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

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SMALL HYDROPOWER DEVELOPMENT IN THE PHILIPPINES*

Prepared by

Zenaida A. Santos**

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** Executive Director, Mini-Hydro Development Office, National Electrification Administration, Republic of Philippines.

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BACKGROUND

In the Philippines, the term mini-hydro refers to systems with developmental capacities of 10 MW or less. Surveys are not yet complete, but hydropower potential of this size range has been estimated to be in excess of 5000 MW.

Mini-hydro plants have been installed in the Philippines in small numbers in the early 1900's. However, it was only in 1947 that a concerted effort was made to develop the enormous potential offered by our small streams. This programme was short-lived because large oil-thermal and other power plants could supply cheap electricity. Transmission costs from dozens of remotely located small sites were also prohibitive.

The rural electrification programme was intensified in the 1960's with the creation of the Electrification Administration (1962) which subsequently became the National Electrification Administration (1969). The primary objective of the NEA was to undertake the rural electrification programme on an area coverage basis with the electric cooperatives as the primary medium. The programme aimed to achieve full electrification of the country by the end of this decade.

When the oil crisis struck in the 1970's, over one million rural consumers were receiving power under the rural electrification programme. Most of that power was generated using oil, either from the plants of the National Power Corporation or from small diesel units owned by the local electric cooperatives. As a consequence, the price of electricity in the countryside was rapidly becoming prohibitively expensive. Small industries using electricity begun to shut down. The government feared the setback of its hard won gains in bringing modernization and economic development to the rural areas.

Faced with a mounting crisis, the government directed the NEA to assist the electric cooperatives in the development of indigenous and renewable energy resources. This was aimed at making the electric cooperatives self-sufficient in energy and to minimize the delays

caused by the energy crisis in the attainment of the electrification goals. In response to this directive, NEA implemented the mini-hydro and dendro-thermal programmes.

THE MINI-HYDRO PROGRAMME

The Philippine Mini-Hydro Programme has the primary objectives of:

1. substituting for oil-based electricity generation;
2. stabilizing and reducing if possible, the price of electricity for the rural consumers; and
3. establishing Philippine manufacturing of mini-hydro equipment.

Several plant development guidelines flow from the establishment of these objectives such as:

1. A power plant will be established only if generation costs will be equal to or less than existing electric grid rate.
2. Power plants to be developed will be synchronized to island-wide grids. In this way, maximum power potential can be realized to minimize generation costs.
3. The power plants will be owned and operated by local rural electric cooperatives. This latter consideration results in decentralized management centers.
4. The power plants are Philippine designed and built. Ultimately, each will be furnished with Philippine made equipment.

With these basic concepts, the programme was established in 1979 with an initial plan of installing 300 MW of capacity at about 240 power plants by 1987.

Programme Planning and Implementation

The following organizations administer the implementation of the Philippine mini-hydro programme:

1. National Electrification Administration
2. Electric Cooperatives
3. Engineering Consultants
4. Construction Contractors and equipment suppliers.

Inevitably the division of tasks among these groups involves some overlap. Duplication and friction both occur; but not with great frequency nor intensity. On the whole the arrangement is flexible and responsive.

NEA's involvement covers the whole development process. NEA coordinates with the cooperatives and the local A&E in the conduct of inventories of potential mini-hydro sites. Sourcing, allocation and disbursement of funds are also the responsibility of NEA. Plans are made for a certain period, say five or ten years and certain targets are set. Projects are then prioritized and scheduled to fit these targets.

NEA conducts the feasibility study which is the prerequisite for the loan application of the cooperative. It also reviews the studies and designs made by the A&E firms and supervises and monitors project construction.

To facilitate the implementation of the programme, NEA conducts training courses to the cooperatives to enable them to identify potential sites, gather preliminary data and consequently, operate the plant. Some of the courses being conducted are data gathering and site selection, contract administration, plant operation and maintenance, and accounting systems and procedures.

The 120 rural electric cooperatives provide the management centres which administer much of the programme. With their awareness of the local conditions and close contact with the people, the cooperatives are in a superior position to identify potential mini-hydro sites and collect the preliminary data needed. Since the cooperatives hire staff locally, they pay wage rates usually way below those paid in Manila. They also disseminate information to alleviate the fears of the rural population on the possible

adverse effects of the project (such as floods and relocation of people). Negotiation for the acquisition of right-of-way is also done easily by the cooperatives instead of outsiders like the contractors. During the construction, testing and commissioning of the project, the cooperative staff are allowed to observe and familiarize themselves with the operation of the power plant. They are also trained by the consultants and equipment suppliers to enable them to operate the plant after it has been commissioned.

A number of private Philippine consulting firms provide technical services to the cooperatives and to NEA. These firms are relatively large and can mobilize the required number and type of personnel. To facilitate the implementation of the program, adjacent areas or regions are assigned to one firm. This enables them to investigate nearby sites and determine the best site to be developed while conducting the study of a particular project.

Consulting firms work with NEA and the cooperatives on a contract basis. With an assurance of continuing assignment if performance is maintained at a high level, these firms can develop an experienced cadre of personnel who know the specific needs of the programme.

At present, NEA is implementing the mini-hydro programme with the assistance of its in-house consultant, the Norconsult, A.S.. The tasks of the Norconsult, A.S. include the review of plans and studies made by local A&E firms and building up the capability of NEA in implementing the programme. Towards this end, they conducted a seminar-workshop on planning and design guidelines for mini-hydro which was participated by local A&E and NEA staff. Prior to their selection as NEA in-house consultant (under ADB), Norconsult worked with NEA in 1979 (under the grant from the Norwegian Agency for International Development).

The Philippines has a very strong construction industry. There are a number of private contractors capable of constructing mini-hydro projects. Hence, project construction is not a problem. Normally,

the responsibility of Philippine contractors covers the hauling and delivery of equipment to the project site, construction of civil and electro-mechanical works, installation of equipment, and testing and commissioning.

Contractors are usually based outside the project area. Whenever possible, only key personnel are brought to the site to administer the construction work. The rest of the staff/labor are hired locally, generating employment to the rural areas.

The plans are to develop the mini-hydro programme relying as much as possible on indigenous resources and expertise. At the start of the programme, there is a heavy reliance on imported equipment. But as the programme matures, local manufacturing will have the opportunity to develop their technology and expertise. Hopefully, the Philippines will have established a viable local mini-hydro industry capable of meeting Philippine needs after the first phase of the programme is completed.

Programme Status

In line with the initial 300 MW programme established in 1979, the NEA, the electric cooperatives and the local consulting firms work hand in hand in the conduct of reconnaissance surveys and feasibility studies of the potential mini-hydro sites. As of 1982, feasibility studies for 95 sites with an aggregate capacity of 131 MW have been completed. Based on these studies NEA approved the loan applications of the electric cooperatives for the development of their respective potential mini-hydro sites. These loans amounted to ₱1.851 M (over $90 M). Purchase orders for 77 sites (100.2 MW) were issued to British, Chinese, French and local equipment manufacturers. Of these, 14.4 MW for 13 sites have been installed. (The description of these plants is shown in Annex I).

Since most of these equipment are procured through loans negotiated during the early years of the programme, they are now ready for installation. With the present economic condition of the country, however, local funds for their installation are very limited.

The thrust of NEA now is to seek funding for local cost and the review/updating of its completed studies for mini-hydro.

NATIONAL ELECTRICAL ENERGY PROGRAMME

In the electric energy sector of the Philippines, there are two government agencies mainly responsible: the National Power Corporation (NPC) and the NEA. The NPC is responsible for the generation and transmission of electrical energy. The distribution of electricity is undertaken by the electric cooperatives, the Manila Electric Company (MERALCO), other private systems and some municipalities. The NEA provides financial, management and technical assistance to the rural electric cooperatives. It is also a regulatory agency that grants electric franchises, establishes rates and supervises the operations of the cooperatives.

At the end of 1986, electric grids cover almost every major island, linking together all the municipalities. About 48 percent of households have been provided with electricity, covering 57 percent of the villages. These villages are located in 92 percent of the municipalities in the country.

The development of energy resources and electric grids were first concentrated on mainland Luzon and Mindanao. There was also a heavy dependence on oil until the oil crisis in the 1970's. The table below shows the sources of electrical energy as of 1986:

Energy Source	Capacity (MW)	Energy Gen. (MMBFOE)
Oil/Diesel	2699.9	13.74
Hydro	2142.3	10.46
Geothermal	894.0	7.93
Coal	534.7	4.51
Non-Conventional Sources	191.1	1.97
Total	6462.0	38.61

Of the 2,142.3 MW total capacity of hydropower plants, 20.2 MW (about one percent) are mini-hydro. The data on the plants installed under the old mini-hydro programme are not complete. Only five plants under the NPC and the 13 plants completed under NEA are included in the preceding table.

The draft Medium-Term Philippine Development Plan for 1987-1992 showed a rise in the indigenous energy supply mix from 48.9 million barrels of fuel oil equivalent (MMBFOE) in 1987 to 64.0 MMBFOE in 1992. The cummulative installed generating capacities of power plants will expand from 6,546 MW in 1987 to 7,114 MW in 1992. Nonconventional energy will be contributing 40 percent to total indigenous energy by 1992, reducing the oil import dependency ration from 49.4 percent in 1985 to 47.2 percent in 1992.

During the initial plans for the mini-hydro programme, a target of 300 MW was set. However, because of the limited funds available and the low cost of fuel oil in mid-1980's, the target was reduced from 300 MW to 100 MW. Hence the share of mini-hydro plants to the total installed capacity would be 1.50 percent by 1992.

The 100 MW mini-hydro plants appear to be negligible as compared to over 7,000 MW total installed capacity by 1992. However, mini-hydro plants are located mostly in small islands, which are not reached by power from bigger plants. Usually, the only alternative source of power in these areas is oil-thermal plants. The high cost of fuel makes the cost of power very expensive to the people in rural areas. This also adds to the problems of financial viability of the cooperatives, With the efficient operation of mini-hydro plants in remote areas, the people are assured of cheap and reliable power which is free from foreign exchange risk and world oil supply shortages.

DOMESTIC PRODUCTION OF MINI-HYDRO EQUIPMENT

In response to the directive of assisting the electric cooperatives in developing their mini-hydro potential, NEA met with local

manufacturing firms and foreign equipment manufacturers and suppliers in 1979. The local firms were briefed on the objectives of the programme and the possibility of manufacturing the required equipment, to expedite the implementation of the programme. Discussions were held with foreign manufacturers for the supply of mini-hydro equipment and the possible joint venture with local firms. Of the manufacturers from the United States, People's Republic of China and Europe, it was considered advantageous to have a joint venture with China because of the following reasons:

1. China's experience in the installation and construction of small hydropower plants in the last three decades
2. installation and construction of mini-hydro facilities had been carried in China at the village level, while U.S. and European installations used skilled labour and trained engineers. Chinese sets in smaller capacities were considered more adapted to Philippine rural conditions.
3. the manufacture of smaller sets in China had been carried out at the commune (small/medium-sized industry) level. Employment of the Chinese technology will make possible the establishment of several dispersed mini-hydro plants in the country, in line with the policy on industrial development.
4. the low cost of Chinese equipment justified the efficiency trade-off.

The Minister of Industry then recommended the following: exploration of the establishment of a joint venture employing the Chinese technology on mini-hydro before entering into any agreement with a U.S. or European company; that equipment be imported in the meantime, from most competitive sources for each particular size needed; and that the primary responsibility for the exploration of such venture with China, as well as the specifications and evaluation of sets to be imported, be assigned to the NEA.

A series of meetings between the Chinese and Filipino delegations were held in the Philippines and China following the approval

of said recommendations. The Atlantic Gulf and Pacific Company of Manila, Inc. (AG&P), the Engineering Equipment Incorporated (EEI) and the Philippine Electric Corporation (PHILEC) expressed their interest to acquire manufacturing technology from China. During the visit of the Mini-hydroelectric Survey Delegation of the Philippines to China in November 1979, the two countries agreed, among others, on the following principles:

1. The forms of cooperation between China and the Philippines were technology transfer and cooperative production.
2. As the Philippines acquired the ability of mini-hydroelectric equipment manufacturing, China would like to provide the Philippines with complete sets of mini-hydro equipment and/or completely knocked-down assemblies and/or parts and components as well as the technical services for assembly, erection, adjustment and testing.
3. A concrete agreement would be formulated after the discussion between AG&P, EEI, PHILEC and the Hangzhou Electric Equipment Manufacturers.
4. During the period of cooperation, China would be sending their experts to the Philippines to provide technical assistance and training as required and mutually agreed.
5. On a government to government basis, China would like to offer the Philippines their favourable price and terms of payment on the basis of equality and mutual benefits.

A timetable was set to facilitate the realization of the mini-hydroelectric projects in the Philippines. In February 1980, negotiations for the following were concluded:

1. Licensing agreement between the China National Machinery and Equipment Import and Export Corporation (CMEC) and AG&P for the manufacture of hydraulic turbines;
2. Cooperative production agreement between the CMEC, the Hangzhou Electric Equipment Works and PHILEC for the manufacture of generators; and
3. Agreement of cooperation between the CMEC and the NEA on the financing and supply of mini-hydro generator sets.

In addition to these, EEI and PHILEC entered into licensing agreements with Voest Alpine of Austria and Barbers of Canada, respectively.

Of the original 300 MW target capacity for implementation in 1980 - 1987, 183 MW was to come from local sources. Unfortunately, the capability of the country to finance these projects had been impaired. Only one project has been completed under the joint venture between the local and foreign equipment manufacturers. Based on its licensing agreement with the CMEC, AG&P won a bidding for the supply of equipment for the Balongbong mini-hydro project. The equipment consisted of two units of 900 kW impulse turbine.

A series of technical discussions was held between the CMEC and AG&P on the approach to the project. Agreements were set in the manufacturing programme to satisfy the technical and delivery requirement of the project, as well as the capabilities of AG&P. A team of five AG&P engineers was sent to the CMEC factory to discuss the details of the design and production methods. CMEC, on the other hand, sent a team of four engineers to the AG&P shop during the manufacturing stage. During the installation and commissioning of the project, CMEC sent a team of specialized engineers to -

1. train the AG&P and cooperative personnel in the proper installation and operation of the equipment;
2. set up a training programme for repair and maintenance;
3. assist in the calibration/testing and commissioning; and
4. evaluate areas of improvement in the implementation of the local manufacturing programme.

Considering that this was the first project under the agreement, some components were manufactured at the AG&P shop, some in China, while the rest were sent to the Philippines completely knocked-down.

Considerations for Domestic Manufacturing

The possibility of indigenous fabrication of mini-hydro equipment is one of the elements that make mini-hydro attractive.

Domestic manufacture can be a way to save both foreign exchange and local currency. This is due to the fact that most conventional small turbines are individually made and have high labour content. Thus, many countries, specially those in the Third World are looking to local manufacturing programmes to bring down the costs of mini-hydro development and application.

A number of things must be considered in deciding whether a country should have a local manufacturing programme or just import from existing suppliers. Some of the most important considerations are:

Country Conditions. Hydropower projects are, by nature, site specific. The physical characteristics of a country's hydrologic resources and its demographic shape determine the characteristics of the mini-hydro programme.

There are countries where the population is relatively sparse and far-flung; mountainous, with many streams and rivers of almost infinite variety in flow and head. The need for electricity is for basic lighting and very light household industries like sewing and handicrafts. In such a case, it is difficult to conceive of grid inter-connection. Consequently, unit sizes will be low, and sophistication of control is not required.

There are also countries with relatively long history of SHP experience, extensive and sophisticated grid system, and with predominantly grid connected possibilities for SHP. Some countries, on the other hand, need SHP to supplant and supplement grid energy sources which are less efficient or more wasteful of precious foreign exchange.

Depending on the needs of a specific SHP programme, and the capabilities of a host country, one can determine what kind or kinds of equipment are required and in what proportion. Some SHP programmes call for low power systems for isolated requirements; some require more technically difficult, higher power and more complex system for the grid connected or large isolated application. With the low power, less technically demanding need, it is possible to envision units requiring very low levels of skills in fabrication.

Equipment Alternatives. Many countries have neither the financial nor technical resources for more demanding alternatives to local fabrication of SHP equipment. Fortunately, much work has been done in this area. Today, there are many low cost alternative designs which will at least allow these countries to begin to avail of their indigenous power sources and perhaps at a later date build up to a more sophisticated program.

One of the simpler approaches has been to take a pump and convert it to turbine. This can be more easily done, of course, where pump manufacture is carried on within the country. Moreover, the conversion of relatively low-cost imported pumps can also be done quite cheaply within the country. Many group manufacture, in fact, have offered conversion assistance.

If the requirements of a country are on a higher level, an inventory of its human resources and production capability is required and this will be covered in a subsequent section the possibility of developing production of materials or equipment not produced within the country should be considered if justified by the market.

Standardization. Standardization is necessary when one conceives of electrical interconnection of a small hydro unit with several others in a local grid or on a national grid. It is impossible to achieve any meaningful interconnection otherwise.

The standardization of relatively low-cost, low powered units, manufactured and fabricated by small village workshops and intended for stand-alone operation, does not require standardization.

When volume of production begins to reach higher numbers that will allow standardization, it can significantly reduce first-cost and engineering effort as well as facilitate repair and maintenance, and reduce operating cost. Indeed, standardization can be applied broadly across the whole system to encompass not only the turbine but generator, switchgear, governor, auxiliary systems, electrical systems and components, even penstocks, gates and valves.

Material supply availability can also influence the capital

cost of a SHP local manufacturing program. Equipment design and engineering should therefore consider as much as possible locally available materials to save on foreign currency and reduce capital costs.

Technical Support Required. The machinery and skills required to begin local production of SHP equipment is quite extensive. If a country already has some metal fabrication capability, the local fabrication of SHP mechanical equipment does not pose a serious problem in purely technical or physical terms. If these facilities and skills are not present, low cost low technology designs are now available which at least allow the initiation of local fabrication.

1. Production Facilities - unless the intent is to export, very few local markets have the volumes necessary to support a "greenfield", dedicated plant, intended solrely for SHP. The more pragmatic approach is to see if SHP manufacture can be installed as an adjunct to an existing production line, such as workshops making ships, tanks, pumps or other industrial shapes and containers fabricated out of heavy metal. In addition to bending, shaping, cutting and welding, founding capability is often useful though not necessary. Testing facilities are also useful but not necessary especially if an existing, proven design of known characteristics, is used.

2. Skills - SHP is a basic and relatively simple technology. However, except again for the most elementary designs, some degree of basic technical skill should already be present if a local fabrication program is to enjoy a greater chance of success. Cutting, shaping, bending, welding and steel castings should be familiar to sufficient numbers of workers and engineers to allow focus and concentration on the job of producing SHP units or components.

Two factors generally bringing this about:

1. A broad based educational system which embraces both professional education as in engineering and,

2. technical skills as in welding, cutting and or shaping of metals due to the existence of feeder industries that support and require the application of such skills.

Obviously, these conditions are difficult to duplicate or

generate over a short period of time.

3. SHP Technology - Specific SHP knowhow, such as design of equipment, or correlative skills of site evaluation is not generally available to less developed countries. Consequently, these skills must be obtained, bought, through licenses, or through other institutions such as UNIDO or SKAT.

Adaptation of existing designs, or of parallel technology, such as pumps, to SHP has been successfully attempted by many countries. Often, however, the "imagineering" necessary for such adaptation is not present if only because of sheer lack of previous experience. What is very common to a Western man may be totally unknown to others.

4. Special Facilities Required - Specialized equipment and facilities for SHP reduction are few, and are not always imperative. Testing of mechanical apparatus, such as turbine capacity and efficiency is really only necessary if the designs are new and untried and if the application is relatively critical. Otherwise, SHP application can handle a fairly wide range of both capacity and efficiency deviation without undue concern. If electrical apparatus manufacture is attempted, then demands of safety dictate that generators, transformers and other auxiliaries conform to indicated standards and be tested accordingly.

5. Training Needs - For both post production and possibly for production needs, a developing country should definitely consider training as an integral factor for local production. There is a need to insure an adequate supply of production workers as well as maintenance personnel for the operation of the units. It is easy to lose workers to more lucrative markets (the Middle East, for example). Since SHP equipment are designed for long life, sound maintenance of SHP equipment is a major ingredient in a successful program. Local fabrication can be a positive factor in that the production process can be observed by operating and service personnel. In addition, training should take into account the needs for supervisor and management as well as technical skills relative to the fabrication of SHP equipment. Often this can be addressed thru formal seminars and workshops both local and international. As the skill levelm on the job training, is generally regarded as the most effective instrument,

Economic Considerations. Nonetheless, the most often cited reasons for proceeding with local manufacture are economic reasons. Lower unit costs and reduced foreign exchange needs are strong incentives for any developing country, not to mention the opportunity to gainfully employ more people and add to the nations technical wealth. However, unless one is careful, these can prove to be illusory.

1. Capital Cost - The capital cost of a manufacturing plant can generally be justified only if, to some degree, the infrastructure for local fabrication is already in place. In other words, if there are already a number of local companies in existence with sufficient capability and excess plant capacity in metals fabrication, electricals, or foundry. This is because in almost every country the total market and unit volume potential of SHP equipment is only in the several hundred; very few can number in the thousands. If you factor in capability to pay for the entire SHP program, the annual and total unit volume potential becomes very small indeed.

2. Savings - Generally, it is cheaper to produce small turbines in developingcountries because the manufacture of turbines is mostly carried out by batch production and considering the lower labor costs of such countries.

While this may be true for turbines, it is not necessarily so with some other mechanical appurtenances such as gate valves, or electricalssuch as generators, transformers and controls. This is because these components are sued in wider markets and not solely SHP, and consequently enjoy larger volumes. This makes them more susceptible to cost improvement arising out of proper jigging, tooling and so on, investments in productivity improving capital equipment. Consequently, it is difficult to match the cost of such products, produced in volume in the industrialized countries.

3. Foreign Exchange Savings - Especially to us in capital scarce developing countries, the lure of savings in foreign exchange is a siren song. Local fabrication definitely cuts down on foreign exchange needs.

What must be kept in mind is that there are costs to this too: slower start-up, snafu's for new operations, cost of new or

incremental plant, training, and productivity loss and funding of capital or plant equipment, raw material, and purchase of end product.

Socio-Political Considerations. All programs of national or internationalscope must contend with socio-political complexities. Social benefits may sometimes outweigh marginal economic gains; locational decisions are sometimes swayed by sheer political muscle.

Funding. Funding is crucial to a successful local SHP fabrication program of any breadth and consequence. In the case of a poor, cash short developing country, cash is the rarest commodity. Interest costs in country therefore are invariably high. Many already have unacceptably high foreign debt. So while conditions of "costs" and "foreign exchange savings" favor local fabrication, the crucial question is one of "Cashflow". The ultimate buyer, the public or private utility in most cases cannot pay in cash nor borrow profitably at the high rates of interest prevailing in country. The utility can pay for equipment out of energy sales if given 10 or 15 years to pay, Otherwise, no.

The principal problem therefore is to improve the buyer's "capacity to pay". This "capacity to pay" can be improved only in long term borrowings or equity. Capital can be sourced internally within the country or from other countries or agencies.

Philippine Conditions

We could say that the above factors have been considered in the plan of the Philippines to establish a local manufacturing industry for small hydro equipment. We have existing facilities and technical skill capable of fabrication of these equipment. The technology has been acquired from China, Canada and Austria through the licensing agreements entered into by our local manufacturers. However, problems have arisen from the capability of NEA and the local cooperatives to pay for these equipment.

The rest of the projects which were supposed to utilize locally made equipment were deferred, primarily due to lack of funding. Local cost was needed to install the imported equipment procured through foreign loan. In the case of locally manufactured equipment, the proposed domestic loan did not materialize. Hence,

funding was needed for both the equipment and construction cost. Since sites which will make use of imported equipment needed less additional funding, these were given higher priority than the other sites.

ANNEX I

DESCRIPTION OF NEA COMPLETED MINI HYDRO PROJECTS

AS OF DECEMBER 1986

	ASIN GRANDE / MADOGAHOS	BACHELOR	MAGAT A RIS	MAGAT B RIS	BALONBONG	COYAOYAO	MANTAYUPAN	BASAK	MENADIAM	ION-DK	BALACTASAN
LOCATION	PAGUDPUD, ILOCOS NORTE	BATIVIBAD, PANGASINAN	RAMON, ISABELA	RAMON, ISABELA	BATO, CATANDUANES	SAGNAY, CAMARINES SUR	BARILI, CEDU	BADIAN, CEDU	ST. BERNARD, SO. LEYTE	CALBAYOG, SAMAR	LAMITAN, BASILAN
CAPACITY	(SEPTEMBER 1986) 4550 KW	(SEPTEMBER 1986) 750 KW	(DECEMBER 1986) 1440 KW	(DECEMBER 1986) 1080 KW	(DECEMBER 1986) 1800 KW	(DECEMBER 1986) 350 KW	(DECEMBER 1986) 500 KW	(DECEMBER 1986) 500 KW	(DECEMBER 1986) 810 KW	(DECEMBER 1986) 1080 KW	(DECEMBER 1986) 270 KW
HEAD	100 M	35 M	3.5 M	3.5 M	200 M	54 M	95 M	67 M	71.5 M	88.3 M	61 M
FLOW	3.25 CMS	3 CMS	55.2 CMS	41.4 CMS	0.81 CMS	0.8 CMS	0.73 CMS	0.994 CMS	1.6 CMS	1.784 CMS	0.60 CMS
TYPE	RUN-OF-RIVER	RUN-OF-RIVER	DIVERSION	DIVERSION	RUN-OF-RIVER	RUN-OF-RIVER	RUN-OF-RIVER	RUN-OF-RIVER	RUN-OF-RIVER	RUN-OF-RIVER	RUN-OF-RIVER
STRUCTURE											
INTAKE	STEEL	STEEL	STEEL	STEEL	STEEL	STEEL	STEEL	STEEL	STEEL	STEEL	STEEL
PENSTOCK	STEEL	STEEL	STEEL	STEEL	STEEL	STEEL	STEEL	STEEL	STEEL	STEEL	STEEL
TURBINE	IMPULSE HORIZONTAL	FRANCIS HORIZONTAL	AXIAL FLOW HORIZONTAL AXIS PROPELLER TYPE	AXIAL FLOW HORIZONTAL AXIS PROPELLER TYPE	IMPULSE HORIZONTAL	FRANCIS VERTICAL	IMPULSE HORIZONTAL	FRANCIS HORIZONTAL	IMPULSE HORIZONTAL	IMPULSE HORIZONTAL	IMPULSE HORIZONTAL
INVESTMENT COST	$ 6.75 M	$ 1.15 M	$ 3.06 M	$ 2.29 M	$ 1.65 M	$ 0.55 M	$ 0.6 M	$ 0.7 M	$ 1.5 M	$ 1.8 M	$ 0.85 M
UTILIZATION FACTOR	19%	91%	51%	69%	62%	74%	99%	96%	70%	44%	99%

* ALL SYSTEMS LINKED TO LUZON GRID
CONTROL SYSTEM FOR ALL PLANTS: ELECTRICAL, MECHANICAL AND HYDRAULIC