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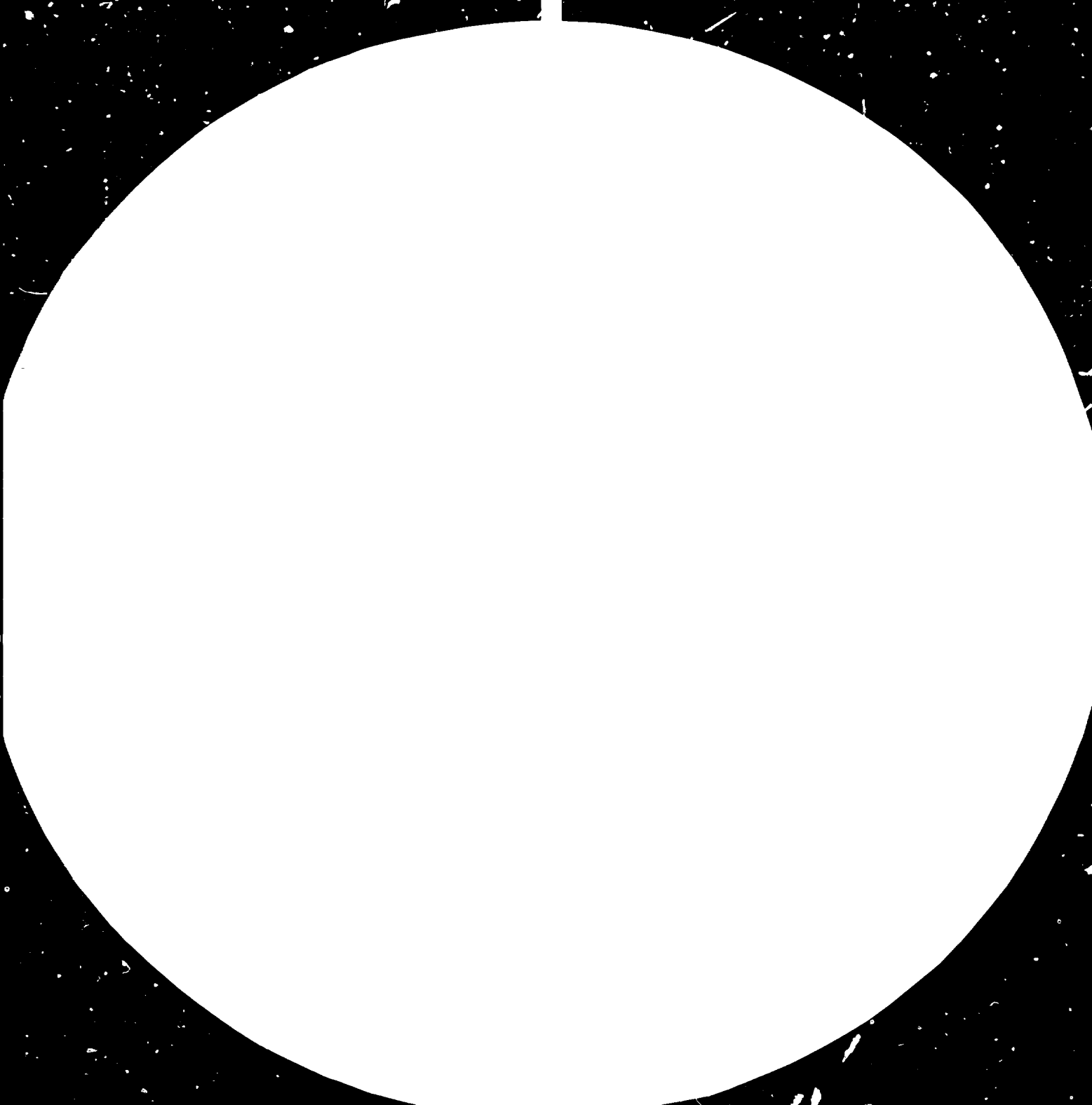

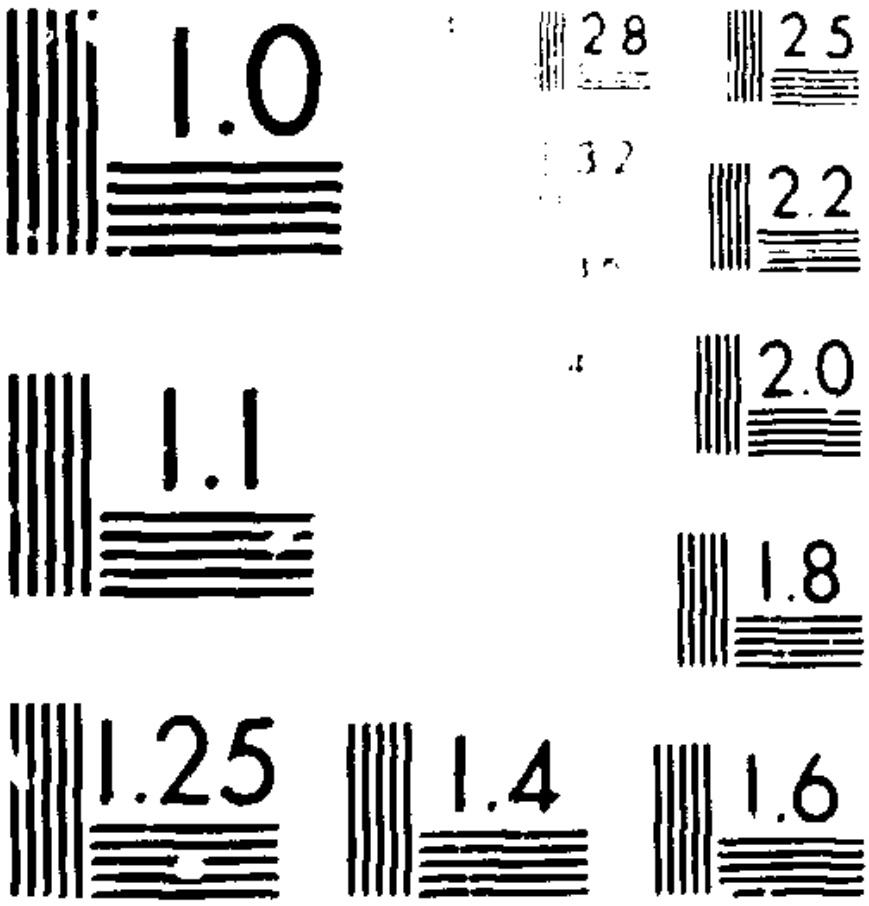
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MEDIUM AND SMALL-SCALE HYDRO POWER PLANTS IN ETHIOPIA*

by

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INTRODUCTION

Ethiopia is situated in the Eastern part of Africa between 4° and 18° North Latitude and 33° and 48° East Longitude. The country has an area of about 1.27 million square kilometers and a population of 30 million.

GEOGRAPHY & CLIMATE

Ethiopia is an equatorial country. The climate however, is markelly different from an equatorial climate. This is influenced by the altitude which varies between zero and 4500 meters above sea level. The climate is mild with temperatures 4°-24°C for the most part of the country (the Dega) and 25°-45°C in the low lands (the Kolla) and along the coast.

In general there are only two seasons in Ethiopia. The rainy season and the dry season. The rainy season for the most part is from the middle of June to the middle of September. The dry season extends from October to May with the "little rains" generally occuring between February and April. The annual rainfall varies between 200 m/m and 3000 m/m. With the exception of the western and southwestern regions 85% of the rain occurs during the wet season, June - September.

SOCIO-ECONOMY

Most of the people live on the highlands (the Dega) and the activities of the majority is agriculture. The country's economy is based on agriculture which accounts for 84% of the labour force. Industry accounts for only 16%.

HYDRO POWER POTENTIAL IN ETHIOPIA

There are several lakes and rivers in Ethiopia and the condition of topography is so convenient as a result of which the hydro power potential of the country is enormous. The energy potential of these rivers and lakes is estimated at 45 TWH (10^9) per year. Presently however, only 3% of the available power potential has been developed.

Note:- Dega means highlands and Kolla means lowlands

The estimated potential of the main rivers alone is as follows:-

River	Potential in Millions of KWH: Economically Utilisable	Gross	Tapped Potential
Abbai (Nile)	24 900.-	79,863.-	586
Awash	1,304.-	4,106.-	499
Mereb-Gash	560.-	1,735	-
Takaze-Setit	5,047.-	14,846.-	-
Baro	1,211.-	3,017.-	-
Omo	4,395.-	16,067.-	-
Wabi Shebelle	7,044.-	21,562.-	-
Biuba	654.-	2,273.-	
Total	45,324.-	143,469.-	1085

BACKGROUND INFORMATION ON THE ENERGY SECTOR

Electricity in Ethiopia is in the main provided by the Ethiopian Electric Light and Power Authority (EELPA), a Statutory Corporation wholly owned by the Ethiopian Government. EELPA was set up by Charter in 1956 for the purpose of generating and distributing electric power for sale to the Ethiopian Public.

The nationalization of privately owned electricity supply undertakings that were operating in the Eritrea Administrative Region on February 2, 1975 has extended the responsibility of EELPA to cover the length and breadth of Ethiopia.

Institutional changes made by Provisional Military Administration Council to consolidate public utilities under the relevant Ministries has also incorporated EELPA under the Ministry of Mines, Energy and Water Resources with EELPA still retaining its autonomy.

EELPA has grown considerably since the time of its establishment in 1956, but it has still a long way to go before it achieves its ultimate desirable goal of making electricity available to all urban and rural communities in Ethiopia.

PRESENT STATUS

Present EELPA operations can be divided into two main parts. The first and the most important part is known as the Inter-connected System (ICS). This consists of the large generation plants which serve the major load areas of the towns of Addis Ababa, Nazareth, Dire Dawa and Harar using a high voltage transmission grid. The installed capacity of the ICS is 225.3 MW of which nearly 95% is hydroelectric.

Present trends of load growth in the ICS is such that there will be a requirement for additional energy and generating capacity in the next 2-3 years. In order to meet this requirement preparations are underway for the implementation of Malka Wakana Hydroelectric Project and the Amarti River diversion scheme. The Malka Wakana capacity is 152 MW and the Amarti Diversion shall have additional production of 170 GWH annually in the ICS.

The second and presently the most expensive part of EELPA's operations is known as the Self Contained System (SCS). The SCS consists of several, local and isolated service areas which are widely distributed arround the country. At present, these service areas number about 45 and have an aggregate installed capacity of 77.765 MW 90% of which is diesel electric and the rest run-of-river type hydroelectric.

In the past few years EELPA has been incurring significant financial losses on the sale of high cost diesel generated power throughout the SCS.

SMALL HYDRO POWER DEVELOPMENT IN ETHIOPIA

GENERAL OBJECTIVE

In order to minimize dependency on expensive imported oil for the generation of electricity by means of oil fired diesel engines in the remote rural towns

and villages and to meet the energy supply needs of the rural population from abundent local resources the development of hydro-power sources has become increasingly important nowadays particularly in developing countries like Ethiopia.

The basic need for electrical energy in the rural areas of this country is for lighting and cooking. At present this energy requirement is being satisfied mostly by the energy obtained from fire wood at the expense of sacrificing the country's potenteal in wood supplies. Today responding to the country's growing need of wood poles for transmission lines and industrial timber has entailed yet another problem.

On the other hand most of the energy required for rural domestic life could also be developed from unconventional sources of energy like for instance Solar Plants, Gobar Plants etc. However, the level of technology in the areas of interest has not developed to such an extent as to make these alternatives readily applicable. At the national level, research studies are coming up and pilot plants on this field of projects have just been geared to the specific intent of adopting same for possible source of energy for every day life. A few government agencies are helping farmers associations in certain parts of the country in making practical uses of biogas plants. Nevertheless, these schemes are to be deployed in self help campaigns of the rural community and EEUPA has no direct role in this particular activity.

SPECIFIC OBJECTIVE

For the most part of the country, the rural areas consist of several villages with a populations of a few hundred people. Usually, the life of the community depends on the existance of a small river or a tributary in close proximity.

Although dry season flows of such rivers are very low head developments are normally good and compensating. This is a typical cross section of the rural areas which makes small hydro power a second to none alternative source of electrical energy for rural Ethiopia.

EXISTING SMALL AND MICRO HYDRO POWER PLANTS

Following is a list of some of the small and micro-hydro power plants owned by different enterprises.

Installation	Installed Capacity KW	OWNER	Remark
1. Ambo	170	EELPA	Almost all power stations are operating at present
2. Jimma	140	EELPA	
3. Woliso	150	EELPA	
4. Bedelle	120	PRIVATE	
5. Debre Berhan	90	EELPA	
6. Debre Marcos	184	EELPA	
7. Dembi Dollo	184	EELPA	
8. Debre Libanos	60	MONASTERY	
9. Jilbo (Ourso)	420	EELPA	
10. Sakisso/Adola	1500	MINING MINISTRY	

Some of these plants have been installed more than 25 years ago. The last micro hydro plant built by EELPA has been in operation for the last twelve years. Since then no micro hydroplant was built by EELPA.

Until the recent oil crisis these micro hydro plants were not favourably considered by EELPA because almost all of them are in operation only during the wet and semi wet seasons and require diesel compliment for the rest of the year.

The reason for this is that practically all of the plants are run of the river schemes with no pondage.

PRESENT PROGRAM

At present studies and preparations are underway to electrify the remote areas from isolated micro hydro stations by harnessing the waters of nearby small rivers. EELPA with its limited man power and resources has worked out a programme for its activities in the next two years on small hydro power development.

Ten small rivers have so far been identified for the purpose and after first reconnaissance and preliminary evaluations of both the projects and the load centres, priority ranking was established for feasibility studies and implimentation.

DIVISION OF RESPONSIBILITY

The Planning and Studies Department of EELPA conducts resource studies of these rivers upto the feasibility stage. The department depends on a team which consists of two Civil Engineers, one Electrical Engineer, one Geologist, two Surveyors and one assistant Hydrologist for the work.

Upon completion of feasibility studies the projects shall be transferred to the Engineering Department for implementation with recommendations on priority of development.

SMALL HYDRO POWER PROJECTS IN THE WESTERN REGIONS OF ETHIOPIA

According to the priority ranking and programme referred to earlier studies of five small rivers in the Western and Southwestern regions of the country are to be carried out between 1980 and 1982.

Of these at least three projects shall have their feasibility studies completed and the rest are to be advanced to the maximum possible level of study.

River characteristics, power potentials and the energy expected to be harnessed from these projects are the following:-

Name of River	Catchment Area km^2	Mean Annual Flow 10^6 m^3	Specific Runoff $lt/sec/km^2$	Annual Energy Potential in 10^6 KWH		Firm Power Capacity in KW	
				1st Stage	2nd Stage	1st Stage	2nd Stage
Hoha (Asosa)	175	53.9	10.6	4.61	10.8	300	1500
Dilla (Nejo)	330	198.5	19.4	3.56	26.6	300	1000
Kudger (Mendi)	400	215.1	17.1	3.56	28.8	300	1000
Ketto (D. Dollo)	960	400.0	12.7	22.25	71.4	1500	5000
Sor (Mettu)	2030	2020.0	31.6	114.96	669.6	2500	20000

Note:-

1st Stage Development means run-of-river scheme

The capacities to be installed vary according to the load centres, population density, growth rates, economic activities of the people in the area etc.

WHY THE WESTERN REGIONS

These rivers of the western regions were gives priority primarily because:-

1. According to present national plans of action the prospects of small scale industry of the area is very high. This includes for example Irrigated Agricultural Project in the valleys including processing plants and gold and other minerals mines.

2. Most of the rivers in these areas have perennial flows which provide less constraints on water requirements during the dry season.

HYDRO METEOROLOGY

The western regions of Ethiopia have a marked difference in climate from the rest of the country. The annual temperature does not vary much (14-26°C) with slightly higher ranges from December to April. The rainfall pattern is also different. The rainy season here starts in the middle of April and extends to the middle of December. The dry to wet monthe ratio here is 4:8 as against 8:4 in most other parts. The annual rainfall varies from a minimum of 1200 mm to over 3000 mm.

Consequently, most rivers in these regions have continuous flows throughout the year. Comparison on seasonal trends of runoffs shows less extremity than in other places.

TYPE OF DEVELOPMENT

Most of the identified rivers shall be run-of-the-river schemes at least in their first stage development. The main reason is to reduce initial cost. The significant structures consist of diversion weirs, 1-5 km of

headrace channel terminated by a head pond, steel penstock and the power house. Second stage development shall include primarily an impounding dam in order to improve the installed capacity.

PRESENT STAGE OF WORK

So far the following items have been carried out:-

- Collection of relevant hydro-meteorological data
- Reconnaissance trips to project sites in order to determine the locations of the various structures.
- Preliminary survey, for head development etc.
- Discharge measurements to check minimum flows where these are not available and correlation is required
- Water resource analysis (on two rivers only). This includes determination of long term average flow, annual flow, flood flow etc.
- Survey of construction materials on project sites.
- Preparation of topographic maps using both EELPA's Surveyors as well as engaging a Mapping Institution.
- Assessment of Expected Power Output etc.

FOLLOWING STAGE OF WORK

The following stage of work consists of mainly geotechnical investigations, design, cost estimate and technical and economic analysis.

Civil works construction is intended to be carried out by engaging local contractors and also deploying the Authority's"Own Force Construction." Most of the construction materials are available in the area. The design of structures shall also take these factors into consideration in order to minimize the cost. The present programme of development relies on the importation of major electro mechanical components like turbines and generators.

CONSTRAINTS

Major constraints regarding intensified studies of small hydro-power projects are related to:-

- The lack of trained marpower in sizeable number.
- Basic data on hydro-meteorology, topograhic maps etc. have to be supplemented in order to advance concrete recommendations on the studies of small hydro power schemes. These are not readily available because country wide coverage of these data has yet to go a long way
- The lack of certain special equipments and facilities associated with the job like for instance, survey and mapping equipments, drilling equipments, heavy-duty vehicles appropriate for the country's difficult terrain flying facilities (eg. helicopter) for reconnaissance of inaccessible areas etc.

UNDP assistance which is scheduled to materialize in early 1981 is expected to alleviate the above constrairts substantially. The arrangement of study tour seminars like this one is also believed to be one of the most effective ways of improving the problems related to manpower training and skill upgrading in the developing countries.

CONCLUSION

Soliciting the problem of rural electrification the construction of MGH plants in Ethiopia has no other economical alternative. The problem at hand is on how to intensify the programme

In view of the vastness of this scope of work, the concentration on small hydro projects entails the development of manpower in sufficient quantity. To date there is no specific programme worked out for the training of such personnel.

On the other hand, the capability of locally producing certain major electro mechanical components, not only reduces the capital cost but also helps in the timing of project commissioning. The technology required to develop this capacity and capability is not however, available in this country.

UNDP assistance and cooperation in the transfer of technology to secure locally the capacity and capabilities of manufacturing components like water turbines and generators for small scale hydro plants would be extremily beneficial and is expected.

Finally this paper wishes to remind all concerned that in order to intensify the implementation of small hydro plants in the developing countries, simplification in the mechanisms of water turbines, governors generators etc. as well as in the design approaches and procedures plays a very important role. It is hoped that this statement will be sufficiently demonstrated by this study seminar and most of us will no doubt benefit from the experience.