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Small Hydropower Plants

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APPLICATION OF STANDARDIZED SMALL HYDROPOWER INSTALLATIONS IN CHINA*

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1. Background of the report

As a follow-up of the Second Consultation on the Capital Goods Industry held in Stockholm, June 1985, the Task Force on Capital Goods Industry, UNIDO decided to hold a meeting on the development of standardized small hydropower plants from design to manufacturing, and asked HRC (Hangzhou Regional Centre for Small Hydropower) to prepare a paper on the Chinese experience in design, manufacturing and operation of standardized models and also in previous SHP projects as well as resources available in China for engineering and contracting services including future plans for SHP installation.

Considering that the objectives of this meeting is to promote the transfer of technology in SHP equipment design and manufacturing so as to enhance the manufacturing capability of developing countries, thus promote the development of SHP in this area, we hope that not only the experience gained both in China and other Asia-Pacific countries as well as in the advanced countries will be exchanged in the meeting, but also some strategy or concrete measures will be discussed and agreed upon. In this paper, some proposals are raised in the final part, which I hope, will be of interest to the participants.

2. A brief review of development of SHP in China

Since 1949, the construction of SHP stations and local grids in China has been quick in speed and large in scale, with the amount standing top in the world. The yearly increments of SHP capacity average at 7-13%. By the end of 1986, the total number of SHP stations and generating units in operation throughout the country were 67,700 and 86,400 respectively, with a total installed capacity of 10,000 MW, 11% of the whole electric power capacity in China. All the SHP equipment installed is made in China. These figures show both the important role of SHP in electric power sector especially in rural electrification, and the self-sustained capability of SHP equipment supply.

The reasons for the fast speed and large scale development of SHP in China are usually attributed to the basis of rich resources, background of whole rural economic development, a series of successively improved policies and strategies as well as quick development of SHP equipment manufacture. During the past 30 or more years, the capability of SHP turbine/generator production matched the demand of construction of SHP station in a way. Currently, the manufacturing capacity even exceeds the construction tempo, the former being 1,000 MW per annum and the latter, stabilizing at 500 - 600 MW per annum on average.

3. Plan of rural electrification

In recent years, the vast rural areas in China have been going through a deep reformation period of transforming from traditional agriculture into modernized one and from self-sufficient management into commercialized production one. The demand of rural electricity supply expands both in quantity and in geometrical scatterness. Thus the realization of rural electrification has become an important issue in the development of rural economy. In 1982, the central government proposed to set up 100 pilot counties of preliminary rural electrification to be completed by 1990. The average power and energy demand level for primary electrification are 100 W of installed capacity per capita and 200 KWh/person/year for electricity consumption. According to a statistics from the 100 counties, the total installed capacity required before 1990, will be 3,040 MW mainly supplied by SHP.

Considering the country as a whole, there are 2,300 counties, in which about 800 rely mainly on SHP for electricity supply. An estimation of demand and possible arrangement of installation indicates that the total capacity of SHP by the end of 2,000 will be 20,000 MW, that means, 10,000 MW of SHP equipment will have to be added during the next 13-14 years. In other words, although the amount of SHP installation in China is already very big, but the market for new installation is still broad.

Besides the usually used types of turbines in previous years, some new installations such as very high head turbines (> 600 m) and very low head turbines (< 10-5 m) and straflow turbine, pump-turbine etc will also be adopted, which may give way to import business.

4. Manufacture and operation of SHP equipment

4.1 Manufacturing capability in general

China has made hydro-power machines for more than 30 years since 1951 when the first 800 kW hydro turbine-generator set was successfully produced. During the past 30 years, around 100,000 sets of small/mini/micro hydro-power machines have been manufactured, in which the units with capacity bigger than 500 kW counted 4,500 sets. These include all the conventional types of turbines: axial-flow (Propeller + Kaplan), mixed-flow (Francis), tubular diagonal-flow (Deriaz), impulse (Pelton + Turgo + Banki). Most of the machine have been operating normally after commissioning, some of which has been running for 20-30 years.

Now, there are about 100 manufacturers for small hydro-power machines with a total annual production capacity of over than 1,000 MW. 10 out of the 100 factories are of medium scale, capable of producing machines

in the range of 500 - 10,000 kW or even larger. They are:

Hangzhou Electric Equipment Manufacturing Works
Chongqing Water Turbine Works
Nanping Electrical Machinery Plant
Shaoquan Water Turbine Plant
Kunming Electrical Machinery Plant
Chongqing Electrical Machinery Plant
Jinchengjiang Electrical Equipment Manufacturing Works
Jiangxi Electrical Machinery Works
Yichang Electrical Machinery Works
Liuchou Water Turbine Works

The spread map for the SHP equipment manufacturer is shown in Fig.1.

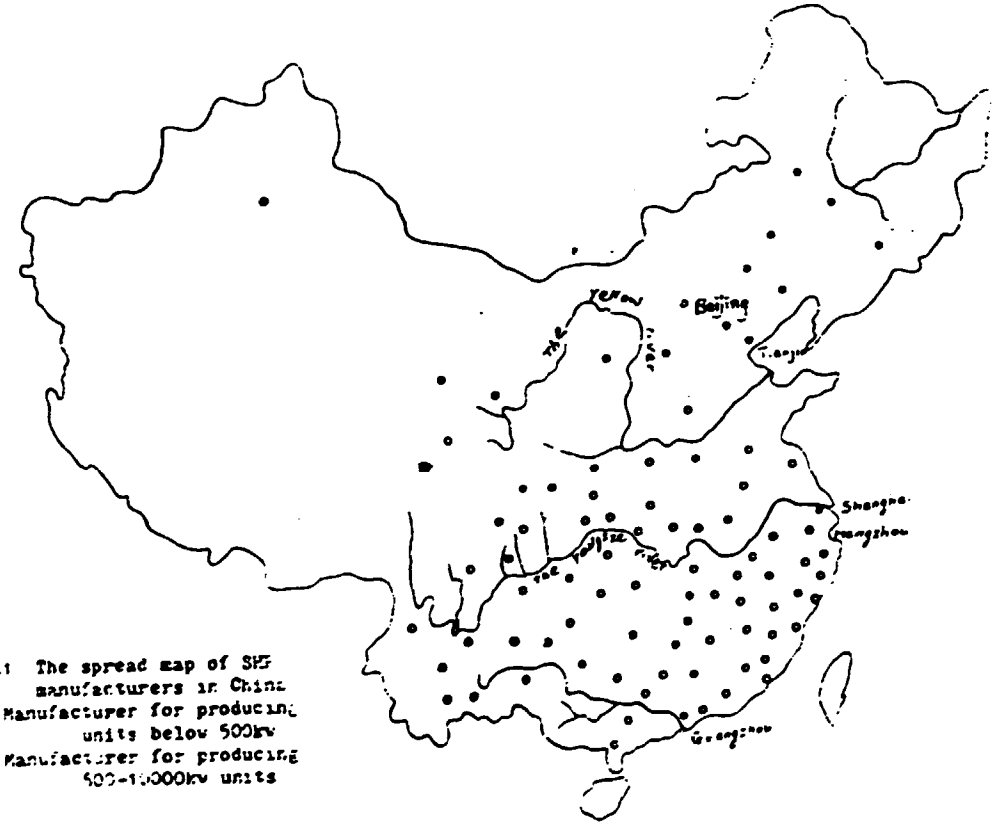


Fig.1 The spread map of SHP manufacturers in China
○ Manufacturer for producing units below 500kw
● Manufacturer for producing 500-10,000kw units

Besides satisfying the domestic demand, a number of SHP equipment has been exported to overseas. Some of the exported SHP machines which has been installed and operated in some countries are listed in table 1.

Table 1 Part of China-made SHP Equipment exported abroad (as per 1986)

No.	Title of SHP station	Nationality	Turbine Type	Head (m)	Discharge (m^3/s)	Generator Type	Speed (rpm)	Capacity (kW)	Governor Type	Units
1	Haerhalin	Mongolia	HL123-WJ-86	11			300	264		2
2		Viet Nam	CJ	120				182		1
3		Viet Nam	Model							1
4	Jinkang	Guinea	HL130-WJ-60	89		SFW118/45-6	1000	800		4
5		Viet Nam	HL310-WG-30			TSWN42.3-6	1000	10x30		
								10x40		20
6		Viet Nam	-			TSWN42.3-6	1000	30		10
7		Albania	-			TSWN74-6	1000	200		2
8		Albania	-			TSWN49.3-6	1000	75		12
9	Sengkouxi	Nepal	HL240-LJ-140	24-43		SF3350-20/3250	300	3350		3
10		Albania	CJ	60-206				92-440		12
11	Charlika	Afghanistan	HL	19				800		4
12		Tanzania	ZD661-WM-100			TSWN99-16	375	160		2
13		Viet Nam	HL210-WG-20			TSWN36.8-6	1000	18		5
14		Viet Nam	HL310-WG-30			TSWN42.3-6	1000	30		20
15		Laos	ZD760-LM-60			TSL42.3-6	1000	40		1
16		Viet Nam	ZD760-LM-60			TSL42.3-6	1000	40		8
17		Laos	ZD760-LM-60			TSL42.3-6	1000	40		2
18		7401	-			TSWN36.8-6	1000	12		5
19		Kampuchea	ZD760-LM-60				1000	30x5		10
								55x5		
20		Laos	HL210-WG-20					12		5
21		Albania	HL210-WG-20			-		12		5
22	Mujielei	Burundi	CJ	274		-		2000		4
23		Equatorial Guinea	HL230-WJ-71	36		TSW118/54-10	600	800	XT-600	4
24	Viola	USA	HL310-WG-30	10.7	0.71			55		1

Table 1 Part of China-made SHP Equipment exported abroad (as per 1986)

No.	Title of SHP station	Nationality	Turbine Type	Turbine Head (m)	Turbine Discharge (m^3/s)	Generator Type	Generator Speed (rpm)	Generator Capacity (kW)	Governor Type	Units
25	Camanche	USA	ZZ440-LJ-142	27.4 41.1	11.3			3562.5		3
26	Hell Hole	USA	HL110-WJ-50	93.9	0.71			800		1
27	Bailey Creek	USA	HL220-WJ-50	45.1	1.8			650		1
28	Camp Far West	USA	HL240-LJ-154	40.2	19.1			7500		1
29	Fleming Hill	USA	HL160-WJ-50	46.3	0.91			300		1
30	Shasta River Hydro	USA	ZD760-LH-80	5.8	2.84			100		1
31	Yolo County	USA	XJ02-W-50/1X125	61	0.28			150		1
32	Virginia Ranch	USA	HL240-WJ-74	30.5	3.7			950-1386		1
33	Virginia Ranch	USA	HL110-WJ-35	30.5	0.28			50-75		1
34	Ecuador	USA	HL240-LJ-14	10.7	0.14			10		1
35	Moccasin	USA	HL240-WJ-150	23.2 18.6	11.6			3000		1
36	Potter Valley	USA	XJ13-L-15/4	4	0.02			5		1
37		Sri Lanka	HL110-WJ-35							1
38		Sri Lanka	HL260-WJ-42							1
39		Sri Lanka	CJ22-W-55/1x4.5							1
40		Sri Lanka	CJ22-W-45/1x4.5							1
41		Sri Lanka	XJ02-W-32/1x9							2
42		Sri Lanka	XJ02-W-25/1x6							1
43		Sri Lanka	HL210-WG-208							1
44	Nilambe	Sri Lanka		110	3.6			2x1600		4
45	Ratchelor	Philippines	HL220-WJ-42	35	1	TSW 85/8-250		3x250		
46	Kongkoi	Malaysia	HL110-WJ-50	25.3	1.88			1x75		
47	Basak Spring	Malaysia		67				2x250		
48	SRDI	Nepal	HL240-WJ-71	23				3x500		

4.2. Seriation and/or standardization

Terminology - In China, seriation is usually understood as lining up a number of series and sizes of turbines which could be an effective tool for consumer's selection for various combination of head, discharge and power output at a station site, whereas standardization may have a wider implication of unification of structural elements of machines. But sometimes these two terms are used mixedly in practice.

During past 30 years, several programmes of seriation of turbine-generator have been set up on the basis of practice of large number of production. Successive revisions have been made for these programmes. Recently, the series of turbines with unit capacity less than 500 kW have been finalized which was publicized in various kind of catalogues, specification documents etc. Fig 2 to Fig 13 show a part of these turbine series.

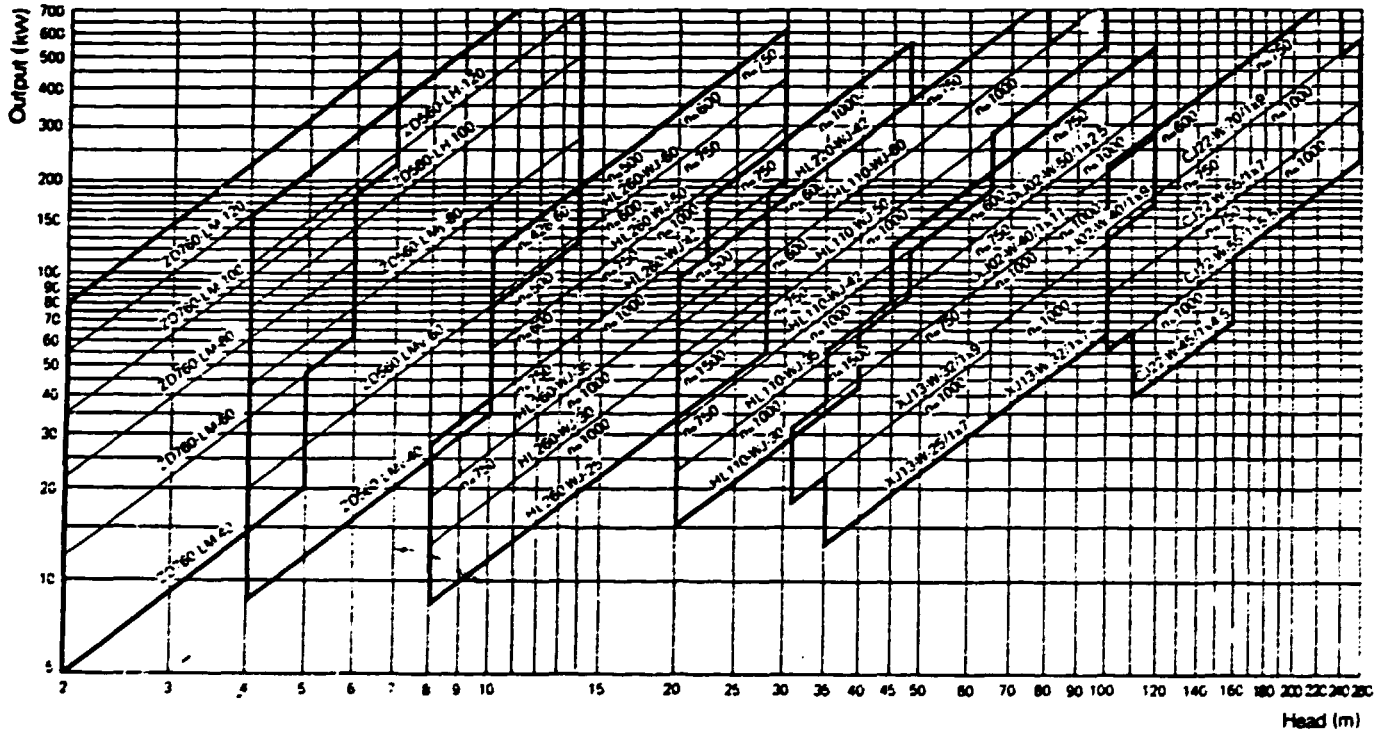


Fig 2

List of Propeller Turbines from 500 KW to 10000 KW

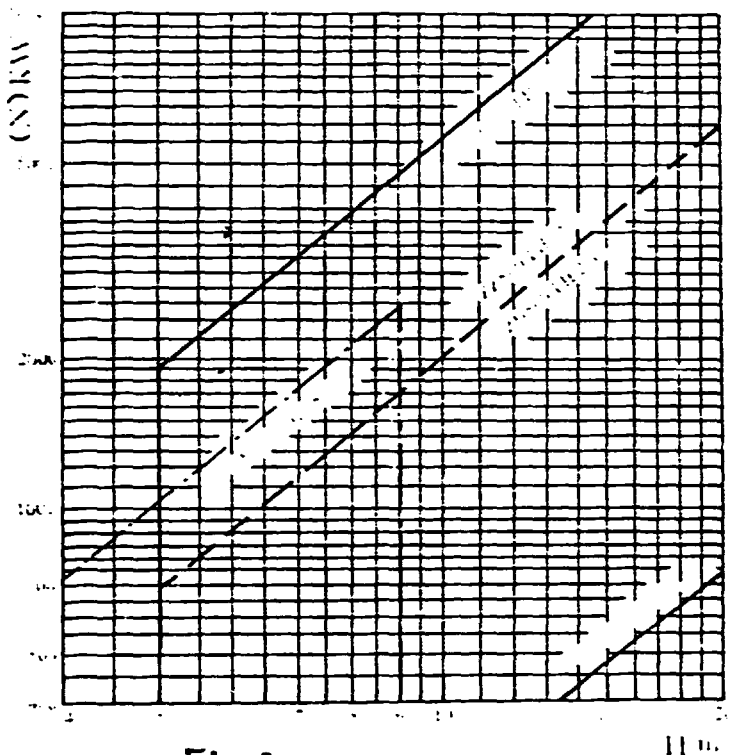


Fig 3

The symbols adopted in turbine seriation represent the 1st character of Chinese phonetic spelling (not English). For example:

HL 240 - LH - 120

- 120 — Runner diameter in cm
- LH — Shaft arrangement and casing
- 240 — Runner type (serial number close to n_s)
- HL — Turbine type

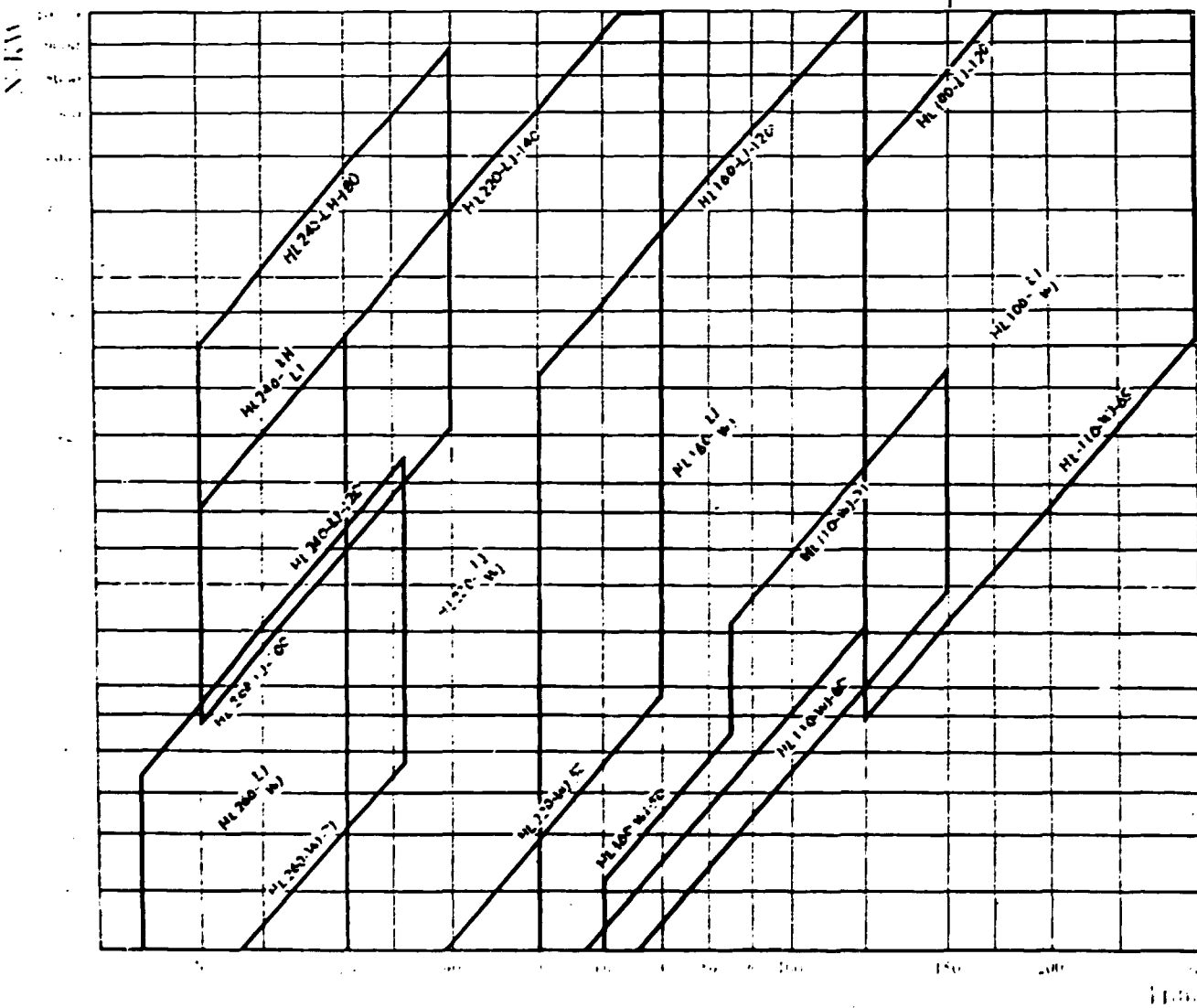
Meaning of symbols:

(A) Turbine types:
- GD - Tubular (fixed blade)
- GZ - Tubular (adjustable blade)
- ZD - Propeller (fixed blade)
- ZZ - Kaplan
- HL - Francis
- XL - Deriaz
- CJ - Pelton
- XJ - Turgo

(B) Shaft arrangement and casing: L - Vertical shaft
W - Horizontal shaft
J - Metal spiral casing
H - Concrete spiral casing
M - Open flume
P - Bulb type
X - Siphon type
S - Vertical well type
Z - Tube type
G - Tank type

Summarizing the seriation already stipulated in China, there are 8 runner types with 32 combination varieties of runner diameter and output for unit capacity less than 500 kW. For unit in the range of 500 - 10,000 kW, there are 19 runner types with 53 varietics.

Hydraulic Range Curved by Medium & Small Francis Turbines Outputs from 500 kW to 5000 kW Fig 4



Installation Drawing I of Francis Turbine Below 500 KW

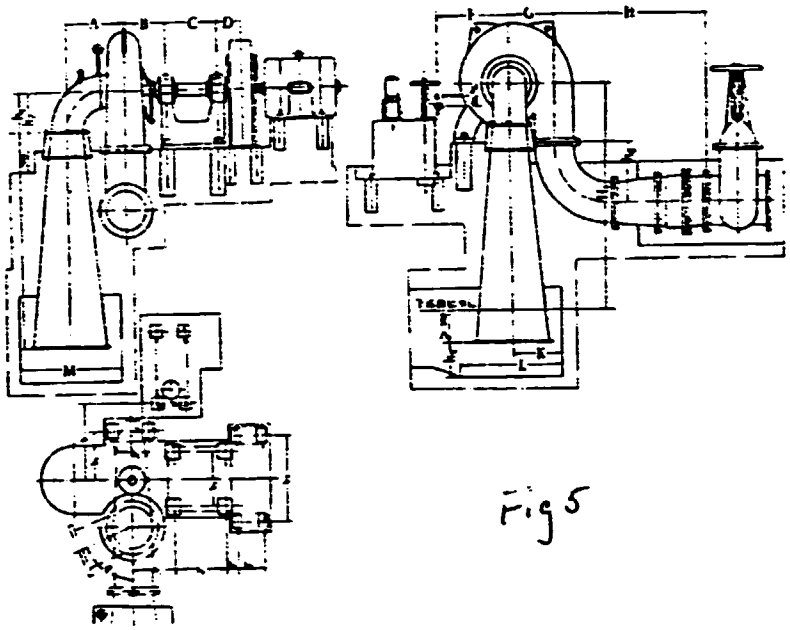


Fig 5

水輪機型號 Turbine Type	HL260-WJ-25	HL260-WJ-30	HL260-WJ-35	HL110-WJ-30	HL110-WJ-35	水輪機型號 Turbine Type	HL260-WJ-25	HL260-WJ-30	HL260-WJ-35	HL110-WJ-30	HL110-WJ-35
A	564	672	786	440.5	506	b3	400	420	420	380	400
B	400	420	420	380	400	b4	500	500	500	500	500
C	500	500	500	500	500	b5	120	120	115	120	120
D	245	245	245	245	245	b6	250	250	260	250	250
E		152	144			b7	500	500	500	500	500
F	700	800	885	680	750	b8	800	800	100	800	800
G	438	521.5	600	441	504	h	2000	2000	2500	2000	2000
H	11455	1630	1680	1380	1470	h1	370	445	520	550	550
K	470	568	700	570	650	h2	550	550	700	450	450
L	1000	1200	1400	1200	1400	h3	100	100	100	100	100
M	1000	1200	1400	1200	1400	h4	100	100	150	80	80
b	705	805	1040	685	755	h5	350	390	455	400	400
b1	450	520	600	430	450	h6	575	725	800	500	590
b2	330	405	430	250	250						

Installation Drawing II of Francis Turbine Below 500 KW

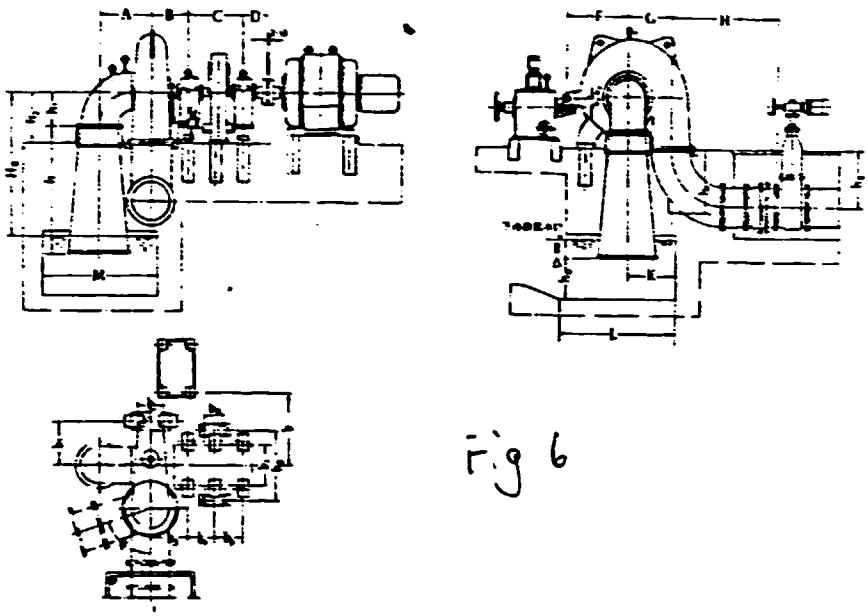


Fig 6

Turbine Type	HL260-WJ-42	HL260-WJ-50	HL260-WJ-60	HL220-WJ-42	HL110-WJ-42	HL110-WJ-50	HL110-WJ-60
A	944	1120	1339	840	605	723	867
B	550	600	630	600	500	550	580
C	900	1100	1100	950	900	1100	1100
D	325	400	400	400	325	400	400
F	1000	1130	1270	1000	850	950	1060
G	700	814	937	690	592	680	782
H	1855	2005	2205	1830	1560	1740	1830
K	840	915	1100	800	790	926	1100
L	1680	2000	2400	1680	1700	2000	2400
M	1680	2000	2400	1680	1700	2000	2400
b	1155	1265	1440	1155	1005	1105	1230
b1	700	800	900	650	550	600	750
b2	530	610	570	450	310	400	400
b3	550	600	630	600	500	550	580

Turbine Type	HL260-WJ-42	HL260-WJ-50	HL260-WJ-60	HL220-WJ-42	HL110-WJ-42	HL110-WJ-50	HL110-WJ-60
b4	500	600	600	520	500	600	600
b5	400	500	500	430	400	500	500
b6	260	330	330	320	260	320	330
b7	650	650	650	650	600	650	650
b8	1050	1260	1260	1140	1000	1140	1260
h	2500	3000	3000	2000	2000	2700	3000
h1	660	740	888	540	600	700	700
h2	700	800	1000	800	700	800	800
h3	35	35	35	30	40	40	40
h4	135	135	135	140	110	110	110
h5	450	650	710	650	550	650	780
h6	950	1100	1320	950	580	660	950
h7	1030	1180	1400	1030			

Installation Drawing of Propeller Turbines Below 500 KW (1)

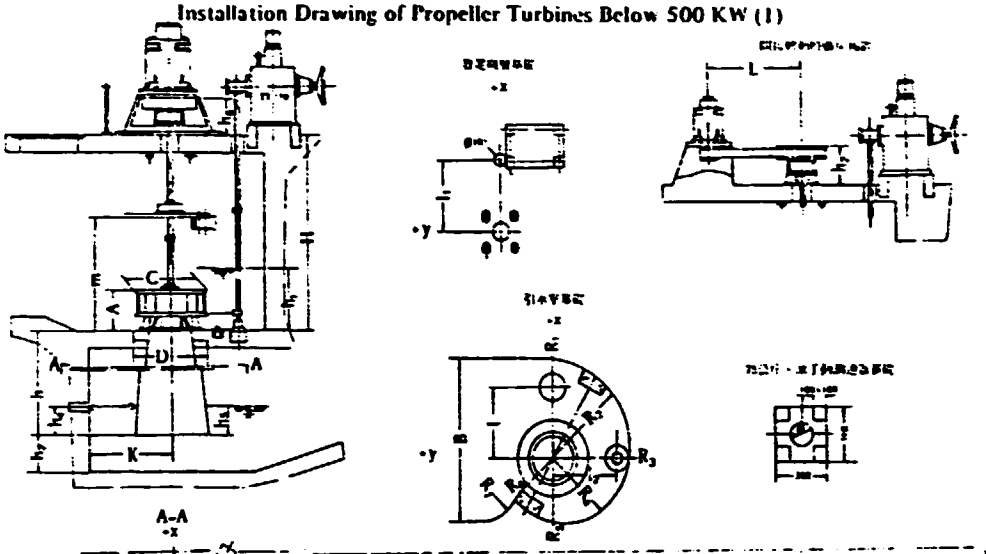


Fig 7

Turbine Type	ZD760-LM-40	ZD760-LM-60	ZD760-LM-80	ZD560-LMY-40	ZD560-LMY-60	ZD560-LMY-80
A	355	570	790	365	570	750
B	1570	2300	2800	1570	2300	2800
C	740	1100	1400	740	1100	1400
D	750	1100	1300	750	1100	1300
F	1600	2400	3200	1600	2400	3200
K	800	1200	1400	800	1200	1400
H	3200			2200	2200	2500
h				1400	2100	2800
h_1	780	1120	1400	780	1120	1400
h_2	309	586	846	570	850	205
h_3	520	780	1050	520	780	1040
h_4	440	440	440	440	440	440
h_5	300	300	400	300	300	400
h_6		616	844	616	844	480
R_1	900	1400	2000	900	1400	2000
R_2	842	1280	1780	842	1280	1780
R_3	785	1160	1565	785	1160	1565
R_4	728	1040	1350	728	1040	1350
R_5	670	920	1135	670	920	1135
R_6	612	800	915	512	860	915
R_7	400	600	600	400	600	600
l_1	700	1000	1500	700	1000	1500
l_2	600	950	1300	600	950	1300
b	250	420	680	420	680	

Installation Drawing of Propeller Turbines Below 500 KW (2)

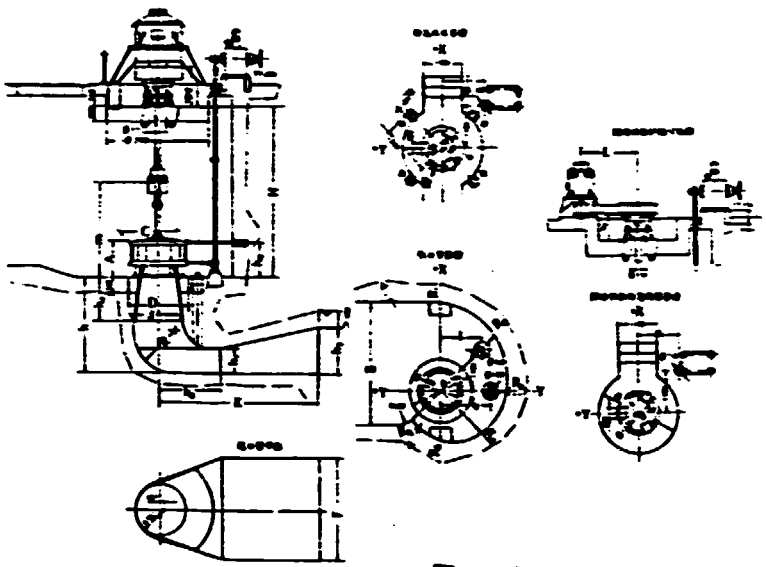


Fig 8

水轮机型号 Turbine Type	ZD760-LM-100	ZD760-LMY-100	ZD760-LM-120	ZD760-LMY-120
A	970	970	1150	1150
B	3300	3300	4100	4100
C	1650	1650	1950	1950
D	1700	1700	2000	2000
F	2825	2825	3390	3390
H		2800		3000
K	4500	4500	5400	5400
d	1352	1352	1622	1622
R	1160	1160	1392	1392
h	2590	2590	3110	3110
h_1	676	676	811	811
h_2	710		710	
h_3	1240	1240	1488	1488
h_4	1240	1240	1490	1490
h_5	940	940	1130	1130
h_6	1750	1750	2100	2100
R_1	2375	2375	3000	2570
R_2	2115	2115	2570	2570
R_3	1855	1855	2230	2230
R_4	1600	1600	1885	1885
R_5	1340	1340	1540	1540
R_6	1085	1085	1195	1195
l_1	1150	1150	1200	1200
l_2	1400	1400	1550	1550
l_3	1106	1106	1330	1330

Arrangement of Pelton Turbine Under 500 KW

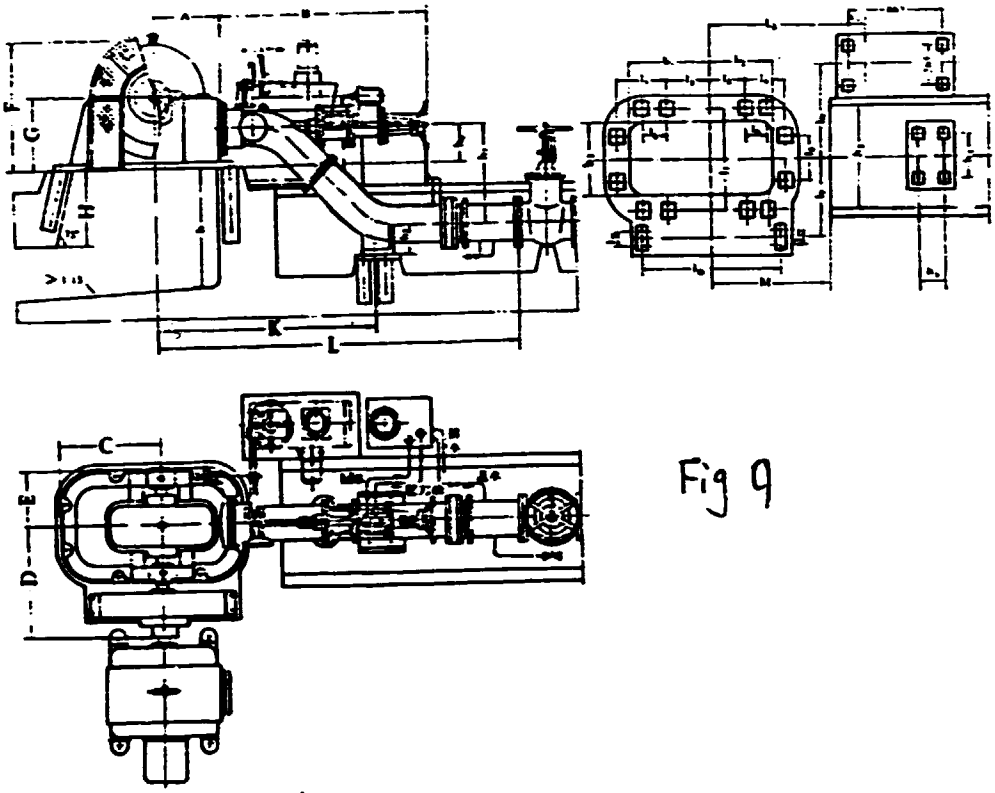


Fig 9

Turbine Type	CJ22-W-45/1x4.5	CJ22-W-55/1x5.5 -55/1x7	CJ22-W-70/1x9	Turbine Type	CJ... W-45/1x4.5	CJ22-W-5.5/1x5.5 -55/1x7	CJ22-W-70/1x9
A	475	627	820	h_7	200	250	275
B	1478	1668	1945	h_8	700	1100	1200
C	570	930	1010	h_9	300	350	400
D	850	1055	1145	h_{10}	180	300	300
E	380	600	685	h_{11}	255	355	350
F	865	1110	1310	l_1	355	575	620
G	460	630	700	l_2	300	320	340
H	500	700	800	l_3	260	320	340
K	1546	1914	2305	l_4	275	360	510
L	2555	2915	3235	l_5		320	320
M	850	1100	1300	l_6			300
b_1	570	800	880	l_7	680	860	970
b_2	445	585	770	l_8	300	400	500
b_3	500	670	810	l_9	525	790	830
b_4	640	650	670	l_{10}	980	900	900
h_1	1000	1460	1550	l_{11}	120	300	300
h_6	655	733	822	l_{12}	120	560	500

Installation Drawing of Turgo Impulse Turbine Below 500 KW

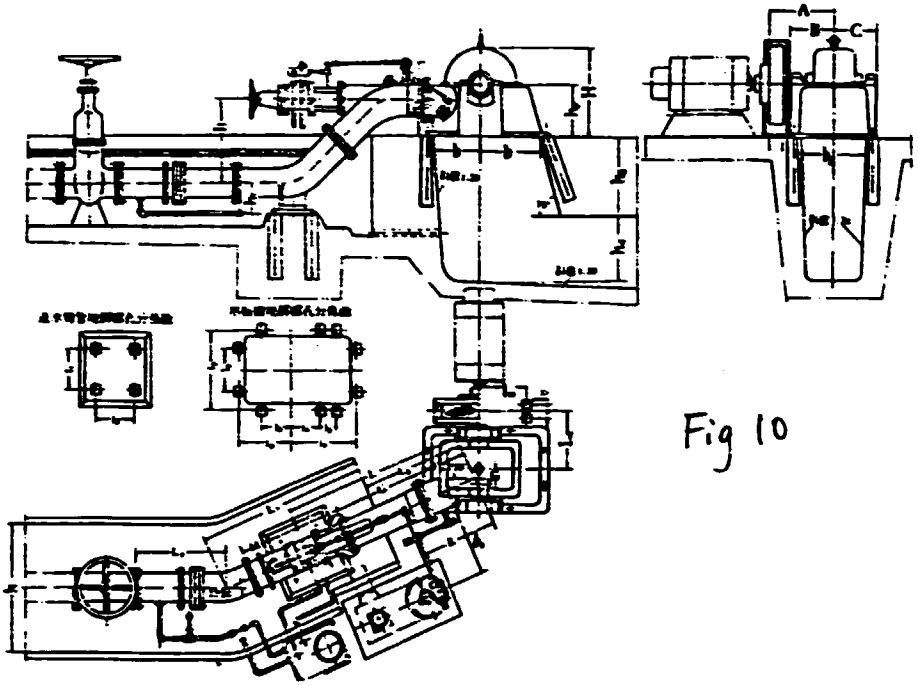


Fig 10

Turbine Type	XJ13-W-25/ 1x7	XJ13-W-32/ 1x7 1x9	XJ02-W-40/ 1x9 1x11	XJ02-W-50/ 1x12.5	Turbine Type	XJ13-W-25/ 1x7	XJ13-W-32/ 1x7 1x9	XJ02-W-40/ 1x9 1x11	XJ02-W-50/ 1x12.5
A	527.5	620	686	820	h_4	500	700	700	800
B	370	440	450	555	h_5	620	710	600	750
C	370	440	450	555	h_6	1000	1000	1200	1200
D	83	110	102	125	h_7	410	500	550	700
E	31.2	40	50	62.5	l_1	335	390	400	490
F	400	545	680	750	l_2	320	350	300	400
G	705	845	1005	1125	l_3	240	300	280	450
H	735	906	1050	1266	l_4	240	300	280	400
K	615	725	910	1035	l_5		220	350	300
L	1511	1832	2190	2405	l_6	430	555	670	760
M	864	937	1000	1040	l_7	535	685	830	945
L_1	1402	1517	1756	1735	l_8	630	810	945	1080
L_2	738	738	738	738	l_9	350	400	400	500
L_3	830	1030	1150	1410	l_{10}	820	980	990	1210
L_4	465	570	626	740	l_{11}	110	100	120	190
h	654	733	822	860	b	385	500	610	690
h_1	230	280	305	330	b_1	490	630	770	875
h_2	285	340	350	450	b_2	540	700	825	940
h_3	585	670	710	840	b_3	600	650	670	700

Fig 11

Hydraulic Range Curved by Tubular Turbine

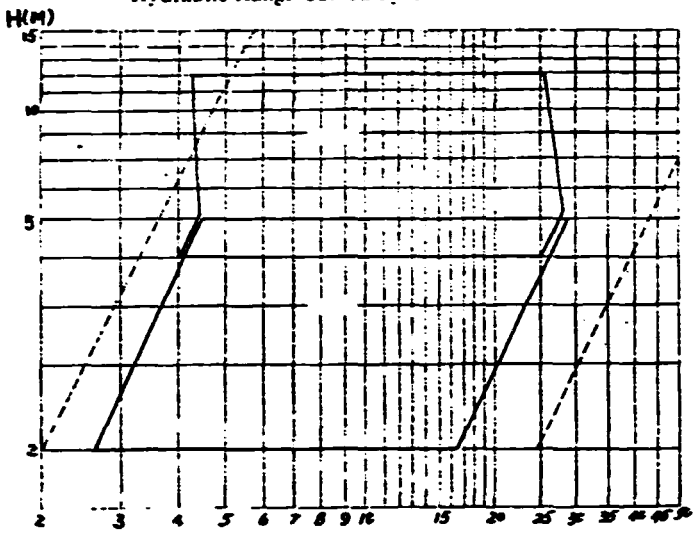
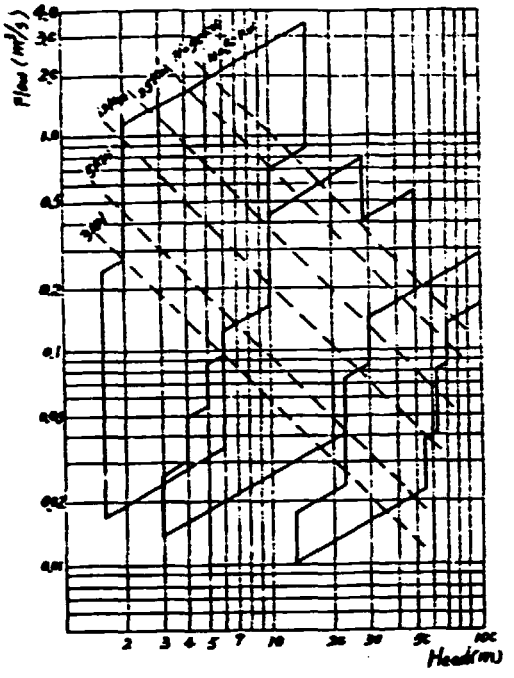


Fig 12

Product List of Micro Integrated Unit



Hydraulic Range Curved by Impulse Turbines from 500 KW to 10000 KW

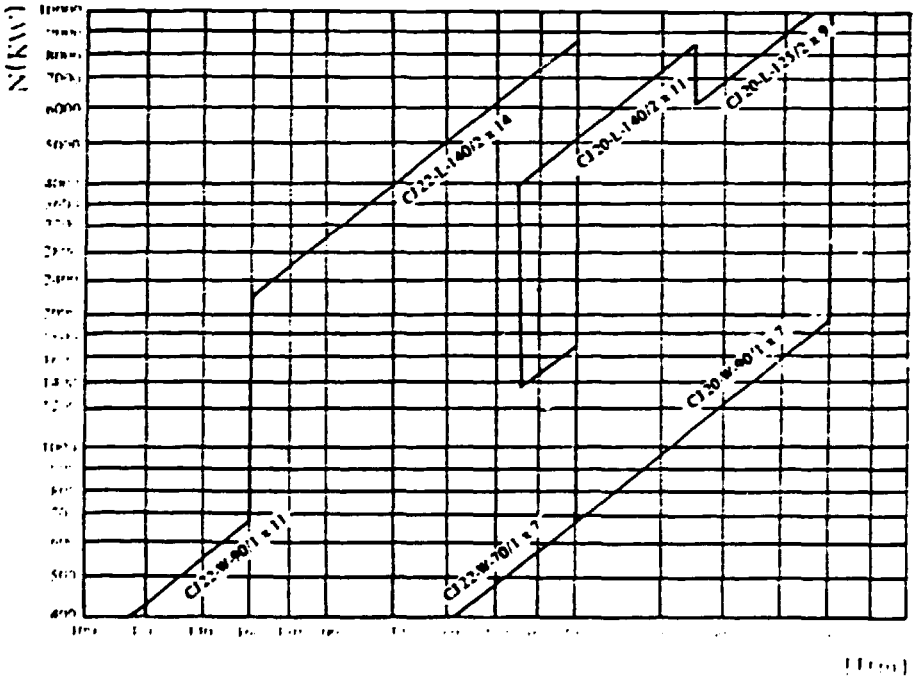


Fig 13

After establishment of seriation of turbines, the manufacturers in China have reached a big merit of development of type-design of SHP equipment, which leads to series production instead of custom-made approach. This can evidently be seen in the following illustration:

In Szechuan and Zhejiang Provinces, the number of SHP turbine generator sets with unit capacity over 500 kW are 820. The statistical figures for some serial design turbines are listed in table 2 and 3.

Table 2 Application of serial designed turbines in Szechuan and Zhejiang Provinces

(Total No. of turbines installed 820) 1986
(unit capacity > 500 kW)

Turbine type	No. of set installed	% of the total (%)
ZD 760	14	1.71
ZD 560		
HL 110	112	13.66
HL 220	76	9.27
CJ 22	71	8.66
HL 260	22	2.68

Table 3 Application of serial designed turbines in Hebei Province
(Total No. of turbines installed 112, 100-500 kW)

Turbine type	No. of set installed	% of the total (%)
ZD 760	23	20.5
ZD 560	5	4.5
HL 260	27	24.1

Take the HL 110 (Francis) type turbine as example, 112 sets of same type have been adopted, counting about 13.6% of the total.

The break down of various capacity range of SHP installations in China is briefly list in Table 4.

Table 4 No. of SHP installations with various capacity range (1986)

	No.	Total capacity
1. No. of turbines with unit capacity $\geqslant$ 500 kW (No. of stations for the above)	4477 1713	4,740,000 kW
2. No. of turbines with unit capacity $\leqslant$ 100 kW (No. of stations for the above)	53000 49500	1,300,000 kW
3. Total No. of turbines installed Total No. of stations	86400 67700	10,090,000 kW

The total No. of installations in 1986 is decreased in comparison with that of 1985. This is due to abandon of some out-of-date micro-hydro installation. In doing so, the number of stations reduced successively during recent years, while the total capacity goes up.

4.3 Operation of SHP equipment in China

Most of China-made SHP machines run normally during past years. The performances of turbines are generally compatible with design. Fabrication qualities are improved consistently. The life span of SHP equipment is also satisfactory. Nevertheless, there are still some insufficiencies in China-made SHP products.

(a) The efficiency is in general about 3% lower than Western made turbines, the deficiency is less for bigger machine and higher for smaller one. Some type of turbine as Turgo may be even worse.

(b) Some fabrication technology goes on behind that of advanced countries, such as low quality of satelite gear box made in small plant, unreliability of water sealing of runner blade of Kaplan turbines and big noise produced from some type of turbines and generators etc.

(c) The anti-cavitation performance of turbines is usually not as good as that of advanced countries, partly due to low fabrication technology such as surface finishing etc, partly due to adoption of over-size of specific flow discharge Q'_1 in design. Silt erosion problems are also serious in some rivers with heavy silt content like North-west part of China.

(d) Low automation level which results in the fact that all the SHP stations in China has to be attended. The technology of hydraulic measurement instrumentation is also low, which makes some insufficient accuracy in hydraulic measurement and some difficulty in the implementation of on-site measurement of efficiency of SHP turbines.

5. Capability of engineering and contracting services in SHP in China.

5.1 Institutional set up

There are four levels of administrative set up in China, i.e., central, provincial, prefecture and county. In the central level, there are 8 survey and design institutes as well as 18 construction bureaux under direct leadership of the Ministry of Water Resources and Electric Power and distributed over several regions in China.

In the lower level, there is in general a design institute (or division) and a construction bureau in each province, prefecture and county. the MWREP affiliated design institutes and construction bureaux are mainly in charge of large and medium size of hydropower and water conservancy projects, but also undertake some SHP schemes. The provincial level organizations are mainly responsible for medium and small size projects. At present, most of the SHP projects are done at prefecture or county level.

5.2 Different range (in power capacity) of SHP projects designed at different levels of institutes/divisions.

In general, the SHP stations less than 500 kW are usually implemented at the grass-root level-township, which is below the county. Stations in the range of 500 kW to several thousand kW are normally undertaken by the county or prefecture level. The provincial design institute and construction bureaux only take charge of medium scale schemes or some selected key projects. Although the definition of SHP stations in China for the moment is for those with capacity less than 12 MW, but there is a tendency of extending the limit up to 25 MW, which could also be implemented at county level in some developed places.

5.3 Capability of contracting services for abroad

With a vast number of technical staff in the field of hydropower and SHP, China can not only be self-sustained in the implementation of SHP projects but also provide engineering services abroad. There are several corporation for execution of international cooperation of water and power projects including SHP stations at central and provincial level. The principal organization of this kind is the CWE, China International Water and Electric Corporation. One example of provincial organization is the Zhejiang Corporation of International Economic and Technical Cooperation which is jointly cooperated with HRC in the field of SHP. The scope of business of these organizations in the field of SHP is undertaking complete or partial feasibility study, survey, design, construction, supply, erection, commissioning and technical personnel

training of various types of SHP projects. The forms of service can be both turnkey contract, joint venture, subcontract, providing technical consultation, providing manpower as well as offering training courses for technical personnel.

6. Strategy for promoting local manufacture of SHP equipment in developing countries

6.1 Establishment of indigenous manufacturing capability

In a number of international meetings on SHP held during past several years, various suggestions have been raised to encourage local manufacturing of SHP equipment in developing countries. Considering the different level of economic and technical development in various third world countries which results in different level of existing local industries and technology/know-how of design and manufacture of SHP equipments, the UNDP/UNIDO 3rd Conference on SHP in Kuala Lumpur suggested that the choice of importing equipment or establishing local manufacture and the choice of using "appropriate" indigenous local technology or "high-level" imported know-how should be made on the basis of factors that are peculiar to each country. To our knowledge, there are a few developing countries in the Asia-Pacific tend to tackle their equipment supply problem mainly based on their own manufacturers, such as China, India. Some other countries, such as Philippines, Thailand, Nepal, Malaysia etc, are initiating in building a limited capability of manufacturing with a greater portion of SHP equipment demand still imported. Some countries even clearly express the tendency of import all the equipment necessary for SHP development due to a limited amount of demand which could not justify the cost for establishing an indigenous manufactures. It may be reasonable to estimate that in the near future, perhaps 80-90% of the demand of SHP equipment supply in the 3rd world countries will still be relying on import. But the main constraint of development of SHP in developing countries in respect of equipment supply is the high cost of importing machines from advanced countries which is usually in the range of $> $1,000/kW. Thus, the reduction of cost of SHP equipment in the international market is one of the salient problem to which great concern should be given.

6.2 Measures for cost reduction of imported equipment

The main factors leading to high cost of SHP equipment in developed countries are their high labour cost and high cost of other input such as raw materials and other overhead expenses. In some developing countries such as China and India, which were catagorized into Group A, according to an analysis made by UNIDO's Stockholm Consultation

with regard to the Manufacturing Value Added (MVA), there are considerable capability of manufacturing of SHP equipment which can not only satisfy their domestic demands, but also for export. The China-made or Indian-made turbines/generators are much more cheaper than that of Western-made machines. In China, the cheap cost is not only due to low-labor cost and low cost of raw materials, but also due to wide application of seriation/standardization of SHP equipment which fairly reduces the cost in comparison with custom-made turbines/generators. Some of the insufficiencies of China-made equipment such as lower efficiency, big-noise and low automation level, could be quickly improved if some technologies from Western countries would be transferred into, or even directly involved in a joint venture. The products thus manufactured will have both good performance, improved quality, similar automation level as those made by Western countries but with lower price. These joint production through cooperation between advanced countries and China will be benefit both to the recipient countries, and the cooperative producers.

6.3 Proposal for joint venture or technology transfer for SHP equipment production between developed countries and China or other developing countries.

In addition to extend the application of some SHP model design prepared by the advanced countries, it would be proper also to take some follow-up action of technology transfer or even establishing some kind of joint venture for some joint production of SHP turbine generator sets. For initiation, a small step may first be taken, such as joint manufacturing of a specific type of trubine with a selected plants in countries like China or India.

The product thus manufactured may be used mainly for export to the third world. With decreased cost but improved performance and quality, it will credibly be welcome by the clients.