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

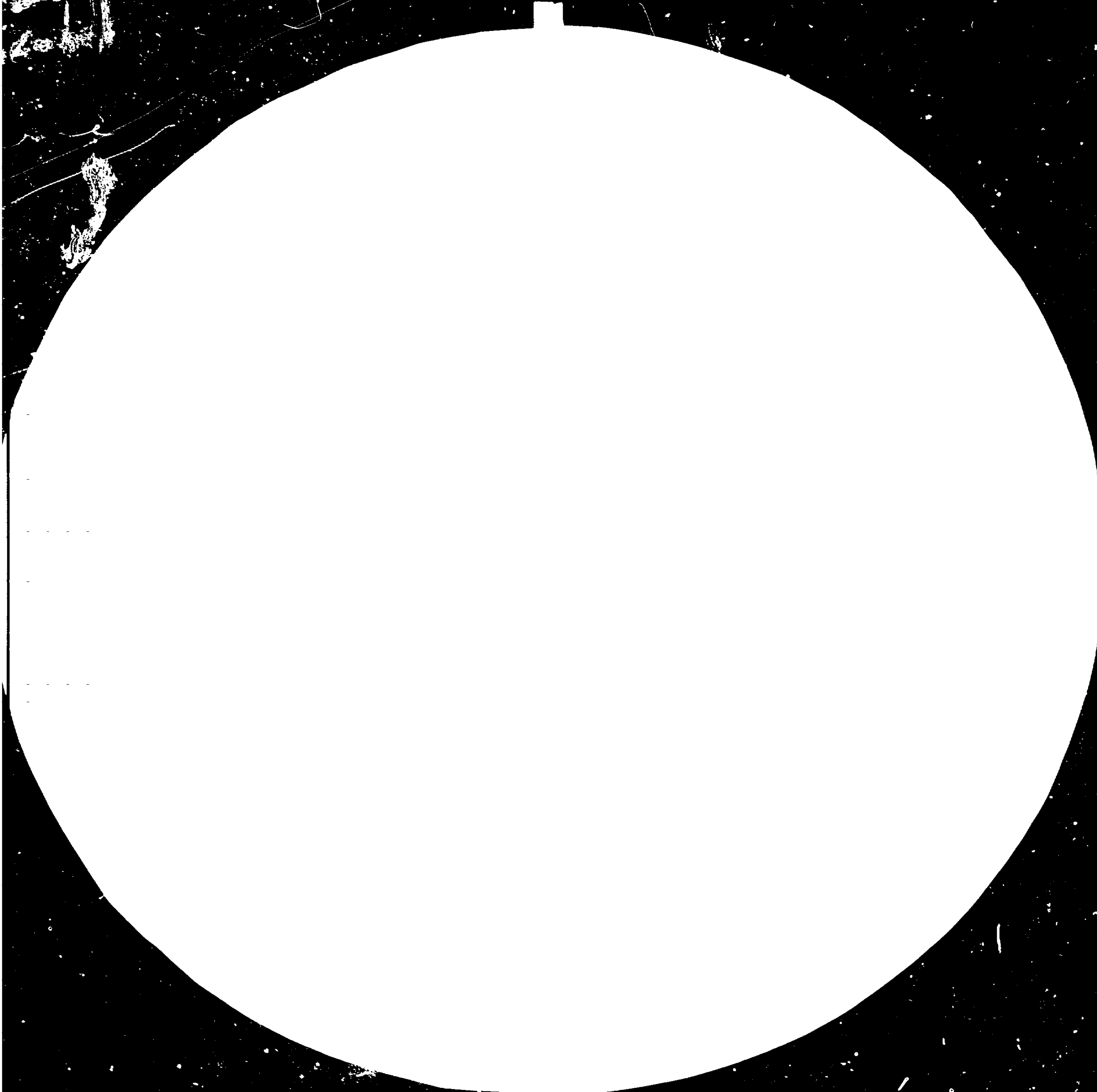
FAIR USE POLICY

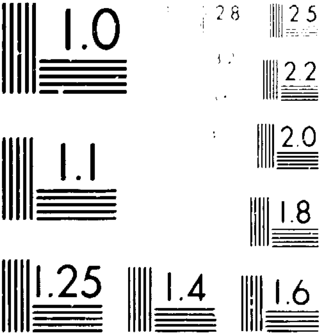
CONTACT

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

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

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




1.0
2.8
2.5
2.2
1.1
2.0
1.8
1.25
1.4
1.6

12739

Distr.
LIMITED

ID/WG.403/3
27 July 1983

ENGLISH

United Nations Industrial Development Organization

Third Workshop on Small Hydro Power

RCTT/UNIDO/REDP/Government of Malaysia

7 - 15 March 1983, Kuala Lumpur, Malaysia

SMALL HYDRO POWER DEVELOPMENT in Fiji*

by

D.S. Pickering**

* This document has been reproduced without formal editing.

** General Manager, Fiji Electricity Authority.

V.83-58866

TABLE OF CONTENTS

1. INTRODUCTION

1.1 We have taken the definition of "mini hydro" as a small (up to 500kW) hydro station, used to supply electricity to villages, which are isolated from the national supply system. Nearly all stations considered are in the 20kW - 150kW range.

1.2 We begin with a description of Fiji. Reference is made to the climate and size of islands (important factors in the hydro resources available) and the demand which affects the scale of development. The authorities responsible for electricity supply are described.

1.3 The engineering investigations to identify sites are set out. Likely demand and the economies of supply are referred to.

2. FIJI

2.1 Fiji consists of a group of over 100 islands in the South Pacific, lying between latitude 15° and 22° South and longitudes 174° West, with a total land area of some 18,400 sq. km. No more than 100 islands in the group are permanently inhabited. It has a population of about 650,000 of which approximately 90 percent lives on the two main islands of Viti Levu and Vanua Levu. It has a typical, tropical oceanic type of climate, modified by the mountainous ranges of the large islands which lie athwart the prevailing South-East trade winds. Temperatures range between 60° and 90° Farenheit (15.7° - 32.5°C). The two main islands have distinct wet and dry zones, with the North-West ('dry') zones experiencing average annual rainfall of about 1,800mm compared with the South-East ('wet') zones which have an average annual rainfall of about 3,300mm.

2.2 Viti Levu, the largest island has a high mountanous interior, intersected by several deep river valleys with substantial areas of flat or rolling coastal lands. These are cultivated intensively, mainly for sugar cane, on fairly small holdings. There are several towns, and a considerable number of resorts in suitable parts of the coast, with significant electrical demand. A 80MW hydro station is being commissioned in the centre of the island this year and this will supply by means of a 132kV transmission line the developed areas in the east and west. At this stage the line will have only the hydro station supply in the centre with substations only at the two ends. Development of 33kV and 11kV lines will see this system supplying nearly all of the islands demand.
An exception is a small area supplied by a remotely controlled diesel station. There are however numerous villages in the interior remote from the main supply system. Some are accessible by road, others not. Most have a 'subsistence' economy, planting and harvesting their crops, and fishing in streams. There is often little commercial growing and selling of crop or other commercial or industrial activity which will provide a cash income for the purchase of electricity or electrical appliances. These villages are where mini hydro would be of use.

2.3 Vanua Levu, the next largest island, has much less development than Viti Levu. It has at present two separate supply and distribution systems. There are areas of development outside these where extension might by justified, although interconnection, because of the distance is still uneconomic. A study has been undertaken of the best means of future development, and there are some useful hydro sites available. While small, (up to 1MW) they are outside the definition of mini hydro given earlier. Other sites of the isolated 'mini-hydro' type are available.

2.4 On the next largest island, Taveuni, investigations into a mini hydro installation has gone on for some years, and it appears likely a station will be built in the next year or so. Some studies have been carried out in other smaller islands, but the usual problem is dry weather flow from the small catchment available, with the wide variation in rainfall.

3. ELECTRICITY SUPPLY SYSTEM

3.1 The main organisation supplying electricity in Fiji is the Fiji Electricity Authority. The Public Works Department, however is responsible for what is called rural electrification, which is the supply of electricity, usually subsidised, to small isolated communities which would otherwise not get it. At present the supply is usually by small diesel sets (up to 10kW), run for a few hours in the evening for lighting loads only. It is in this area that mini hydro would be expected to be of use.

3.2 The Fiji Electricity Authority (FEA) was established by Act of Parliament in August 1966 as a Statutory Authority to promote and encourage the generation of energy to aid the economic development of the country. The Act required it also to advise Government on all matters relating to the generation, transmission, distribution and use of energy and to establish and operate such electrical installations as the Authority might deem it expedient to establish To show the increase in demand, - at the time of its establishment, the Authority's installations were limited to two Government owned suppliers at Lautoka on the main island of Viti Levu, and Levuka on the island of Ovalau, and to the power supply at Nadi International Airport on Viti Levu. Total consumers numbered 2,500. Since then the FEA has taken over and expanded a number of electricity supplies, including the Suva City supply. At the end of 1981, the Authority owned and operated a total of all power supplies with an installed capacity totalling 85 MW and a firm capacity of 44 MW. The total number of consumers at the end of 1981 was 42,244. During 1981, it sold 206 GWh of electricity, with a maximum demand of about 40MW.

4. POTENTIAL HYDRO POWER

4.1 Both topography and climate have important effects on hydro resources available. The climate here has distinct wet and dry zones, and the rainfall pattern can vary quite quickly over a catchment of between adjacent catchments. As well, there is a pronounced pattern of dry and wet seasons each lasting about half the year. There is also a great difference between wet and dry flows in most long term hydrographs, and this is particularly so in the smaller streams in the mountains where much of the hydro potential is located. The result of all this is wide fluctuations in flow unless storage is available, and this is quite unlikely in our mini hydro sites. Low flows can be up to one tenth of mean flows, and can range from .001-.01m^3/sec/km^2.

4.2 Topography is often steep and rugged, and one expects to find useful sites. However, there are difficulties, and not very many good sites. In the case of the 80MW station being completed this year in Viti Levu we are fortunate to have a high central plateau ending in a vertical escarpment. Not only does this provide good head, for a reasonably sized flow, but the plateau is flat enough for a dam to provide adequate seasonal storage. On the other hand particularly in Vanua Levu the mountain ranges are the steep razor backed type, so that usually when catchments have reached the size to carry useful flows, there is little head available. Another factor from the geological origin is that there can be permeable strata in the formations, or stress or temperature cracking. Many of the rocks too, decompose or weather to red clays in the local climates. They are very sensitive to moisture, and difficult to work in any sort of wet conditions. It is the case too, that there is little fine material in sand sizes, causing problems in getting these materials at low costs, not only for dam construction but also in road and other construction. Sites are often located in isolated areas, with high access and transmission line costs. For mini-hydro there appears to be no sites with storage. Also many streams drop quickly so little head is available when the flow is adequate for mini hydro the reference to clays applies mainly to pipe line routes along the side of a valley to gain head.

4.3 The end result is that while much of Fiji has high rainfall and is steep high country; there can be serious deficiencies in low flows. For mini hydro, particularly, storage is unlikely, and 'firm' output is usually quite low, compared to 'average' output.

4.4 Fiji has capable organisations dealing with meteorology and with hydrology. A few recording stations have records going back many years, and there are now quite a number of stations. However, it is often the case they are not close to a catchment under investigation. There have been studies in various investigations of assessing run-off from rainfall and evapotranspiration and also of extending records from a relevant station by seeking a correlation with a distant station with a long record. Results have often been uncertain, probably mainly due to the factors mentioned earlier of variable rainfall patterns in steep and broken topography and due to small and concentrated storms moving in a random fashion. Runoff and catchment losses can also vary from that expected from rainfall figures. Some dry flow studies over small catchments in one part of the country showed quite wide and surprising variations in results, may be due to different losses and different ground water storage conditions in catchments of volcanic background. It would be sound practice to check dry weather flows over several years, probably with a V-notch before installing a mini hydro set.

5. INVESTIGATIONS

5.1 In Fiji, while we have some problems with deciding on design flows, we are well off for information for identifying likely sites. The country has a good series of 1:50,000 maps with 100 feet contours. While not close enough to clearly identify sites, they do serve to fix catchment boundaries, and also steep grades in creeks as a first step. We also have an excellent series of aerial photographs produced by New Zealand Aerial Mapping in 1978. As well as showing topographic features these show villages (allowing an estimate of size) access tracks, possible signs of instability in the country, and also land use such as cultivation in a power house or pipe line site, or logging in a catchment. A recent census of Fiji gives information in village sizes and occupancy.

5.2 Desk studies using map and aerial photos are the first step in identifying possible useful sites. In many areas creeks drop quickly so that by the time the catchment is of a useful size, there is little head left to be developed. A potential supply has to be linked fairly closely to a village, and this also limits the useful sites. Some desk studies and information on costs indicate that below about 20kW costs become uneconomic and this requires a load from a large village or a group.

5.3 Engineering costs can easily get out of hand with mini hydro. We have taken the next stage after desk studies as ground reconnaissance using an aneroid for heights, and an enlargement of an aerial photo, to mark in details, as a record. Some sites are accessible (within a few kilometres) by road, for others a helicopter is necessary. This hopefully identifies likely layouts, and the next stage is cutting lines, and a survey of intake - silt traps - pipe line - power house route to fix levels (the aneroid often gives doubtful results) and distances. Some study of foundations is needed, but structures are usually small (or the scheme is uneconomic). The main foundation problems are likely to be with benches for pipelines. Flood levels at the intake and also the power house are needed, and an indication is usually given by vegetation levels. Signs of the creek carrying silt, (or large rocks in flood) or other debris are noted. Logging in the catchment can result in a considerable silt and timber load. To keep costs down, much of the line survey can be plotted on the aerial photo enlargements.

6. DEMAND

6.1 We do not yet have enough information in demand. With the Public Works Department rural electrification, each home usually has 1 20W fluorescent tube, and a plug. The plug appears to be used only for an iron, there apparently being few other appliances in villages. Thus a village of about 25 dwellings is supplied by a diesel set of 7.5 KVA running for about 3 hours each evening. Study is needed on whether a hydro set of say 80 kW would create increased demand, or whether industry such as saw-milling, or crop processing would be set up.

6.2 We need a study on the level of reliability required, linked with reliability of water supply for stated periods. For lighting loads alone, cuts for a week or so a year could be acceptable. If the load includes industrial use such as a saw mill or refrigerators, or commercial use, or in the health centre, greater reliability is needed. In some cases use of a standby diesel may be justified to carry the essential part of the load.

7. ECONOMICS

7.1 As with demand, more work is required on the economics of mini hydro, not only on the cost of an installation, but on how the costs should be met. The supply of power to remote areas might be regarded as a social cost, as is the provision of roading, schools and health centres to these areas. The degree of support, of course, is for Government to decide. There is a good deal of aid provided to Fiji by various countries and organisations, and electricity supply can feature in this. The amount of aid can have great effects on the viability of a scheme. With aid, it is necessary to be clear whether it includes the whole scheme or the turbine/generator or engineering alone. The pipe line costs and/or distribution home wiring costs alone can be substantial, in villages with little cash available. With aid, too, Government select schemes from a range of proposals, of which hydro is only one, so selection means some other scheme is not carried out.

7.2 In the smaller sizes of hydro say below 20kW, the costs per kW go up rapidly. A 4kW Pelton wheel/generator costs about $10,000 landed in Fiji; while costs of installation, pipe line, distribution will increase this several times. For a small set, the cost of the intake, clearing for a pipe line and power house, engineering and investigations remain more or less constant over a range of sizes, while the cost of the pipe line, desilting arrangement and building for the set, do not go down pro rata with the output. This, for the first sets we propose to limit the supply to large villages or group, with a demand of 20kW or more.

7.3 Investigations should also consider the alternative of supply from the existing system. It seems that by the use of SWER (Single Wire Earth Return) systems, and careful design for economy, that linking of the main hydro system should also be considered, when the length of line connecting is up to 10km.

7.4 We are interested in work by a Chinese organisation in producing a range of standard turbine/generators which is claimed to substantially reduce costs of this equipment. Pipe lines often cost more than machine, and we need more information on the relative merits of plastic, asbestos-cement and steel at various sizes and heads.

8. REVIEW OF INVESTIGATIONS

A good deal of work so far has resulted in some likely sites being eliminated and others shown to be promising.

A. A low head scheme. The village was within 6km of an existing distribution line, and the set would have been too small anyway. Eliminated.

B. An area in the northeast. This was looked at in the dry season. Flows were far too small for any development. Eliminated.

C. Several villages along a sizeable river were looked at. Demand would be fairly low, these appeared little head available, and the river was subject to very high floods. Eliminated for the time being.

D. A scheme to supply several villages, and possibly commercial and service centres up to about 100KW. This has been investigated under aid for several years. It is technically sound, but expensive. With aid it is likely to be built in the next year or two.

E. A reconnaissance of two sites in rugged country near several villages. Both of these, from catchment area and head should produce 50–120kW, but a considerable length of distribution line will be required. These and a further similar site are worth further investigation. The next step will be a helicopter reconnaissance of areas not reached on foot, and then line cutting and survey.

9. SUMMARY

Fiji has potential for mini hydro and has facilities for identification and investigation. Costs are likely to be high. Further investigation is needed of demand and development of future electrical loads.