OCCASION

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

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

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

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

09261

United Nations Industrial Development Organization

Distr.
LIMITED
ID/WG.305/16
13 November 1979
ENGLISH

Seminar-Workshop on the Exchange of Experience and Technology Transfer on Mini Hydro Electric Generation Units

Kathmandu, Nepal, 10 - 14 September 1979

DEVELOPMENT OF MINI/MICRO HYDROPLANTS IN THAILAND.*

by

P. Premmani **

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

** Director, Technical Division, National Energy Administration, Thailand.

id.79-9049

TABLE OF CONTENTS

1. Introduction

At present, energy supply to people in the rural area is insufficient and comparatively low when compared to that in major cities in Bangkok Metropolitan area. Since energy is one of the vital inputs required for the development of the country, it is necessary that it be provided in a suitable form at the lowest price and at the appropriate location according to priority in order to accelerate the development in the rural area by means of increase in productivity, incomes and standard of living of the people. Electricity is one of the preferable forms of energy which could be used in various aspects such as mechanics prime mover for water pumping, rice milling, mechanic tools in workshop, small scale industries, lighting for houses, food storage, radio, electric fans and as a source of power for communication equipments and many others. For this purpose, the government has established a programme for rural electricification which is included in the Fourth National Economic and Social Development Plan (1977 - 1981). It is anticipated that 90 - 95% of the whole population in Provincial Electricity Authority's area would have access to electricity with in the next 1[illegible] years. The plan for supplying electricity to rural areas will be carried out by means of expanding transmission line from existing substations, setting up the diesel generating plants and generating electricity from renewable sources, for example, mini/micro hydro plants. However, there are problems encountered in the development of this plan which could be described as follows:

1.1 High investment cost is required for the expansion of transmission line to the scattered villages but the power consumption and the load factor of the system are relatively low. This is due to the fact that electricity will mostly be used for domestic purposes.

1.2 Although the investment required for setting up the diesel generating plant is relatively low but because of high, operating cost including fuel and O + M, the cost of electric power production is rather high. At the present electric tariff rate, the supply of electricity from diesel generating plants is facing a heavy loss. Moreover, there is also the problem of transportation of diesel fuel supply to remote rural areas where access are difficult or impossible in the rainy season. Storing of the fuel for use during this season would also be a problem.

1.3 Generation of electricity from hydro power is very desirable because hydro power is indigenous, renewable and it can be developed near the area where the load is. Moreover, it could be used as a key component in the development of rural community. However, in the past, only a small number of mini/micro hydro generating plants have been built as a result of high development cost when compared to the major hydro generating plants or diesel plants. The power produced from these big projects are used mainly in the municipality area of the towns or districts, and some spot along the transmission line route only. In order to develop mini/micro hydro power plant more widely, it is necessary to find a solution which would reduce the development costs.

Thus, the goal for future development of mini/micro hydro generating plants in Thailand will be as follows:

1.3.1 to substitute diesel generating plants in the remote rural area;

1.3.2 to supply electricity to small power grid with or without connexion to the main grids;

1.3.3 to supply electricity to districts, subdistricts (tambon), and villages.

At present, power supply to rural areas by means of diesel generating plants is about 90 MW.

Due to lack of standard classification of mini and micro hydro generating plants, the interim classification is adopted in this report as follows:

(i) 0-100 Kw - micro hydro generating plant;

(ii) 100 Kw - 5 MW - mini hydro generating plant.

2. Mini-micro [illegible]

2.1 Potential

It is indeed a tremendous [illegible] estimate of the hydro potentials of the country, especially for a developing country where intensive hydro-power [illegible] only began about two to three decades ago. The limitations [illegible] only confined to lack of human resources [illegible] also to the [illegible]ility of accurate maps and hydrological investigations.

In this present [illegible] where it is thought that there is good potentials for [illegible] have been singled out. Their boundaries are shown [illegible] in Figure 1. The catchment areas of each of the river [illegible] from the 1 : 250,0[illegible] scale map. Dry season [illegible] for all the stations within the boundary [illegible] for a basin or the area within the boundary.

To estimate the [illegible], the head is taken as the average of the difference in elevations of the [illegible] or stream where a project could be developed [illegible] of the catchment to the point where it could be developed [illegible] estimating the power [illegible]

[illegible]

[illegible] in [illegible]

[illegible]

[illegible] in meters.

The total potential [illegible] at 1,0[illegible]6 [illegible]. The details of each zone is given in the [illegible]

Zone	Total catchment [illegible] km^2	Flow litre/sec/km^2	Capacity [illegible]
1	[illegible].720	2.05	7[illegible].9
2	[illegible],[illegible]20	4.23	432.6
3	20,[illegible]50	2.68	419.[illegible]
4	6,[illegible]	6.95	8[illegible].8
5	2,350	10.55	48.1
6	1,500	4.51	12.8

If [illegible] potential could be realized for mini/micro development, [illegible] amount to [illegible] MW of mini/micro hydroplants, and [illegible] capacity [illegible] MW, then there would be no less than [illegible] projects for development.

2.[illegible] Present Position

Presently, there are altogether 41 mini/micro hydro projects which have already been investigated to a certain extent. Desk studies for these have already been carried out and these reports are available.

The details of each project and its capacity are given in Table No. 1. The total capacity for these 41 projects is [illegible] MW.

Out of these are two projects for which feasibility studies have been completed. One project is under construction and the other is planned for construction within a year.

Intensive detail studies are being carried out for the remaining projects and it is estimated that at least [illegible] pre-investment studies for 8 projects would be completed within [illegible] years.

3. Status of mini/micro hydro plants

3.1 Plant under operation

At present, 7 mini/micro hydro power plants have been completed and are under operation. The details of each plant can be described as follows:

3.1.1 Na Bon mini hydro plant. This plant is located in Nakorn Sri Thamarat Province, Southern Thailand and was completed since 1960. It was designed by the Royal Irrigation Department who also supervised the works of the project. It is owned by the Rubber Organization of Thailand. The electricity produced is used in the rubber industries which is situated about 13 kilometers away from the plant and the details of this plant are shown in Figure 1. The equipments installed were imported from Europe and are working very well over after 19 years of operation without any problem. At present, the load demand of the rubber industries is in exceedance of the plant capacity. Therefore, the power line is connected from the main grid to the rubber industries and the plant is being operated in synchronizing with the power from the main grid. One of the salient feature of this plant is that the power canal is designed with concrete cover plate to protect tree leaves and other undesirable materials to fall into the canal which may cause damage to the turbine wheel and inlet nozzles.

3.1.2 Mae Hong Sorn mini hydro plant. This plant is located in Mae Hong Sorn Province in Northern Thailand and electric power and the transmission line are connected from this project to the town of Mae Hong Sorn and Kun Yuam district which is about 12 and 45 kilometers away from the plant respectively. It is designed and constructed by the National Energy Administration and it is in commission since 1972. The details are shown in Figure 3. The equipments were imported from Europe. Before completion of this project, the electricity supply to these areas were generated from diesel power plants. A number of problems were faced then. These include shut down for maintenance and some difficulty in transport of diesel fuel by road during rainy season. After this plant has been in commission, the system is supplied with more steady power resulting in the rapid load growth at an average rate of 17% per annum from 1972 to 1979. Due to the fact that this plant is designed as a run off the river project, deliver it generates the power lower than its installed capacity during dry season. After 5 years of commission, a diesel generating unit has to be installed in order to meet with power demand which has increased to far beyond the capacity low stages river flow condition. With 7 years operation experience of this plant, the following problems have been observed:

3.1.2.1 the power canal is damaged by water seepage under the concrete lining causing differential settlement of canal sections;

3.1.2.2 there is a problem connecting with the controls of speed and output frequency of the governor. It is understood that the governor may have been damaged during the initial stage of power generation as the initial load was rather low when compared to the installed capacity of the plant. However, the effect is small and the performance could be improved with proper maintenance.

3.1.2.3 sliding of mountain slope occurs occasionally during the rainy season but so far it has not interferred with the power generation.

It is planned that a new additional mini hydro plant will be developed in this area in the near future in order to meet the expected load growth and to replace the power generation by diesel plant.

3.1.3 Ban Yang Micro Hydro Plant. This plant is located in the Fang District, Chiengmai Province in Northern Thailand and the electric power from this plant is supplied to the Fang District which is about 26 kilometers from the plant. At present, the plant is operated in synchronizing with the diesel power plant representing a power system isolated from the main grid. The plant was designed and constructed by Electricity Generating Authority of Thailand (EGAT) by the recommendation of H.M. the King for supplying electric power to the hill tribe village. It has been in commission since 1974. At the initial stage of power generation, electric power was supplied to a factory which produces milk from soya bean, agricultural experimental stations, as well as for domestic uses. The first turbine-generator set of 12 Kw capacity was designed and built locally by EGAT personnel. Later, another two units of 50 Kw crossflow turbines were imported from Europe for this plant. From operating experience of EGAT, there are some problems associated with the power generation of this plant which could be described as follows:

3.1.3.1 The 12 Kw francis turbine has a problem of controlling speed when it is operated in synchronizing with the diesel plant located at the Fang District. This problem may have been caused by insufficient governor torque and fly wheel affect. However, this turbine works rather well when operated without synchronization.

3.1.3.2 Excessive worn in impellor blades was observed in the cross-flow turbine and this affect may be due to the fact that this plant has no sand trap in the headrace section. Sand bed load may flow into the intake during flood season when the intake is submerged under the water level. The turbine impellor has to be repaired after 3 years of operation.

Ban Yang micro hydro plant is a run of the river type without any reservoir storage and the capacity of the plant is determined by the minimum flow during dry season. The details of this plant are shown in Figure 4.

3.1.4 Ang Kang Micro Hydro Plant. This plant is also located in the Fang District, Chiengmai Province in Northern Thailand. Ang Kang is a mountain peak of about 1800 - 1900 meters in elevation from mean sea level. Many agricultural research and experimental stations are located in this area. Their main purpose is to study and determine the suitable crop for high elevated land. The agricultural activities creates the need of electric power for lighting, domestic uses, water pumping etc. Therefore, by the recommendation of H.M. the King, the plant is designed and built by the Royal Irrigation Department (RID) and the project was in commission since February 1979. The details of this plant and turbine are shown in Figure 5 and Figure 12, 12/1, 12/2 respectively. This plant is different from the other plants in some design aspects. Due to insufficient inflow of the water in the stream during the dry season, the flow from intake is diverted and collected in an artidicial pond. The capacity of the pond is so designed as to provide sufficient quantity for operation for a period of about 4.5 hours in the evening. The power plant is not operated during the rest of the day. The turbine was designed and built locally by RID personnel. The generator, switchboard and governor were taken from the old plant located in one of the irrigation diversion dam. Due to a very short operation period, there is no report on the problems from this plant at presen .

3.1.5 Doe Pui Micro Hydro Plant. This plant is located in the Muang District, Chiengmai Province in Northern Thailand. Doi Pui ranks third in height among all the mountain peaks in Thailand. There are some hilltribe villages situated on this mountain peak. The plant was built by the village under the direction and supervision of the Chief Abbot of the monastery about a year ago. The turbine was manufactured by a local machine shop and the generator is supplied from local factory in Bangkok. There is a provision for pondage of water sufficient to operate the plant for about 4 hours a day in the evening. The electric power is supplied to the hilltribe village and the electricity is sold at the rate of US $ 1 per one 40 watts flourescent bulb per month. However, due to improper design of turbine and without any control for speed regulation except flow control, the output speed and power of the turbine do not match that of the generator resulting in lower voltage output, frequency and speed fluctuation. At present, a new cross flow turbine has been designed and built under the supervision of [illegible] personnel. This turbine has been installed since July this year. Unfortunately there is no laboratory test to verify the performance of the cross flow turbine. However, field report indicates that the turbine is running at a steady speed and the generator is producing the rated voltage and power output. Moreover, the turbine seemed to be achieving a much higher efficiency because with the same pondage and generator output, the water in the pondage could be used to operate the turbine for 9 hours instead of 4 hours with the previous turbine. The details of this plant are shown in Table 2.

3.1.6 Pong Yaeng Micro Hydro Plant. This plant is located in the Mae Rim District, Chiengmai Province in Northern Thailand. The plant supplies electricity to the farm belonging to a private owner. The plant and the turbine are designed and built under the supervision of the NEA's personnel. In this project, a diversion weir and water channel already existed. They have been constructed by the villagers. The sand trap, head tank, penstock and power plant have been added and connect the exisiting channel. The turbine speed regulation is provided by manual control. The details of this plant are shown in Table [illegible]. It has been in commission since July this year. There is no laboratory test to find out the performance of the turbine. To date no operating result has been obtained.

3.1.7 Mae Chon Micro Hydro Plant. This plant is located in the Mae Chaem District, Chiengmai Province in Northern Thailand. The plant is intended to supply electricity to the Watershed Management Station of the Royal Forestry Department (RFD). At this station, a reservoir was built to store water for use in raising tree nursery all year round. Afterwards, the headrace channel, penstock and power plant were built and connected to the reservoir by the Royal Forestry Department's personnel. A turbine manufactured by a local machine shop was installed, the same problem as experienced in Doi Pui micro hydro plant occurred. Therefore, under the request of RFD's personnel, a new cross flow turbine has been designed and is being manufactured under the supervision of NEA's personnel. It is expected to be installed in the coming dry season. The details of this plant are shown in Table [illegible].

3.2 Plant Under Construction. There are three mini/micro projects under construction at present and the detail of these plants can be described as follows:

3.2.1 Mae Kuem Luang Mini Hydro Plant. This plant is located in the Mae Ai District, Chiengmai Province in Northern Thailand. The electric power from this plant will be delivered by transmission line to Fang District in Chiengmai to replace the diesel generating plant and to Chiengrai Province which is about 120 kilometers away. It will connect the main power grid at Chiengrai substation. By connecting the main grid, the available energy of this plant which has about 80% plant factor would be totally consumed. The benefit from this plant is by far better in spite of higher investment cost of long transmission line. The project consists of dam, headrace pipe, sand trap, surge tank, penstock and power plant. The details of this project are shown in Figure 6. The dam is provided with small pondage for daily regulation required during dry season for a full capacity power generation during peak hours. The project is designed and built under the supervision of the National Energy Administration and the turbine and generating sets are imported from Japan. The power plant is expected to be in commission at the end of 1980.

3.2.2 Huai Mae Phong Mini Hydro Plant. This plant is located in the Dok Kam Tai District, Chiengrai Province in Northern Thailand. The electric power from this plant will be delivered by transmission line to Dok Kam Tai District and interconnected with the main power grid at Payao Province which is situated about 25 kilometers away. This project differs from the others by its nature being a multi-purpose project. It will provide electricity and water for irrigation in the dry season. The project consists of a storage dam, headrace pipe line, surge tank, penstock and power plant. In addition, it is also provided with a regulation dam for supplying water to the sprinkler system to irrigate the area of about 640 ha. The details of this project are shown in Figure 7. The project is designed by the National Energy Administratio under the advisory of expert team from Switzerland. The power plant equipments will be imported from abroad and construction of the civil works will be carried out by local contractors. This project will be completed in 1981.

3.2.3 Huai Nam Dang Micro Hydro Plant. This plant is located in the Mae Taeng District, Chiengmai province in Northern Thailand. It is planned that the electric power from this plant will be supplied to the hilltribe resettlement village and Watershed Management Station of the Royal Forestry Department which is about 2.5 kilometers away. At present, about 300 hilltribe families are being moved into this resettlement area but it is planned to expand this village to about 1,000 families. Electricity supply from this project will be used for domestic purpose, as well as for operating other village facilities, for example, rice mill, saw mill, water supply pump etc. Moreover, in order to conserve firewood which is used for heating in winter season and to utilize electric power during the offpeak period, the electric heating will also be considered. Besides various uses in the village, the power will be used in the Forestry Station for drying of tree seeds and to pump water to the tree nursery areas. This project is designed and supervised by the National Energy Administration and the construction work is being carried out by the RFD's construction forces. The turbine is designed by the NEA personnel and will be equipped with an imported governor. Other hydraulic equipments will also be fabricated locally. The details of this project are shown in Figure 8. It is anticipated that the power plant will be in commission in January 1980.

3.2.4 Micro Hydro Plant for St. Joseph's Youth Centre. This plant is located in Muang District, Chumporn province in Southern Thailand. The electric power from this plant will be delivered to St. Joseph's Youth Centre where it will be used mainly for domestic purposes. Here, small earth dam of 10 meters in height will be built to provide water supply for the centre and 5 kw cross flow turbine will be installed at the down stream side of the dam. The head of the power plant will be about 5 - 6 meters and it is expected that the turbine will be operated about 5 - 6 hours in the evening during the dry season due to insufficient storage in the dam. It is expected that the power plant will be completed before the end of this year. The turbine for this plant will be designed by the National Energy Administration. The details of this plant is shown on Figure 9.

3.3 Power Plants to be Constructed in the Near Future. In the next fiscal year (starting from October 1979), there is a plan for the construction of a new micro hydro plant which can be described briefly as follows:

3.3.1 Nam Mae Pang Micro Hydro Plant. This plant will have an installed capacity of about 20 - 25 KW with a net head of about 30 meters. It is located in Prao District, Chiengmai Province in Northern Thailand. The electric power from this project will be delivered to a nearby village by 3500 volts line at a distance of about 2 kilometers. This power plant has a distinct feature in it that is it will be the first of the project to be build with the participation of the people from the village. The basic idea is that the government will provide power plant equipments, hydraulic equipments, steel pipe, conductor and insulator for transmission line, cement and steel bar, engineering design and construction supervision. The contribution from the villagers will be in the form of labour force required for the construction, local material such as sand, gravel, wood, and wood poles for the construction of weir, intake, sand trap, power house and transmission lines. It is expected that the contribution from the villagers would amount to about 30 - 40% of the project cost. It is also planned that all the equipments will be made locally except for some parts of the switchboard. The project is to consist of the following components:

3.3.1 Diversion weir made in front of wood or stone;

3.3.2 unlined earth canal;

3.3.3 concrete intake and sandtrap;

3.3.4 steel penstock;

3.3.5 power house made from wood with concrete substructure;

3.3.6 transmission line with wooden pole. It is expected that construction cost will be about 1250 - 1500 US $ per kw installed and it will take about 6 months to complete the project.

3.4 Micro Hydro Plant to be Developed Under the Technical Assistance from USAID. The Thai and U.S. Governments have already signed an agreement for cooperation on the Research and Development of Non-conventional and Renewable Energy Programme. The period of this programme will be 5 years starting from the end of 1979. Under this programme, it is tentatively planned that 10 pioneer micro hydro projects for village devolopment will be constructed. The village would be selected according to the following criteria:

3.4.1 Village participation in the project planning and construction and in designing utilization schemes that are broad-based and likely to be eubstained.

3.4.2 Unit cost of development is to be under 2,000 US $ per kw (including power transmiseion).

3.4.3 Project involves plan to utilize power with a high load factor.

3.4.4 Development (initial) ie between 5 and 20 kw, electrical equivalent.

3.4.5 Project fite into a development plan for the village.

It is expected that construction of 1 - 2 micro hydro plants under thie programme will etart in 1980.

4. Development Trend

4.1 Project Cost Reduction. From the past experience in hydroelectric development in Thailand, eeveral problems are found to be involved in this development of micro/mini hydro plants. These include:

4.1.1 high development cost;

4.1.2 long transmission line from power plant to load center;

4.1.3 low load factor;

4.1.4 Most of micro/mini hydro plants are of "run of the river" type and have high plant factor which does not match with the low load factor. Therefore, there ie a need to utilize the power during the off-peak period in order to improve the efficiency and economy of the power plant operation;

4.1.5 problem on transport of material to the site.

To overcome all the problems at the eame time eeems to be very difficult, especially to improve the load factor and to use the off peak power. This will take time and involves other inpute as well as investment. Perhaps, a good approach would be to explore the poseibility of reducing the development and investment cost. The possible solutions leading to this goal may be as follows:

- Reduction of civil work cost by utilization of local material and labour;

- fabrication of component and material at site to reduce high cost of transportation;

- utilization of various development stages to match with the load demand;

- utilisation of less conventional and sophisticated components and equipments, at least in the initial stage of development;

- development of local facilities for the production of turbine, governor and generator;

- participation of the villagers in the project development will further reduce the government contribution to the project. In this case, the project may be a part of community programme.

4.2 Design Trend

4.2.1 Dam and Weir. The concrete dam and weir is considered to be the standard design for most of the projects especially when bed rock is shallow because it requires almost no maintenance. Sluice way is necessary in most cases for removal of sand deposit in the area near intake. Wooden dam should also be considered because it is much cheaper as it is already available in the vicinity of the damsite. This also shortens the construction period and the villages know already the technical know how of the construction of these weirs.

4.2.2 Headrace. Both open channel and pipe line have been used in many projects. Long pipe lines are usually made of concrete or A.C. pipe where as short headrace pipe may be steel pipes or A.C. pipes. Buried concrete of A.C. pipe lines require smaller width of hill side cut and bank height and has less problems of bank stability. But this has a weakness in that extreme care must be taken to ensure that there is no leakage through the pipe connexions. Open channel head race also have leakage problems along concrete joint, especially when there is differential settlement between concrete lining section. However, when the hill slope has a medium to low gradient, open channels can be built satisfactorily.

Unlined channel should be considered, since the village has a long experience in building this type of channel for irrigation purposes. When the soil is not pervious and some seepage is acceptable, this type of channel will offer a good solution in reduction of construction cost.

4.2.3 Sand Trap. Provision of sandtrap will be necessary in order to protech turbine impeller from excessive wear due to sand particles.

4.2.4 Penstock. Penstock is usually made of steel or A.C. pipes.

4.3 Selection of Head. Higher head is desirable and when it is possible the head should be 20 meters or more. This is due to the fact that minimum flow is used in the design of turbine out put and usually there is relatively low flow during the dry season. A higher head will allow a bigger power output of the power plant.

4.4 Selection of Turbine. For micro hydro plants, two types of turbines will be used. Cross flow turbine will be used for medium head where as pelton turbine will be used for high heads. The cross flow turbine is preferred for medium head because of its simplicity in construction and maintenance is relatively simple. For both cases simple mechanical governors will be adopted. However, utilisation of electric governor in smaller units may be allowable in order to gain some practical experience from this type of governor.

5. Research and Development of Turbine

To reduce the cost of micro hydro plants is a prerequisite for further wide spread development. The cost of turbine generating set is found to represent about 20 - 30% of the total development cost of depending on the nature of each project. If the turbine-generating set is manufactured locally, it is estimated that the cost may be reduced by about 40 - 50% of the imported one. Locally made turbines could be designed to suit local conditions, to use local materials and to allow easy maintenance by local skilled labour. In view of the aforementioned reason, it is of great interest to develop the capability in manufacturing turbines and its accessories in Thailing through a programme of research and development.

After reviewing [illegible] conditions of micro hydro plants in Thailand, [illegible] will [illegible] classified [illegible], and only a limited number of sites will fall into the category of low head development. From these observations, [illegible] that mostly cross-flow and pelton turbine will be used for medium and high head respectively. It is tentatively planned that the initial R + D will start with cross-flow turbine.

At present, the author [illegible] actively engaged in the R + D of cross flow turbines, [illegible] capacity 50 kW/unit. The fund to carry out this research was granted to the author by the Office of the National Research Council. The turbine is coupled to the imported generator and governor and at present, fabrication of the turbine-generator set is complete. The details of the turbine set and its specifications are shown in figure 10 and Appendix 1 respectively. It is scheduled that the turbine set will be tested in the laboratory some time in November 1979 when the new hydraulic laboratory will be completed. The lay out of test facilities is shown in Figure 11 and it is expected that the facilities of this laboratory will be much improved with the fund under the UNAID programme on Non conventional/renewable energy.

After testing and necessary improvement, the turbine set will be installed at Huai Nam Dang micro hydro plant for actual operation which is planned to be in commission in January 1980. It is hoped that the experience gained in this research will be useful to strengthen the development programme of micro hydro plants in Thailand in the near future.

Appendix 1 Specification of Cross Flow Turbine

1. **Turbine**

1.1	type	Cross-flow "Banki"
1.2	discharge	115 liters/second
1.3	net head	75 meters
1.4	efficiency	70% (anticipated)
1.5	speed	750 rpm
1.6	impeller diameter	0.40 meters
1.7	impeller width	0.1-0.15 meters
1.8	brake horse power	73
1.9	material of construction	
1.9.1	runner	: stainless steel
1.9.2	shaft	: high tensile steel
1.9.3	bearing	: roller or ball bearing
1.9.4	casing + frame	: mild steel
1.9.5	nozzle valve	: stainless steel
1.10	run away speed	: not exceed 1350 rpm

2. **Generator**

2.1	capacity	50 Kw, revolving field type synchronous alternator
2.2	output voltage	380 volt (AC)
2.3	speed	1500 rpm
2.4	efficienty	: 90.5%
2.5	insulator	rotor - class "F" stator - class "B"
2.6	No. of Pole	: 4
2.7	excitation	: self excited
2.8	power factor	: 0.8
2.9	phase	: 3.4 wires

3. <u>Switch board</u>

3.1 volt-meter

3.2 ammeter

3.3 frequency meter

3.4 watt-meter

3.5 control switch

3.6 circuit breaker

3.7 synchroscope

3.8 fuse

3.9 watt-hour meter

4. <u>Governor</u>

4.1 Type : Electro-hydraulic

4.2 Turbine nozzle valve control : by hydraulic cylinder

4.3 Electronic sensing through electronic control circuit, tachogenerator and solinoid switches

4.4 Provided with hand pump for moving the turbine nozzle valve during starting of turbine

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.

C-209

80.06.23