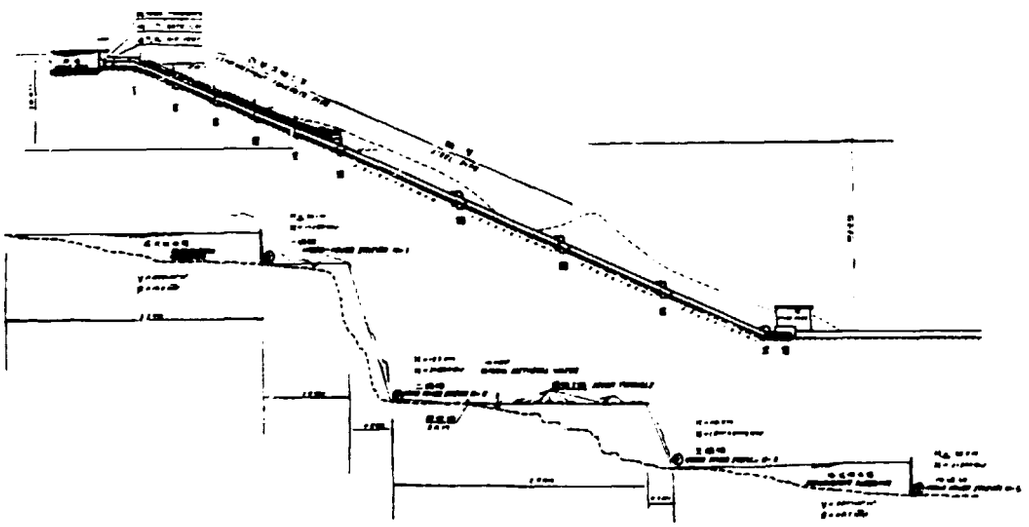

Fig. 1

Fig. 2

stepped power stations in all with a total utilized water head of 211 m and a total installed capacity of 3085 kw. The generation of one kwh by this stepped station requires water of 4.78 m^3.

The stepped power stations in the Paichangtan and Yunxi river systems have a total installation capacity of 7675 kw accounting for 51.2% of the total in the county and are the major stations in the present power network, of which, the former undertakes the major load of the network, and the latter undertakes the regulation of load.

Table 3 Main Parameter of Paichangtan Stepped Power Station

Station	Type	Catchment area (km^2)	Reservoir capacity (10^4m^3)	Diverted flow (m^3/s)	Designed water head (m)	Type of turbine	Type of generator	Installed capacity (kw)
No. 1	Dam-	9.5	1670	1.05	22.0/36.0	HJ300-WJ-50	T721	1×289
Yangsimiao	Dam-head race	6.50	420	1.30	35.0 50.0	HL702-WJ-50	TSWN 99 37-8	1×400
No. 2	Head-race			1.05	157.0	QJ-W-92/1x11	TSW143/44-10	2×800
No. 3	-do-			2.70	66.5	HL702-WJ-50	TSWN99/66-6	800
						TSWN/99 37-6	TSWN99/37-6	+500
No. 4	Dam	69.7	560	4.40	26.0/36.0	HL300 WJ-60	TSWN99/37-6	2×500
Total			2650		271.5/295.6			4580

3. The planning for the small hydro-power network

The independent small networks in Tungcheng County are all powered by hydro-power stations. Although the stations are scattered, they are in keeping with the feature of scattered power consumption in the coutryside. But, the lay-out of the networks should be well considered that it can concentrate a proper amount of electric energy to meet the needs of the state enterprises for power and at the same time to satisfy the demands of the ordinary consumers.

It is very important for an independent small network to gain a trust from the consumers. Thereupon, electricity should be adequate in quantity and high in quality. But the existing stations in the county are small and compact, by scattered, so, only after the distribution lines are rationally laid out to constitute a small hydro-power network and become one entity, can their role be brought into full play. The alignment of line must be suited to such a characterstic, i.e. the main lines (including the lines of the communes and brigades) should go along the river to the central sub-station in the county seat; and we should not only consider the

load distance but also the distance for taking the power from the stepped station and the convenience of connecting the commune and brigade power to the network; the existing maximum capacity among the stepped power stations is 4740 kw. In accordance with the above situation and the state standard, the network voltage selected is 35 kv.

The distribution of the electric load in the county is that the industrial consumers are concentrated around the county seat and the agricultural consumers are widely scattered. At present, the industrial power equipment capacity is 17805 kw while the agricultural power equipment capacity is 15038 kw, totalled at 32843 kw. It is anticipated that the number of places where electricity would be available will reach five "one-hundred-percent" by 1981 (i.e. all the factories, communes, brigades, production teams and villages), and the power consumption will be increased by a wide margin. In order to make the power supply reliable, economical and safe, we have set up five sub stations of 35 kv, one of which is in the town seat and the other four are at Marshi, Jiuling, Shinan and Shadui respectively for management of power supply to ordinary consumers and commune-run enterprises. The one in the county seat is the central sub-station concentrating all the power in the county for unified dispatching and distribution, and supplying power to the consumers nearby. The power supply radius of the 35 kv-line is not greater than 50 km; the 10 kv-line leads directly to the communes and brigades, whose power supply radius does not exceed 20 km. All the hightension lines are of threephase overhead line with reinforced concrete prefabricated poles.

The mains are extended from the county seat in all directions, and form an open-ring circuit. Since we used thermal power and ran some mines and factories before 1972, those enterprises should be taken into account in erecting the new network mains. The transmission line and distribution line should be erected respectively so that maximum economical results may be obtained in the power networks. Special lines are creted for the key factores. The hydro-power stations of three river systems are connected according to the above-mentioned principles by 315.8 km hightension line, thus forming a small hydro-power network.

In considering the further development of the hydro-power stations in future, a 110 kv-line will be erected in the county to be connected with the state power networks.

Constructoin is the foundation while management is the key link. The small hydro-power stations are widely scattered and very popularized. In order to effectively exploit and utilize water resourses and creat more wealth for the state the relationship between the state and the collective, between the construction and the management and between the generation and consumption should be well handled. For this reason, "Tungcheng Small Hydro-Power Corporation" was set up in January 1980, which is under the leadership of the county hydro-power bureau, practises business management and supervise the construction and management and the generation, supply and consumption in unified way.

The key to the management and dispatching of the small hydro-power network is to manage and dispatch water resource well. The volume of flow should be regulated on the basis of the load and in unified way in connection with the regulation performance of various stations. In the power networks there are some power stations mainly engaged in generation and, also some power stations mainly engaged in irrigation incorperated with generation. The peak-to-valley load in the net-

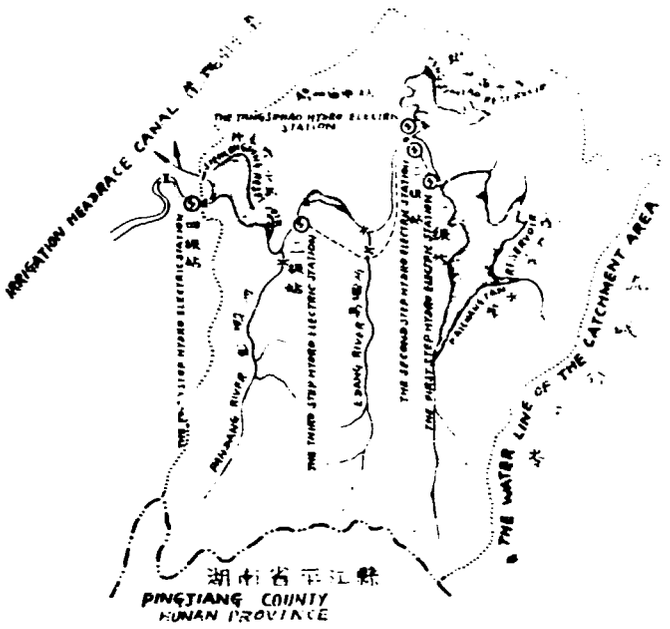

Fig. 3 The 35 kv Network of Tungcheng County.

work differs greatly. In order to raise the reliability of the power supply at all times, the scientific management of water resources must be strengthened so as to make the unified regulation of water and electricity, use the water rationally and the electricity in a planned way. When rainning, the runoff-river type hydro-power stations should be in full operation, while the reservoir hydro-power stations should be stopped to reserve water and to be used during drought. The Paichangtan and Huanglong stepped hydro-power stations are mainly engaged in power generation and at the same time irrigate 2000 hectares of farmland. The combined operation of hydro-power stations in three river systems ensures sufficient water for irrigation all the year round and sufficient electricity with quantity basically balanced between dry and rainy season.

The most of the hydro-power station in our county are set up in cascade. The stepped hydro-power stations have their own laws of change in regulation and application. The generating flow of the first step station should be in conformity with the outputs of other step stations in the lower reaches. If a change takes place in a certain step station, a new regulation plan should be worked out. In order to solve this problem, the volume of the forebay of the station with conduit should be enlarged. And some reservoirs for water regulation should be added in certain sections of river where conditions allow. Taking Paichangtan water system as example, Yang simiao reservoir was built on this lower-right tributary as a compensation regulating water sourse for the third step station, thus correspondingly increasing the output of third step station by 650 kw. In addition, the Shenlongping key water control project was built in the lower reaches of the third step station as an inverse regulating reservoir. These measures have greatly imporved regulating performance of stepped stations.

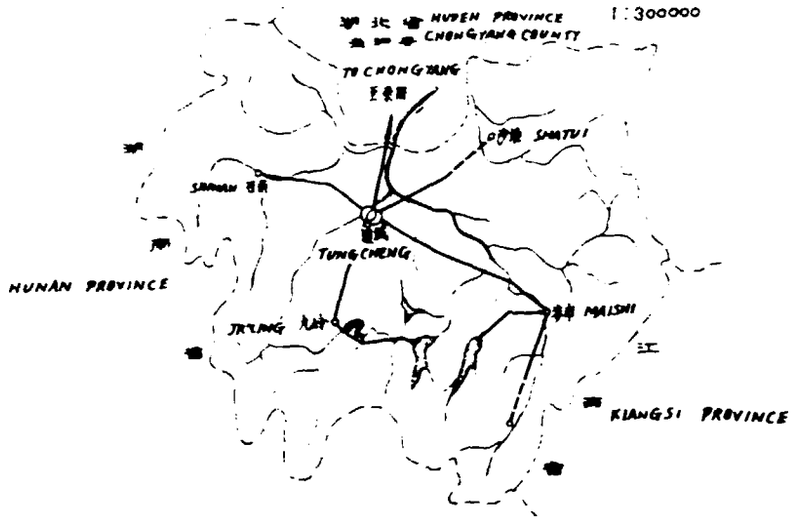

Fig. 4 The Plan of Paichangtan Stepped Stations

The load dispatching ensures the demands of national economy for power in a lower water season, and provides ample electricity in a high water season to nitrogenous fertilizer by electrolytic water and phosphate fertilizer by electric furnace process, and other enterprises with great power consumption, e.g., the cast steel production by electric furnace process, are either in full swing to consume the seasonal electirc energy. Only in specially dried peroid (like 1978 and 1979 two successive years of drought) would the power be supplied to the countryside area by area in turns and timed so as to ensure the use of electricity by county-run and province owned enterprises in the county.

The commune and brigade-run stations, under the unified plan of the county hydro-power corporation, are assumed mainly to provide power for the nearby area.

Under the leadership of the corporation, the station are managed at different levels with unified dispatching and technical standard. The county hydro-power corporation is responsible for maintaining and repairing the lines of 35 kv and county-managed lines, and communes are responsible for their own networks. The county small network is independent on generation and supplying from the state network but it has a commercial relation with the state network, that means it can either be connected with or separated from the state network, so that it can supply the state network with surplus electricity and make up the insufficient electrity from the state networks on the basis of equal value exchange. This principle is also applicable to the commune network.

The rapid development of the small hydro-power in Tungcheng county stems from the execution of the policy that mobilizes the enthusiasm of the masses in harnessing the river and running the power. With a proper help from the state, by relying on the masses and by practising hard working and industry and thrift, we have achieved greater, faster, better and more economical results in harnessing the river and running the power. Our concret policy is to give active help to com-

munes and production brigades so as to enable the peasants to be well off as quike as possible, and to act on the spirit of "the burden being taken on by the county while the advantage being given to the communes and production brigades". On handling the relation between the county network and the commune-run and brigade-run stations, we have conscientiously solved the following two problems: one is to encourage the commune-run and brigade-run stations to be connected to the county network; another is to give them a technical guidance in management and operation. Although our stations are not big, we use every means to join them together through network. Many a little makes a mickle. Small hydro-power can also solve big problems. To have our own small hydro-power network is to havt an initiative in economic construction. Therefore, all trades and profession in the county have got a correspondingly greater development.

Though we have achieved certain success in small hydro-power construction, we have only exploited a half of the water tnergy resources, there are still a lot of work to be done in construction. For the existing stations, it is imperative to strengthen scientific management, carry out technological innovation and transformation and tap the potentialities so as to raise the utilization rate of the equipment and installations and gain still greater economic benefit. Presently, we are devoting ourselves to the completion of opening up Huanglonghe water system, and striving to make the installed capacity of small hydro-power to 30,000 kw in not so long a period so as to supply more energy for the realization of electrication in the rural area in 1990, and to deliver more electric energy to the state network to support the socialist construction of our country.