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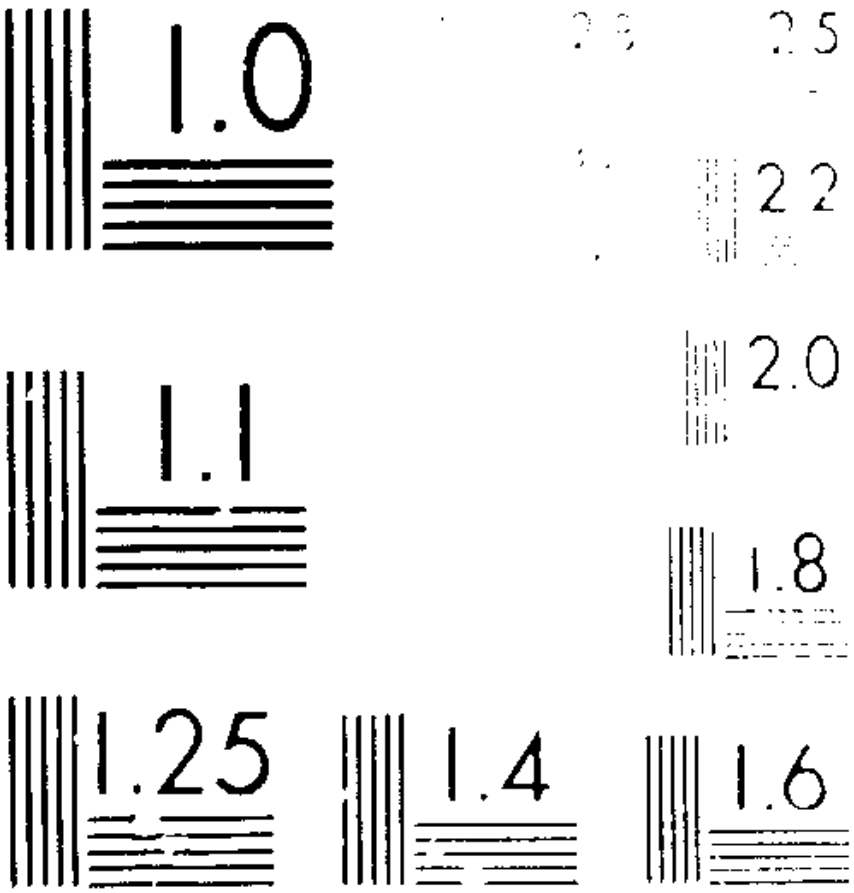
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UNITED NATIONS INDUSTRIAL
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# GROUP STUDY TOUR

# IN THE FIELD OF

# MEDIUM AND SMALL SCALE

# HYDRO POWER PLANTS

# TO THE

# PEOPLE'S REPUBLIC OF

# CHINA

Final Report*

*This report has been reproduced without formal editing.

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## The Background

1. In the framework of a series of group study tours to the People's Republic of China in various subjects, the Government of the People's Republic of China and UNIDO agreed to organize jointly a group study tour in the field of medium and small-scale hydro power plants. Basic considerations that led to this project were the following:

2. Energy is a key factor for industrialization and the power plants play the largest role in supplying energy for industry and for the other needs of the population. Despite the fact that electrical power is the biggest source of energy used for industrial purposes and illumination, many developing countries are still unable to provide the minimum power supply. This is mainly due to the inability of the respective countries of utilizing their local resources for power generation, the unawareness of the potential of local resources, the lack of investment capital, as well as the lack of necessary infrastructure including transmission facilities. Another reason for the shortage of power supply in the developing countries is the unavailability of qualified technical personnel to build new facilities and to operate and maintain the existing power plants and the related facilities.

3. In the phase of the increase of all prices and the unavailability of certain raw materials locally, the developing countries have to look for alternative local sources for power production.

4. In countries where infrastructure such as transportation and transmission facilities are not readily available or difficult to establish within a certain period due to natural and geographical barriers or other reasons, the establishment of big power plants is not practicable, and the medium and especially small-scale power plants become one of the best means for electricity production.

5. In case of remote areas, and where small rivers or suitable small flowing water resources are available, one of the cheapest means of power production are the medium or small-scale hydro power plants. These are especially suitable when a continuous and even flow of water is available.

6. It was the common understanding of both the Government of the People's Republic of China and UNIDO that the former disposes of excellent facilities and highly qualified specialists to demonstrate the development, innovation and progress in this field.

7. The aim of the study tour was to familiarize senior personnel employed with governmental or semi-governmental organizations in selected developing countries and engaged in construction, operation and maintenance especially of hydro power plants with the respective scenario in the People's Republic of China, to visit significant pertinent facilities there, to study the Chinese experience, to acquire first-hand information and, last but not least, to exchange views with their Chinese peers. Thus the study tour should assist the participants to contribute to overcoming the shortage of power supply in their home country particularly on the local and provincial level by means of medium and small-scale hydro power plants.

8. On behalf of the Government of the People's Republic of China the Ministry of Water Conservancy was entrusted with the local organization of the study tour.

Time and Programme

9. The study tour took place from 14 May through 2 June 1979.

10. The programme included visits to selected medium and small-scale hydro power plants, irrigation systems, hydro power equipment manufacturing plants and, for comparison's sake, a thermal power station.

11. The programme was rounded off by cultural elements.

12. Further details can be seen from Annex I.

The Participants

13. Of the 15 selected candidates from 15 developing countries 13 participated in the programme; the selected candidates from Bangladesh and Ghana withdrew at the last minute so that they could not be replaced by stand-by candidates.

14. With a view to the increasing importance that energy gains in the scope of UNIDO's activities, one representative of the Centre for Natural Resources, Energy and Transportation (CNRET) of the United Nations in New York and one of the Economic and Social Commission for Asia and the Pacific (ESCAP) in Bangkok were offered by UNIDO the opportunity to participate in the study tour at their organization's cost, which was accepted. UNIDO itself was represented by two Senior Industrial Development Officers, one of them responsible for technical aspects of energy and one for training.

15. The participants proper were selected jointly by the Government of the People's Republic of China and UNIDO.

16. Further details can be seen in Annex II.

The Organization

17. During the entire duration the study tour was accompanied and taken care of by two representatives of the Ministry of Water Conservancy who also acted as interpreters. At all stages, be it on province, county, people's communes or plant level, the group was received by competent senior officials and specialists. The distance Beijing (Peking) - Guangzhou (Canton) and down to the Pearl River delta was covered by train, coach or ferry boats; the way back to Beijing via Shanghai by plane.

Technical Aspects

18. From a technical viewpoint as well as under consideration of the social and economic situation in the People's Republic of China at the time when the construction of medium and small-scale hydro-

power plants up to the present scope was decided - let alone any strategic considerations, it appears that the gigantic efforts having been made in this field were fully justified. The results achieved so far are remarkable and can serve as good examples to many other developing countries.

19. The following figures demonstrate the development in this in the People's Republic of China since the liberation (i.e. 1949).

Number of medium and small-scale hydro power plants:

| | | |
|---|---|---|
| before | 1949 | 26 |
| | 1978 | 86,500 |

Total installed capacity:

| | | |
|---|---|---|
| before | 1949 | 2,000 kw |
| | 1978 | 5,000 mw |

20. Today, between 10 and 33% of the needed electricity in rural areas are produced by medium and small-scale hydro power plants.

21. In this connexion the administrative structure of the People's Republic of China seems to be important. In rough terms it is organized as follows: Nation - Province - County - People's Commune - Production Brigade - Production Unit. It is a principle that the responsibility for and the utilization of hydro power stations are with the administrative body that was responsible for the errection of the station. In other words, a station erected on county level is managed and utilized by that county. As a matter of fact, most of the hydro power plants visited were run by counties. During their erection, certain support (mainly technical) is provided by the Province, while the Ministry of Water Conservancy may give financial support up to a certain (relatively low) percentage of the total cost.

22. The entire system or network of hydro power stations in the People's Republic of China has the following order of priorities: Irrigation - electric power generation - navigation (where applicable) - fishery or fish breeding (where applicable) - environment protection - recreation (where applicable).

The fact that irrigation (understandably) is given priority over power generation contributes considerably to a widely observed underutilization of installed capacities. However, it was extremely interesting to observe how consequently practically all given chances offered by nature have been utilized for both major purposes and what compromises were found between the two major priorities. Beyond that it was highly impressive to see how preconditions were artificially created where they were not provided by nature. This became particularly striking during the visit to the Red Flag Canal system.

23. The average installed capacity resulting from the above mentioned figures would be below 60 kw per power plant. This is clearly in the range of what is called mini or even "baby" hydro power plants. In the programme of the study tour, however, only very few of such little units were included which was quite in line with the title under which the study tour was organized, namely, medium and small-scale hydro power plants. The average installed capacity of the hydro power plants visited was somewhere between 200 and 400 kw with a number of bigger and a few smaller ones.

24. The UNIDO study tour visited the following Counties and projects therein:

Linxiang County - Honan Province

This county covers an area of 3 mill. mu [a/] with a population of 780,000. Four seasonal rivers run through it. Farm land: 800,000 mu of which 600,000 is irrigated. 15 communes.

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a/ 1 mu = 0.07 ha or 0.17 acre
15 mu = 1 ha; 6 mu = 1 acre

The first mini hydraulic power station was built in 1951 with a capacity of 15 kw for lighting and grain processing.

The most interesting project in this county (and perhaps in all China) was the Red Flag Canal, constructed between 1960 and 1969 in the Taihang Mountains to lead the water of the Changho River into the county.

The main trunk canal is 70 km long, 8 m wide and 4.3 m deep with a flow c[illegible] $m^3/s$. With its three main branch canals and its wide ramification throughout the county the system has a total length of about 1,500 km.

More than 700 structures of various kinds were built within this irrigation system. These include 134 tunnels (24 km), 150 aquaducts (6.5 km) and a number of reservoirs and dams of various sizes. The estimated earth and stone removed amounted to $4 \times 10^6$ cubic meters and the work was estimated at $3.5 \times 10^6$ man days. Upon completion of the total system the irrigated area increased from 1,200 mu to 600,000 mu, the underground water table increased by 2 to 3 m in 10 years, seasonal rivers now have water all year round thus increasing scope for further mini-hydro development. Before the canal was built, the county purchased 10,000 tons of food grain per year from the State, now it sells 30,000 tons per year to the State.

The grain production per mu increased from 50 kg to 300 kg; in 1968 only 10 small mini hydraulic power stations of a total capacity of 400 kw were existing, while in 1979 there are 83 stations with 135 units and a total capacity of 17,000 kw. The largest unit is 1,600 kw, the smallest one 5 kw.

Along the canal itself 64 mini hydraulic power stations were built with a total capacity of 11,000 kw. In 1978 electricity consumption was $68 \times 10^6$ kwh (average per capita: 87 kwh) of which 68.5% came from mini hydraulic power stations.

Hydraulic Power Stations Visited

(1) Station No. 2 of the Red Flag Canal

Consisting of 3 units each with:
Capacity 320 kw; 400 v; r.p.m. 500; cos.$\varphi$ = 0.8.
Q = 2.2 - 3.82 $m^3/s$; h = 10 - 30 m; r.p.m. = 375 - 600.

(2) Xancun Commune Mini Hydraulic Power Station

This power stations is under construction; it consists of two units and will be extended by a third one.
Capacity 100 kw; 6,300 v; r.p.m. = 1,800; cos.$\varphi$ = 0.8.
Q = 2.2 $m^3/s$; h = 60.5 m.

(3) Hongying No. 1 Hydraulic Power Station

This hydraulic power station is the first one constructed in Linxiang County; it uses water coming from Branch No. 1 of the Red Flag Canal. Two units of 1,250 kw capacity each, 600 r.p.m., 0.8 cos. $\varphi$ and 6.3 kv; one transformer of 3,200 kva, (step up 6.3/35 kv).
Q = 7.6 $m^3/s$; h = 36.7 m
Working hours/year = 6,000.
No. of workers:

| | |
|---|---|
| 3 shifts x 6 workers = | 18 workers |
| + for maintenance | 9 " |
| + for cleaning | 9 " |
| Total: | 36 workers |

(4) Huanghna Hydraulic Power Stations

These power stations use mountain streams which are collected in a reservoir of 1 million $m^3$ storage capacity. The water flows through a 2 km canal into a second reservoir of 820 $m^3$ capacity and then through two penstocks into two mini hydraulic power stations:

No. 1 - One unit 100 kw; Q = 0.135 $m^3/s$; h = 115 m.
No. 2 - Two units 200 kw each; Q = 0.187 $m^3/s$; h = 145 m.
Two step-up transformers 2 x 240 kva, 0.435 kv.
Type of turbines used : Pelton.
Both power stations were commissioned in 1978.

(5) Cascade Mini Hydraulic Power Stations

One of the most interesting mini hydraulic power stations visited was a cascade of 23 stations along a 7 km irrigation canal with a total installed capacity of 1,085 kw. The one visited has the following characteristics:
Capacity 40 kw: Q = 1 $m^3/s$; h = 4 m.

Hengdong County - Hunan Province

42 communes with a population of 520,000; 520,000 mu of farm land in a territory of 3.2 mill. mu. Annual output: 140 x $10^6$ kwh. 66% of the Brigades are electrified.

(1) Yangtang Turbine Power and Turbine Pumping Station

This power station is located on the Mi River and is a multiple purpose project for irrigation, power generation and navigation. It consists of a dam 260 m long and 7.8 m high and has an overflow section with 43 auto-controlled gates. It has a power plant on each side of the dam and 3 turbine-pump sets by which power from turbines is used directly to pump irrigation water on higher levels. Some details:

Turbine Power Sets:
Right side . 4 units x 250 kw capacity; turbines: Q = 6.8 $m^3/s$, h = 5 m.
Left side : 6 units x 1,500 kw capacity; turbines: Q = 40 $m^3/s$, h = 5 m.
Total annual working hours = 4,334 hours.
Total annual generated power = 43.37 x $10^6$ kwh.
Annual transportation capacity on the river = 400,000 tons.

Turbine Pump Sets:
Discharge of pumps = 3.4 $m^3/s$.
Pump head left bank = 36.5 m; right bank = 20.5 m.

(2) Gangxi - Turbine Power and Turbine Pumping Station

This station is constructed down stream of the Mi River and is used also for irrigation, power generation and navigation.
It consists of:

(a) A dam 438 m long and 18 m high of masonry construction and has an overflow section with 17 gates;
(b) an irrigation canal of 210 km;
(c) turbine power sets:
    10 units of 1,250 kw each, Q = 16 $m^3/s$, h = 10.5 m.
    total annual working hours = 6,150; total annual generated power = 76.8 x $10^6$ kwh.
(d) Turbine Pump Sets:
    Right side Q = 2.41 $m^3/s$, h = 36.5 m;
    Left side Q = 3.15 $m^3/s$, h = 41.5 m.
(e) Ship lock: 400.000 ton/year transmission capacity.

The Mi River in this County:
Total length = 82.5 km;
slope = 1 x 2,500; water drop = 33 m;
max. Q = 5,930 $m^3/s$; min. Q = 72 $m^3/s$;
annual average Q = 247 $m^3/s$.
It is planned to install until 1985, 4 low head turbine-pump-power stations which will irrigate 180,000 mu of farm land and dispose of an installed capacity of 44.5 mw.

Mini Hydraulic Power Stations Visisted

(1) Dage Power Station

Two units, 125 kw and 120 kw capacity, h = 18 m.

(2) Chawang Power Station

One unit, 40 kw, capacity, h = 20 m; Q = 0.30 $m^3/s$.

(3) Shizan Power Station

One unit, 5 kw capacity, h = 10 m, Q = 0.08 $m^3/s$.

In this county there are about 30 mini hydraulic power stations with a capacity below 10 kw each.

Conghua County - Guangzou (Canton) Province

In this county the Liuxihi River is the main water resource. It runs 113 km within the county. The territory is 3 mill. mu of which 340,000 mu is farm land for a population of 360,000. The hydro power potential is 85,000 kw of which 65,000 kw are already utilized, while 20,000 kw will be developed during the next 3 years. 14,000 of the 65,000 kw utilized are generated by mini hydraulic power stations of which 80% are connected to the grid. The unit capacity of these mini hydraulic power stations range from 5 kw to 150 kw. The annual total generated power in the county is $9.6 \times 10^6$ kwh. 96% of the Production Brigades are electrified.

Use of Wood and Concrete in Hydraulic Power Stations

Between 1950 and 1960 the people of this county used runners and penstocks up to a diameter of 30 cm made of wood, and after that they also used concrete for runners and penstocks.

Miuri Dam and Hydraulic Power Station

This project consists of:

(1) An arch dam, 250 m long, 78 m high with a reservoir 320 x $10^6$ $m^3$ storage capacity.

(2) A divergent tunnel, 2 km long, 6 m diameter, lined with concrete (4.5 m internal diamter).

(3) An earth dam, 220 m long, 29.5 m high.

(4) An underground hydraulic power station, 27 m high, 44 m long, 12 m wide, with 4 units of 10.5 mw each. It has a substation raising voltage from 10.5 kv to 110 kv by two step-up transformers of 31,500 kva each.

Q = 12.96 $m^3/s$; h = 97.5 m.

The project is also used for irrigation, flood control and fish breeding. The construction started in 1956 and the first unit was installed in 1958.

Total annual power generated = 150 x $10^6$ kwh.

Parts of the power station equipment are imported from the Soviet Union.

Wuzhi Mountain Mini Hydraulic Power Station System

It consists of four mini hydraulic power stations using water from a reservoir of one million $m^3$ of water collected from mountain streams in an area with an annual precipitation of 1,900 mm. The total water head is 393 m.

The project was started in 1970; so far the following stations exist:

Station No. 1: 2 units, 200 kw each, h = 80 m, total Q = 0.7 $m^3/s$.

Station No. 2: 3 units, 200 kw each, h = 120 m, total Q = 0.8 $m^3/s$.

Station No. 3: 2 units, 360 kw each, h = 183 m, total Q = 0.8 $m^3/s$.

1 unit, 200 kw, h = 170 m, Q = 0.164 $m^3/s$.

Station No. 4: 1 unit, 15 kw, h = 6 m, Q = 0.4 $m^3/s$.

Total installed capacity: 1,935 kw.

Annual utilization working hours : 2,000.

Total annual generated power : 3.87 x $10^6$ kwh.

Some Technical Details of One out of Five Further Stations Visited on the Liuxi River

5 units, 160 kw each, Francis turbines, h = 4.2 m, Q = 5.7 $m^3/s$, 50 hz, 400 v.
Two of the units are connected with a step-up (10 kv) transformer of 560 kva capacity; the other three units are connected with a step-up (10 kv) transformer of 630 kva capacity.

The Tianho Dam and its Mini Hydraulic Power Stations

The reservoir has a storage capacity of 10.34 x $10^6$ $m^3$ of water used for the irrigation of 15,000 mu of farm land.
There are two power stations:
Station No. 1: 2 units, 160 kw each, 400 v, 50 hz, 1,000 r.p.m.;
Turbine: h = 26 m, total Q = 1.5 $m^3/s$.
Station No. 2: 3 units, 320 kw each, 400 v, 50 hz; turbines: h = 98 m, total Q = 1.2 $m^3/s$.

Xinhui County, Guangzhou Province

The population of the county is 780,000; out of 2.4 mio mu territory, 750,000 mu are farm land, 750,000 mountains and 900,000 water. The county lies deep in the south of the Chinese main land already in the tropic belt, forming part of the Pearl River delta region. The total hydro power potential is with 17,000 kw (of which 12,800 kw developed so far) rather low. Electricity supply is about 100%; annual consumption is 35 x $10^6$ kwh (mainly from grid) which allows only for about 45 kwh per capita.

The Gudou Mountain System

The Gudou Mountain lies in the south-west region of the Xinhui County. Its highest peak is 1,000 m above sea level. It covers an area of 405,000 mu. This area is rich in water resources. The design work of the project began in 1970 and was completed within six months time.

So far the local people have constructed 11 reservoirs to accumulate 42,000 $m^3$ of water from the rain fall over an area of about 100,000 mu. Today they are running altogether 29 units in 19 small hydro power stations with a total installed capacity of 9,261 kw. The tail race water is further used to water 75,000 mu of farm and garden land and 45,000 mu of forests. The entire system is run by two peoples' communes.

Some Technical Details

| | |
|---|---|
| Maximum unit size: | 1,000 kw |
| Minimum unit size: | 84 kw |
| Maximum water head: | 225 m |
| Minimum water head: | 6.5 m |

Shanghai

Greater Shanghai with more than 12 million inhabitants the largest city of China and said to be the largest in the world was visited on the way back to Peking. More for comparison sake, the Minhang thermal power plant was visited. The total installed capacity is 348 mw produced by both medium (98 mw) and high (250 mw) temperature units, the maximum unit size being 125 mw. The plant disposes of six boilers and 8 transformers (maximum size of the latter 180 mva). The fuel is mainly crude oil and partly heavy oil. The specific fuel consumption is 241 g/kcl/kwh. Power generation in 1978 was 2.5 x $10^9$ kwh.

Observations and Recommendations made by the Participants

P. Adhikari

25. It has been evident by the tour that the People's Republic of China has hastily completed its first phase infra-structural development and is steadily entering the second, more advanced stage. For continued development of this kind due consideration should be given to the following:

Many of the counties have developed most of their mini hydro potential. In some counties power is supplied through a larger grid. In some municipalities (like Shanghai) there is acute shortage of supply. Review and overall planning of the energy situation at this point of time may be considered.

Most counties have a number of power stations and have their own power grid. The installed capacity of power stations with single or multiple units vary from 5 kw to about 12,000 kw. The standard unit sizes are 5, 15, 40, 100, 125, 160, 252, 1,000, 1,250, 1,600 and 3,000 kilowatts.

The county grids are also connected to other county and province grids.

From the operation point of view, maintaining constant voltage and frequency in the system will present a problem which shall increase with an increasing number of stations. To overcome isolation of the station, more attention to operation problems may be beneficial for future developments.

The small projects are built and owned by Production Teams, Production Brigades, People's Communes and Counties independently.

The planned capacity is achieved by installing several units in one station. The specific output is therefore reduced, problems in synchronisation between the units and with the grid also exist. The planning of larger units in future may be considered.

F. Anik

26. It was observed that the mini hydroelectric power plants on mountainous streams were set up without any knowledge about the water regime (i.e. without any prior water measurements being carried out). Therefore, since the amount of energy to be generated had not, at the outset, been exactly determined, the hydroelectric potential is given as installed capacity (kw) rather than as kwh. In order that the operating regime of mini hydroelectric power plants may be correctly established, periodical flow measurements are suggested to be performed at the diversion works of plants in operation. If the water regime of the stream was known it would not only be possible to increase subsequently the installed capacity of a plant, but its firm power could also be determined. In the case also of new hydroelectric plants proposed to be set up, water measurements should at least be made during one dry season, and by way of correlation on the basis of figures available reflecting the water measurement data of adjacent rivers or streams, the regime of the stream can thus be established by approximation. Once the water regime is known, it would then be possible to determine the economical installed capacity of mini hydroelectric plants with greater accuracy.

Concrete lined conveyance canals obviously need maintenance and repair at frequent intervals, as could be seen in the Codou mountain. Although the masonry canals of the Red Flag Canal System *e.g.* were of older structure, they were in a better condition.

Considering that reservoir levels were low (some close to the minimum operating level), and that there were dams with leakages, it is suggested that the dams should be looked into from a safety viewpoint and the necessary precautions taken.

In most of the hydroelectric plants visited it was observed that neither of the units was running at full capacity. In spite of water shortage the reason for this was that a great number of forebays of the power plants were spilling water.

By erecting a large number of small units in the power plants, there happens to be a drop in overall efficiency. The installation of a single turbine capable of generating firm power and energy, the generation of secondary energy in times of abundant flow by using a second unit and keeping it on stand-by when the stream flow is low, would not only result in an efficiency but also secure an economy in initial financing. Furthermore there can be a possibility of generating peaking power with the second unit.

In the People's Republic of China, the hydroelectric potential of an area is always given in kw. What is significant in this respect is the quantity of total energy. The dependable capacity is far more important than the aggregate installed capacity. With these figures unknown, it will not only be impossible to ascertain whether or not the energy requirements are met, but there will also be no means of working out a daily and annual operational plan for the power plants in keeping with the curves of energy demands. According to the information provided, my impression was that the mini power plants were unfortunately operated in a haphazard way. The reason for this conclusion is the following:

There is need for investigating the load flow in the 35 kv transmission and distribution system. There was no evidence whether or not the active power generated in the plants (if load flow was not studied) had reached the stage actually provided for in the design. Although $\cos\varphi$ in units is foreseen as 0.8, it was observed that this figure was not reached in any power plant, and that it dropped on the whole to 0.6, whereas in certain plants it was found to be 0.5. Under these circumstances, it was impossible to make use of the maximum power which the plants could actually generate.

If the small system were linked to the inter-connected network, it would be necessary to study the load flow, otherwise there would be no possibility of ensuring the stability of the system, unless mini hydro power plants are operated as compensators. From this standpoint, even if the system were small, it would be necessary to study the load flow in the system connected to the mini hydroelectric power plants, and determine the generators' power factor according to the study of load flow in connection to the system.

As long as no precautions are taken to keep the reactive power at a level foreseen in the designs, it would be impossible to operate the energy transmission and distribution system in a stable way.

In the explanations given during the first meeting held in Peking 10 billion kwh of energy was alleged to have been generated with 5,200,000 kw installed capacity by the end of 1978. The value of this energy production is on average equivalent to 2,000 operating hours. These 2,000 hours/year is a low figure. Should measures be taken to minimize the reactive power generation it will be possible to increase the energy generation from 10 to 13-15 billion kwh with the same installed capacity. Under these circumstances, and with a view to meeting the ever increasing energy demand, highly economical advantages could be secured through delaying the construction of new power plants by a number of years.

The manufacturing technology of electro-mechanical equipment for power plants, the cooling of turbines and generators as well as the meters on boards can well be discussed. But, the failure of implementing the advanced technology for keeping the cost of electro-mechanical equipment of mini hydroelectric power plants low by way of manufacturing them locally may be dwelt upon as a policy, and it would therefore be preferable that discussions on this particular issue be dispensed with.

M. Aydin

27. In spite of the Chinese people's large experience in building and exploitation of hydraulic power stations, there are still some hints to be considered, observed during our tour.

Many of the power stations visited lack measuring instruments such as load indicators, power factor indicators, etc.

In some power stations one finds measuring instruments which either do not function or they indicate incorrect values. This should be overcome by having damaged instruments repaired or new ones installed, since obviously any worker in the power station will not care at all about the value of readings and their effects if he is aware that repair is not being carried out and that precise indicating instruments are not being installed.

In many hydraulic power stations visited, it was obvious that many small generating units have been installed in the same power house. Now since China is seeking improved technology and the best efficiency, I suppose they should plan to change small generating units in power stations for a few larger units and use the Kaplan turbine with flexible blades, which is convenient for dams with different water level during flood and irrigation periods.

Building so many mini hydraulic power stations has given the Chinese people much experience in multi-purpose exploitation and utilisation of water resources.

My impression was that the Chinese people adhere to the principle of maintaining independence and keeping the initiative in their own hands, relying on their own efforts, struggling hard and building their country through diligence and frugality.

M. Djurović

28. It had been noticed that buildings for hydro plants were built too large in size. It might be possible to accommodate the same machines in smaller buildings.

Electric generators are over-dimensioned in size as well as in numbers. More care should be given to the selection of generators, in order to have the best duration curve.

It would be very useful to apply the same sizes of generators as well as turbines throughout the People's Republic of China.

As far as production of electric generators is concerned further improvement of design as well as technology should be undertaken. A large specific loss (6w/kg), a bad cut of laminations as well as an improper use of magnetic material (in plates) was observed.

Transformers are overdimensioned. With an adequate selection of units, losses would be reduced. By considering the number of transformers in a network system this could result in a significant reduction of constant losses.

Transformers below 1 mva do not have Bucholch relay. This limit should be brought lower (600 kva).

Heating of electrical machines as well as control devices were observed to be high bearing in mind that machines were working far below the full load. Cooling of machines should be improved by means of a better design and construction work. One should not suggest further investigations into water cooling systems of small hydro generators. This method should be investigated in the field of turbo generators. Water cooling of transformers should be designed on a completely different basis. Cavitation is serious; one should pay more attention in trying to avoid it.

To obtain more information on utilisation of mini hydro plants further measurements are required. Permanent measurements of appropriate electric quantities are required in order to obtain load flow.

A suggestion to try to use energy locally generated by mini power plants should be put forward; if this is achieved, losses can be reduced. At the same time investment cost in transmission and/or distribution lines would be reduced. Very small power plants, such as 15 kw, should not be connected to any grid.

Too many voltage levels were observed. Such a variety of voltages should be avoided (6.3, 10.5, 35 kv), studies should be undertaken to replace all of them by one, for example 20 kv which would ideally suit the needs for rural areas.

It has been observed that the load factor often is bad. Even 0.5 was recorded. This meant that more attention to the power factor should be paid.

It would be good to make further observations of the water flow with a view to install new units in already existing stations, thus making "the best fit" for the duration curve.

Losses in lines might be reduced by means of better construction and crafts work.

H. Gaerlan

29. China as a whole does not have a national integrated grid, but isolated ones in provinces. These isolated grids encompass the small and medium hydro plants systems. With the new movement of China to modernize and undergo massive industrialization, a national grid with large power plants is necessary. Therefore, the following suggestions are made:

The small and medium size hydro plant systems are monuments of the efforts of the Chinese people and should not be abandoned in the event of interconnection with the giant grids. However, when the situation arises that interconnection becomes necessary the fault-level of the system at the particular point of connection would tremendously increase beyond the interrupting capacity of the existing power circuit breakers. This means a replacement of the existing ones by others with higher ratings, which is a very expensive solution.

It is suggested therefore that series reactors be installed at the point of connection with values low enough not to affect the voltage regulation of the quality of supply, but high enough to maintain the original value of the fault-level within tolerable limits.

It is noted that the 35 kv nominal voltage level systems are not effectively grounded. This means that no line-ground fault relaying is possible. The international observations states that 80% of faults are of line-to-ground nature. Also, ferro-resonance phenomena shall be prevalent when the large grid is established. It is suggested therefore, that effective grounding be warranted by the usage of grounding transformers or impedance coils whose values are based on technical studies.

With the establishment of the national grid or large regional grids it is almost sure that stability problems, fault problems, abnormal voltage waves due to switching or lighting phenomena, and weak system characteristics shall arise. I am very sure that power systems engineers in Peking or Shanghai are capable of solving them, however, the staff at county levels may not be sufficiently trained to do so. It is suggested therefore that county engineers be familiarised with such technologies and remedial measures and be allowed to use computer programmes prepared by experienced system engineers. Computers should be installed at prefecture level for county engineers' use.

Load dispatch and controls based on international standards should be introduced to the bureau personnel at county levels.

Protective relaying schemes which are internationally accepted should be adopted.

Efficiency improvements for equipment and installation are necessary to maximize the usage of water, materials and human resources.

F. Montaverde-Zubiran

30. I see many advantages in the way in which the Chinese have developed their areas:

The installation of small hydro power plants is applied in what I would like to call complimentary form giving top priority to the agricultural aspect (irrigation), but almost equal importance to power generation.

Since the Chinese people have done all the work themselves they treat their stations very carefully and obtain as much benefit from them as they can.

The use of suitable reservoirs for fish breeding provides an excellent source of high protein food.

The way in which reforestation is done provides the country with rain and avoids erosion.

The hydro power station system is a great school for the future Chinese generations (as it was for the participants of the study tour).

The Chinese applied their own technologies (very simple ones), labour force and materials.

The produced energy is used to assist agriculture (e.g. by the production of fertilizers or agricultural machinery), and also for the production of equipment for the hydro power stations.

Bio-gas is produced from organic wastes.

There is hardly any environment pollution in connexion with or caused by small hydro power plants.

Better security measures should be developed particularly in installations of high voltage and one standard voltage for distribution should be introduced.

S. Niekoop

31. There are some remarks to be made on the electro-mechanical equipment and civil-technical structures. Most of them are probably well known by the Chinese experts, however, in brief some may be summarised here.

Improvement of the efficiency of the electro-mechanical equipment could be realised in the second phase of developing mini hydro power plants by:

Application of better casting methods for runner blades and finer tolerance to reduce surface roughness. This will also reduce cavitation problems; using relative simple methods to reduce clearings at rotor bearings. The number of standardized turbine-generator sets could be adjusted to meet the site conditions so that this will help reducing cost. Application of general standards all over China is very important. The space in the power houses in relation to the installed capacities could be reduced in some cases.

A. Oseni

32. The Chinese hydro power plants cannot be studied in isolation. They are closely linked with the country's irrigation programme. The small and medium scale hydro projects were primarily developed for agriculture. The mode of operation of most of the hydro plants is determined by the irrigation requirements. There was hardly any free space of land that was not planted with one type of food crop or the other. Every piece of land was well irrigated and made suitable for agriculture. Some plots were being used for three crops a year while others were for two crops a year.

It was clear from discussions that the hydro development projects were primarily for irrigation and that irrigation requirements still dictated the mode of operation of the hyiro electric plants. Since this mode of operation may not satisfactorily meet the electric power requirements of the consumers, it will be advisable to have alternative or supplementary sources of power in the form of fairly large thermal plants whether at provincial or county level (but not at commune level). The power plants should be connected to the grid to feed down to the commune and other lower administrative levels.

E. Rendon Vasquez

33. China has made tremendous efforts in the construction of small hydro power stations in the catchement areas of her major rivers. These utilities have been linked with hydraulic projects also of medium and small size which, in great number and with notable efforts, have been constructed on these rivers.

The technology used is local and of predominently artisan character; they have been in accordance with the possibility of being implemented by the populations of the areas where the utilities have been located.

Although the principle object of the established hydraulic works has been the augmentation of arable land, the use of the water was in the majority of cases harmonised between agricultural and energy demands.

The small and medium scale hydro power stations have been integrated into electric systems supplying centres of important charges and great consumption the electric demands of which are additionally covered by bigger power stations. This has, nevertheless, already raised the question whether it is foreseeable where the difficult problems of electric stability will come up.

In the electric stations visited a type of operation was found organised according to standards of common use as well as a permanent delivery register. In the majority of cases no systems of intercommunication between the power and despatch stations were found. This indicates the type of operation essentially based on the power stations.

It is important to emphasize the formulation of global plans (master plans) for the hydraulic developments in which studies and future utilisation of water resources are considered.

The possibility of standardisation of the equipment used should be examined.

At the same time it might be advisable to increase the technological capacity of the personnel in charge of the projects and installations of the small hydro power stations.

N. Rizk

34. It is of prime importance that during the next phase of development of mini power stations the following general remarks be taken into consideration:

Highly qualified teams of experts of different specialisation should examine all constructed schemes and put their recommendations for improvement of certain defects so as to bring the whole system to higher standards. The present system with such improvements can cover increased demands for a number of years to come.

Exchange of experts and know-how with foreign manufacturers of wate. turbines and generators would be useful. It is worth mentioning in this context that a big number of such manufacturers will be interested to invest substantial amounts in this field. A standardisation of the whole system will bring the unit cost of the installed capacity to a minimum.

The harmonization between agriculture and electric development co.tributed substantially to the accelerated growth of the national economy. To enable the quick implementation of the small and medium size hydro power schemes one must be independent from any overseas or international sources.. The team work performed by each county, starting from the propulsive masses nearly fully independent from the central Government, was a unique and successful example.

The know-how and the experience gained by the substantial number of workers and farmers in the rural areas who are respor ible for the installation of these hydro stations can be considered as an excellent training programme for the future development of such schemes besides the psychological effects of these power stations being under the eyes and touch of the entire population all over the rural areas.

J.F. Rola Pereira

35. My suggestion is confined to a single aspect of general order although with multiple incidences. It regards the recommendation that new projects of medium and small-scale hydro power plants will in future be studied not just on account of the immediate and local needs, the technology and the means available in small regions - as I guess it has been done up to now for the reasons we had the opportunity to perfectly understand - but it is imperative to start studying them under wider views, in space and time, taking into consideration their integration in the development plans for industrialisation and electrification, set up at medium term plans for large regions.

I guess the Chinese authorities are already well aware of this need, but to carry it out involves aspects closely connected with the political and social organisation of the Nation that necessarily has to go through a continuous evolution, in synchronization with the economical development itself.

With the same purpose, I think it would be of the utmost importance to launch a large training programme to which UNIDO could make a very valuable contribution by providing skilled experts for the setting up of general plans and designs of multi-purpose hydro schemes as well as in designs for hydroelectric power plants, to be included in those plans.

Also of the utmost importance will be to develop the manufacturing of equipment for such power plants, creating, through vast areas, great and modern industrial units using the most updated technology. As for this aspect, it is to be referred that a great deal of the technology delay we have found in the medium and small scale hydro power plants is due, in my opinion, to the lack of equipment other than of regional manufacture. I think that UNIDO, in this sector, could also provide an extremely valuable collaboration to China, not only training experts needed for the industrial units, but also advising contacts to be made with experts from other countries capable of working out standard projects of such units and participating in the installation and start-up of the production.

P. Songpongs

36. Natural resources planned for maximum development.
It was obvious that all projects visited had been planned to make maximum use of the natural resources irrespective of economical justification or capital investments. This is due to the surplus of labour and lack of natural resources. Feasibility studies of resources or other alternatives of development are less important in these areas.

Local problems in development could be achieved by simple technology. From the history of many projects visisted it appeared that they lacked both proper material for construction and technology at the beginning stage. All the materials were collected from the local resources, such as stones, bricks, wood etc. Many projects have been completed by simple methods and equipment. This resulted in savings of time and foreign currency.

The combination of small hydro power projects to other developments. The most popular combination of the small hydro-power projects to other developments in China is the combination of electric development schemes with irrigation plans.

D.S. Taware

37. After seeing many mini hydro power stations it was noticed that the range of manufacture of the generating units is rather limited in as much as the units of standard ratings of 12 kw, 55 kw, 100 kw, 125 kw, 250 kw, 320 kw and 500 kw were used. There were few units of 1,250 kw, this might have been found necessary by the People's Republic of China in order to cope up with mass-production programmes coupled with the need to manufacture different sizes of units according to individual site conditions.

It appears that perhaps because of the approach regarding standardisation of unit sizes, the capacity of units at certain installations is in excess of the power that could be developed, ie. at certain places units are oversized. Such an inference has been drawn as the group during the study tour observed that at many locations the actual outputs from the units in operation were much less than the plate rating.

It was often observed that whenever the installation in a power station comprised more than two units, one of the units was not in operation presumably because the same might have been considered as "stand-by". The above observations of the group were discussed with the authorities of the People's Republic of China during the summary concluding session after the tour. The PRC authorities, however, clarified that under-utilisation of the capacity was due to low water conditions in certain cases while in other cases the full development as per the ultimate plan has not been achieved. Also, it was stated that the capacity of the installations has been fixed taking all the above aspects into account and to ensure that, in due course, it could be fully utilised.

The generation voltage except for higher units of 500 kw and above was 400 v. The voltage is then stepped up to 6,300 v, 10,000 v, or 35,000 v depending upon the quantum of power and the distance over which the power is to be transmitted.

The local areas are served by forming county level grids and by inter-connection with province or state grid at 35 kv at required locations. The People's Republic of China has the experience that the people in remote areas could be better served by this arrangement rather than by constructing big power stations some distance away and connecting these by long and unreliable transmission lines.

In regard to the operating problems in connexion with quality of power supply in as much as poor voltage and frequency regulations were concerned, the group was informed that these problems do exist because of the existing system of operation of the mini hydro power stations. The People's Republic of China however, is taking steps to improve the quality of supply in rural areas by augmenting sub-stations' capacities and improving the existing arrangements wherever necessary.

At times, the problem of matching the generation with loads becomes so acute that they have to resort to "load shedding" or sometimes tripping of non-essential feeders.

It was also observed that mini hydro power stations were developed in conjunction with irrigation, navigation and fishery development and the cost of head works, i.e. storages, were mainly allocated to irrigation works, while only the cost relating to the power house and equipment were considered under power.

We were also informed that the cost of labour during construction was not considered as investment. Despite this, the construction cost of mini hydro power stations is of the order of Yuans 800 - 1,000/kw.

It was also observed that the provisions in the power houses were of the bare minimum. In many power stations permanent arrangements regarding power house cranes, dewatering pumps etc. were not made. The main generating equipment was of a very simple nature.

All the equipment for the mini hydro power stations was manufactured in China and was of the conventional designs, i.e. vertical or horizontal shaft arrangements, and no installation was found with bulbs or tubular turbines for the small units installed on canal drops.

The project construction, i.e. construction of power house buildings, colonies, roads etc., was very impressive.

In general, I gathered the impression that considerations of economics were not so vital in mini hydro project construction and we were informed that all these were based on existing needs.

Every county was endeavouring to become self-sufficient and possesses a small factory which could manufacture the equipment and repair the same.

The equipment manufacture is done at three different levels, viz. (i) county level, (ii) province level and (iii) state level. Generally the manufacturing of units up to 500 kw is done at county level according to the needs of the particular county, and the standard of manufacture may not be the same from one county to another. The manufacturing of large units of 500 kw and above is standardardised by the Tientsion Institute of Design under the Ministry of Industrial Machine Building and all the detailed engineering drawings are carried out and issued by this institute to the counties. The actual product, however, differs from county to county as the techniques used are different.

**Benefits** perceived by the Participants

P. Adhikari

38. About 70% of Nepal's population's accommodation is situated in the hills, they are agriculturists and also domesticate animals. Some areas are densly populated whereas others are sparsely populated. Every household has 6-7 family members and 4-5 heads of cattle, pigs and fowls. Their energy requirements are mostly domestic, such as fire-wood which they obtain from nearby forests.

Due to an increased demand for agriculture land, the forests are depleting and the rural population is gradually facing difficulties meeting their fuel requirements. No coal or oil resources have as yet been explored. Kerosene is imported and due to the non-stable supply, the farmers are faced with difficulties.

Hydro power potentials are immense, rural hill areas have an innumerable number of peripheral streams suitable for hydro-power development. Limestone quarries are found in most of the villages, these could be used for the manufacture of chemical fertilisers. Every household has sufficient organic wastes for the production of bio-gas for meeting their own needs.

Due to lack of suitable education facilities as well as job opportunities, the young people from rural areas are continuously trying to move to urban areas. The present Government has laid great stress on the development of substitute energy resources for rural communities through a combination development of mini hydro power stations and bio-gas plants.

In view of the above general back-ground, this UNIDO study tour to China has been of great interest from the view point of our country.

P. Anik

39. Inspired by the experience gained during the study tour through the People's Republic of China I would say that the electrification of rural areas in Turkey (and in similar countries where the use of paid labour is imperative) might well be possible providing the views suggested below were adopted as a policy by the State.

The number of towns and villages presently in Turkey is nearly 40,000. Administrative departments, district centres and major sub-districts are now entirely provided with electrical energy.

The number of villages where electrical energy was made available by way of mini-hydroelectric power plants or transmission lines from the inter-connected system by the end of 1978 was 13,000. The supply of electrical energy to 5,000 villages per annum has been taken into account in the yearly budget programmes. According to the State Planning Organisation's schedule, all villages in Turkey will be provided with electrical energy by the end of 1983. However, in the personal opinion of the writer of this report there would still be a possibility of setting up mini hydro electric plants if the suggested solution were considered. Although wide areas are expected to be irrigated, no State would give preference to the taking care of farmland and pastures in this respect. As in the Chinese example, if a solution is sought to the problem of building mini hydro electric plants for generating electrical energy and at the same time irrigating small farmland and pastures, minor streams could be developed into a state capable of serving multi-purposes.

Although inofficially described, hydro electric power plants whose installed capacities go up to 2,000 kw are considered as mini-power plants, and those whose installed capacities vary between 2,000 and 20,000 kw are classified as medium-scale power plants in Turkey.

According to the unit prices prevailing in Turkey, mini hydro electric power plants are found not to be feasible when compared with the cost of transmission lines or other types of power plants. If, however, the generation of electrical energy is supplemented also by irrigation from water sources, mini hydro electric power plants, subject to the following conditions, may then prove to be economical.

Should the State accept the principle of allocating the investments of the storage reservoirs (or diversion structures) and the conveyance system at the headrace and tailrace of the powerhouse, as well as those expenses which are to be incurred for access road building to the irrigation works, and if it further espouses the policy of not refunding the investments destined for the irrigation of farmland, mini-hydroelectric power plants may then turn out to be feasible.

Under such circumstances, the cost of mini-hydroelectric power plants would include solely the costs of penstocks, powerhouse, switchyard area construction and electro-mechanical equipment. On the other hand, there would be a saving in cement, reinforcement bars, in the usage of timber forms through the utilisation, if possible, of local materials in the construction of a number of structures, let alone the income to be secured to local people recruited as labourers as a result of the construction being of the masonry type.

Not only would this suggested solution enable villages or groups of villages to be supplied with electrical energy, but help irrigate farmlands and pastures thereby supplementing to a wide extent as contributary factor to the wellbeing of the rural population.

M. Aydin

40. After this study tour, I have to admit that I feel very encouraged to give more attention to many water resources existing in my country, mainly in the north-east part of Syria which is not utilized yet for either power generation nor for irrigation.

The water precipitation in this area reaches 1,700 mm/year and the preliminary study shows that many small and medium hydraulic power stations can be installed to generate about 4"0 x $10^6$ kwh per year and the possible installed capacity can be around 257 mw in total.

I think the Ministry of Electricity in Syria might benefit very much from the Chinese experience through contractual relations or through Governmental contacts to utilize the whole water resources available in my county with up-to-date advanced technology.

M. Djurović

41. The study tour has shown that energy problems might be solved very usefully by means of small power plants, particularly if construction work as well as running of them is based on self-reliance of the people who use the energy. At the same time this has shown that people can be technologically educated by letting them do all the work on such projects.

The use of mini power plants should be encouraged and one can think of obtaining better turbines and generators for small heads and sizes. This can even be recommended as a topic to very well known manufacturers all around the world. It is hard to imagine how much energy might be generated in the world using China's approach in mini power stations. It seems that this might not be the only way of getting energy in developing countries, but a supplementary way to provide energy even in highly developed countries.

H. Gaerlan

42. In this study tour I have noted that China at county level had planned and implemented the tapping of small and medium size hydro energy potentials for irrigation and electricity supply, no matter how small the capacity may be. The total appears reasonably large from the view point of my country which consists of 7,000 islands and in which irrigation and electric systems' development is most needed. There are at least ten large islands densely populated with sufficient electric supply and operating on isolated grids, while the rest of the islands do not have this.

With these observations, the Philippines should go into a crash programme or mini hydro plant development. This will not only provide electricity for the people in the small islands, but could serve to promote interconnection by submarine cables with the national grid when economically feasible. I firmly believe that the people on these small islands should enjoy the same rights and privileges, comfort and luxury as those in the cities or large municipalities.

P. Monteverde-Zubiran

43. The installation of small hydro power plants should always form part of the integrated development of a zone or region.

After this visit, the programmes that we have throughout Latin America to install small hydro power plants will change in their content so that the project should include:

(a) An important local allocation in terms of labour force and materials;

(b) possibilities for agricultural development;

(c) direct contributions in kind by the interested country (e.g. vehicles, technicians, premises);

(d) assistance from countries with experience in the installation and

(d) operation of small hydro power stations such as China, Nepal, etc.

Man is able to reach imagined goals when he really wants to .

It is an absolute necessity to launch a great programme for the installation and fabrication of such small hydro power plants for the future development of Latin America.

The mechanical system of pump power stations (turbines plus pumps)

We shall accelerate our programme in the field of bio-gas after having seen such systems in operation.

S. Niekoop

44. The development of rural areas has to be based as much as possible on existing natural resources (including human). This could be done gradually so that the local population can absorb the knowledge offered and transform it into activities, which have to result in productivity.

The guidance and aid of the Government is of essential importance in order to reach a harmonious development and to make use of latent possibilities.

Concerning application of technologies the technical schools and technical faculties of our university could make an essential contribution. In this context there is useful information regarding simple appropriate technologies which can easily be collected from abroad (for instance, "Stichting Tool", Amsterdam, Netherlands). Motivation of the population is of essential importance.

A good development might be reached in the construction of simple (but reliable) micro hydro power stations by meaningful application of appropriate technologies.

In the realisation of hydro power stations in rural areas it seems to me possible to make use of electro-mechanical equipment made in the People's Republic of China. This is in general simple in construction; the efficiency may be somewhat lower than the one of that produced in the "Western" countries, but the possibilities for maintenance and repair would correspond more to the level of local technologies.

The production of bio-gas seems to be a possibility of "alternative energy (fuel) production" in Suriname which is worthwhile studying. The basic materials are present and the climatic conditions seem to be reasonable.

A. Oseni

45. One outstanding feature of the whole project development was the underlying principle of self-effort and self-reliance. This principle has made it possible to achieve much within a relatively short time.

This is a principle that should be encouraged in our country. This may be started with the National Youth Service Corps programme which is now operating in our country. In this programme, all university and technical college graduates have to give one year's compulsory service to the Government. These graduates may be used on national development projects.

The hydro plants visited showed that with simple machines and control equipment it was possible to construct hydro power stations at reasonably low cost. This should serve as an encouragement to us in the development of small hydro plants. It is possible with simple machines to minimise the cost of small hydro plants and make the project viable.

The Chinese effort in the field of agriculture is also worthy of emulation. We should endeavour to develop all available land for agricultural production. Large scale irrigation programmes should be encouraged with planned control of flow of water from reservoirs rather than depend on rainfall which may be unpredictable with respect to time and quantity. Planting and harvesting periods can be properly and reliably programmed with irrigation.

One other advantage of the study tour was the opportunity of meeting and exchanging views with experienced professionals from other countries. The discussions were found very useful.

E. Rendon Vasquez

46. The Chinese experience has been developed in accordance with her geographic, social, economic and cultural reality. Besides, the existence of a certain type of already given infra-structure could be supposed. Consequently, there should be a possibility of transfer suitable for the adaptation of such experience to the reality of other countries.

The value of the efforts by which a people has solved their problems by their own solutions is worth mentioning. This should serve as an example to countries like Peru to make use intensively of their own technologies putting, where necessary, perserverance and courage into the solutions.

With particular regard to the case of Peru we shall have to mention that we already have a very numerous rural population disposing of existing traditional experience in communal work including the so-called Rural Communes, the inheritage of the empire of the Incas. On the other hand we believe that the equipment of the power stations could be perfectly produced in the numerous plants and workshops existing in our country.

N.I. Rizk

47. As regards Egypt it is recommended that the same planning of small size hydro electric units in the extended system of irrigation and drainage canals should be adopted to cover the rural electricity demands during the coming years. This should be done in addition to the plans presently under execution which provide feeding rural areas from the main grid.

J.F. Rola Pereira

48. It is of interest to draw a short parallel between the situation in Portugal and what we had the chance to see in China and to refer the benefits we could gather applicable to our case.

Today, in Portugal, we dispose of a single electrical grid covering the whole country and interconnected with Europe at 220 kv and also at 400 kv from the end of 1979 onwards.

Nearly 60% of our hydro resorts are under operation or in progress. The remaining, of worse quality, will be exploited in accordance with the results of the studies on the economic feasibility, considering the cost of the alternative solutions for electricity generation.

In principle and generally speaking, the hydro developments to be erected will aim at reaching a capacity able to meet the peak load consumption of the interconnected grid in which they turn out to be far more economic than the alternative thermal solutions. The erection of hydro stations is therefore closely connected with the increase of the said peak of electricity consumptions.

No small-scale hydro power plants were erected in Portugal since 1960. The event of its future erection will exclusively depend on the economic feasibility after taking into account the first investments and exploitation expenditures. Yet, we must admit that some of those power plants, mainly those which would be integrated in multi-purpose hydro schemes to be used for irrigation and water supply for industrial and urban purposes, might be found to be economical.

In view of what I have said, I have to conclude that, although the study tour has been extremely interesting and fruitful to understand the social and political evolution in China for the past years and to understand the process of elaboration of the first electricity generating centres in small-scale hydro power plants included in hydro schemes for irrigation, I could not find any benefits directly applicable to similar developments in Portugal. Nevertheless, the Electricidade de Portugal cooperate with both Portuguese and foreign entities, and here some of the lessons learnt from the experience in China will certainly be very useful, not only in what is to be done, but also in what is to be avoided. Among those entities I shall mention the electricity generators of the small islands of the Portuguese archipelagos of Madeira and Azores in the Atlantic and the new Portuguese speaking independent countries in Africa, such as Cabo Verde, Guiné, S. Tomé e Principe, Angola and Mozambique with which Portugal has been signing agreements for cooperation, technical assistance and mutual aid.

P. Songpongs

49. The procedure of development in China can be classified as a bottom-up way. Projects are initiated by local authorities or groups of people, and central organizations will be asked for help under particular circumstances. The eminence of this method is that the local people have taken part from the beginning until the completion of the project. This could be very useful in rural areas of my home country because the local people would not only assist in the construction, but also enhance the development plan to meet the goals within a short time.

The second useful point from this tour is to simplify the small hydro power development as a common construction work which can be done in any place where the water is available. In the remote areas where a few kilowatts of electricity are required the machines can consist of simple turbine-generator sets with a common water conduit and no expensive automatic governor. This is very important for developing countries where capital investment and technology are scarce, but the remote areas to be developed are numerous.

The third point is that the development of small hydro stations is not done only for electricity, but should be planned along with the other projects, especially agricultural areas. It is obvious that benefit from farm land is much more when surface water or ground water can be pumped up for the farm land all year round. This point is very important to my home country because many small hydro power projects have been dropped due to inadequate economic justification. Economic feasibility could be met easily, if pumping systems for near-by farm land were added to power generation projects.

D.S. Taware

50. The geographical situation in India, particularly in Maharashtra, and the general development of the rural areas in the interior are very similar to China. I therefore feel that it is worthwhile that the State Government considers a change in approach regarding generation and supply of electric power in rural and remote places away from big power stations.

In Maharashtra, large hydro power resources have been utilised earlier and nothing appreciable can be developed in the future in the form of big hydro projects in the context of allocation of waters of major rivers like Krishna and Godavari. On the other hand, a massive irrigation development programme has been launched and thirteen major projects are already under implementation. It would be prudent that the power potential of these sites be evaluated and developed. According to a first evaluation, the potential of the thirteen sites is estimated at 88,000 kw giving an annual energy generation of 360-mio kwh.

The energy generation, though seasonal in many cases should not be ignored since it will give relief to the state power system particularly at times when the peak demand increases during the fair weather season.

It would also be worthwhile to investigate whether mini hydro plants could be installed on the irrigation canals at suitable locations - at head works or along rivers whenever there is a drop which could be economically harnessed.

The operation and management of the small power stations could be managed by irrigation maintenance crews or by rural cooperative societies which could be formed wherever possible.

The study tour as such

The composition of the study tour was very good in respect to both qualification and homogeneity of the participants. The fact that apart from the rapporteur three more UN officials accompanied the study tour can be considered as an asset for both this particular study tour and future activities of a similar nature and their co-ordination.

During the first days a number of the participants expressed their wish to have the duration of the study tour shortened by a couple of days. As a matter of fact two of the participants and two of the UN officials left the group for urgent reasons before the completion of the study tour.

With regard to the arrangements of the international flights it seems to be advisable that those responsible in UNIDO route both the non-convertible and the convertible lags of these flights not only under cost aspects, but also with regard to their practical implementation.

The implementation of the study tour from both an organisational/administrative and a substantive view-point can be called excellent. For any future activity of this nature only two alterations might be worth considering, namely, to shorten the duration by two or three days and to include a few more real mini or "baby" hydro power plants. The enrichment of the programme by cultural/touristic elements can be considered as well balanced having in mind the importance of the socio-cultural environment in the People's Republic of China as well as the fact that the tour brought with it extensive night travels.

Acknowledgements

Gratitude and highest appreciation is to be expressed to all who contributed to designing, preparing and implementing this successful study tour, in particular the staff members concerned of the Ministry of Water Conservancy and all those who met the group at the different places. Special mentioning is owed to the two ladies of the Ministry of Water Conservancy who accompanied the group during the entire tour and fulfilled this job with the highest degree of competence, in the spirit of friendship and with an attitude of cordiality.

A list of responsible persons met by the group is attached as Annex III.

UNIDO
Industrial Operations Division
Training Section

Annex I

# GROUP STUDY TOUR IN THE FIELD OF MEDIUM AND SMALL-SCALE HYDRO-POWER PLANTS

## Programme

| | | |
|---|---|---|
| May, 14 | | Arrival in Beijing (Peking) |
| | 15 a. m. | Programme introduction; first information on mini-hydro power plants in China |
| | p. m. | Sightseeing in Beijing |
| | evening | Official opening dinner party |
| | 16 | Sightseeing in Beijing (continued) |
| | 17 | Great Wall and Underground Palace |
| | evening | Leaving Beijing for Anyang by train |
| | 18 morning | From Anyang to Linxian County by coach |
| | 18 and 19 | Visitsto the Red Flag Canal Project and related power stations |
| | 19 evening | Leaving Linxian via Anyang for Changsha by train |
| | 20 morning | Arrival at Changsha; sightseeing programme; programme discussion for the day to follow |
| | 21 | To Hengdong County by coach |
| | 21 and 22 | Visits to hydro power stations, a turbine-pump station and a hydro power station equipment manufacturer in Hengdong County |
| | 22 evening | Leaving Hengdong County via Hengyang for Guangzhou (Canton) by train |
| | 23 morning | Arrival at Guangzhou; |
| | afternoon | Leaving Guangzhou for Conghua by coach; |
| | evening | Programme discussion at Conghua |
| | 24 | Visits to power stations in Conghua County |
| | evening | Return to Guangzhou |
| | 25 a. m. | Leaving Guanzhou for Xinhui |
| | p. m. | Programme introduction and discussion |

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|---|---|---|
| | 26 | Visit of hydro power stations and water reservoirs an the Qugou mountain area |
| | 27 a. m. | Return to Guangzhou |
| | p. m. | Free |
| | 28 a. m. | Visit of a generator factory |
| | p. m. | Sightseeing |
| | evening | Leaving Guangzhou for Shanghai by plane |
| | 29 | Sightseeing in Shangai |
| | 30 a. m. | Visit to thermo-power plant |
| | p. m. | Shanghai harbour (by boat) |
| | 31 a. m. | Leaving Shanghai for Beijing by plane |
| | p. m. | Interim report writing |
| June, | 1 | Evaluation seminar; closing of the programme |
| | 2 | Departure of the participants |

MEDIUM- AND SMALL-SCALE HYDRO-POWER PLANTS
STUDY TOUR
C h i n a , 1979

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(4) DJUROVIC Momir
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(7) NIEKOOP Stephanus Petrus Raymond
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(8) OSENI Ayuba Atanda
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(9) RENNON-VASQUEZ Edmundo
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Ministerio de Energia y Minos
PERU

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Head, Hydro-Electric Projects
Ministry of Electric Power a. Energy
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Bangkok, Tahiland

List of Chinese Officials Met

Peking

| | |
|---|---|
| Mr. Li Boning | Vice Minister of Water Conservancy |
| Mr. Deng Binli | Deputy Director of Water Projects at Farmland Department |
| Mr. Sun Guolu | Chief of Foreign Liaison Div., Dept. of Foreign Affairs |
| Mr. Bei Lin | Engineer of Water Projects at Farmland Department |
| Mrs. Yang Xiuying<br>Mrs. Zou Youland | Interpreter |

Hohan Province

| | |
|---|---|
| Mr. Han Peicheng | Director of the Province Water Conservancy Bureau |
| Mr. Duan Yipo | Director of Linxian County Water Bureau |

Hunan Province

| | |
|---|---|
| Mr. Rong Xinho | Deputy Director of the Province Water Conservancy Bureau |
| Mr. Li Zhiqing | Director of Agriculture Office of Hengdong County |
| Mr. Tang Shiwan | Engineer of the County Water Bureau |

Guangdong Province

| | |
|---|---|
| Mr. Shen Tian | Director of the Province Water Conservancy Bureau |
| Mr. Zhu Zhikei | Engineer of the Province Water Conservancy Bureau |

Shanghai

| | |
|---|---|
| Mr. Wang | Deputy Director of East China Power Administration |

[redacted]