HYDROPOWER OF ETHIOPIA: Status, Potential and Prospects

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1. Introduction

The Ethiopian government has for long recognized that economic progress will depend principally on the development of the hydropower resources of the country.

Ethiopia is endowed with abundant water resources distributed in many parts of the country however, it has not made significant progress in the field of water resources development during the past four decades. In particular, the exploitation of hydropower potentials was not noticeably successful in spite of being given priority as a major field of national development

Considering the substantial hydropower resources, Ethiopia has one of the lowest levels of per capita electrical consumption in the world. Out of hydropower potential of about 15,000-30,000 MW, only about 360 MW (i.e. less than 2 percent) has been exploited by 1997 (Table 1).

The total production of the above mentioned hydropower plants is 1,469.0 GWh/yr. (1994-1995).

Table 1. Hydropower Plants and Installed Capacity

Plant	System	Installed Capacity MW	Guaranteed Capacity MW	Energy Generation in GWH/year	Year of Commission
Finchaa HPP	ICS	100	100	616	1973
MelkaWakena HPP	ICS	153	148	434	1988
AwashII HPP	ICS	32	26	135	1966
AwashLII HPP	ICS	32	32	135	1974
Koka HPP	LCS	43.2	25	70	1960
TisAbbay I HPP	ICS	11.4	3.8	27	1964
Total ICS		**371.6**	**334.8**	**1,417**	
Yadot HPD	SCS	0.35	0.3,5	1.2	1990
Sor HPP	SCS	5	5	48	1990
Dembi HPP	SCS	0.8	0.8	2.8	1991
Total SCS		**6.15**	**6.15**	**52**	
Grand Total		**377.75**	**340.95**	**1,469**	

Presently, more than 90% of energy consumed in the country is derived from biomass fuels and is almost entirely used for cooking. The use of these fuels has resulted in massive deforestation and soil erosion.

The population of Ethiopia was estimated in 1995 at 57 million and is thought to be growing at an annual rate of about 3.1%.

In recent years, since the country has merged from the drought and civil war of the 1980's and since the implementation of a comprehensive program of economic reform, the economy has recuperated and is now growing.

Such economic growth is essential to lift the people from severe poverty but can only be sustained by adequate infrastructures and in particular adequate supplies of electrical energy.

The expected continued economic growth (in an environment of power shortage that had recently resulted in rationing) coupled with the rapid expansion of the transmission grid, will increase the number of consumers and thus the total energy demand in the next few years. This condition should evidently lead to an energy development program for accelerating the development process notably in the undertaking of studies and preparation of detailed engineering designs of hydropower projects that could be implemented within the shortest possible time.

The major electric power planning and market survey study conducted so far had forecasted power and energy demand and supply to the year 2040. A 1993 forecast predicted the possibility of both power and energy shortages being very acute starting from 1995.

The existing power generation in Ethiopia and the projected energy requirements from the .year 1990 through 2040 indicate and prove that the power generation needs to be increased by 4 times by the year 2000, more than 14 times by 2020 and about 25 times by 2040.

To overcome the deficiency in electric power supply, in Ethiopia, special attention has, recently, been given by the government to Medium Scale Hydropower Development (MSHD) in the range of 40 MW to 60 MW capacities, (rather than Large Scale Hydropower Development Schemes). Experience has shown that the latter require huge investment, lengthy processes for securing finances as well as longer construction periods which might consequently not meet and fulfill the targeted demands for electricity in the different regions of the country within the shortest possible time. With this set goal, for surmounting the acute shortage in hydroelectric energy in Ethiopia, the government has given priority to the development of a number of favorably and fairly distributed hydropower resources.

The rapid development of these schemes will definitely promote and speed up National and Regional developments at different and strategic river basins which is one of the government's program for harnessing the immense water resources potential of the major river basins of Ethiopia.

Under the Ethiopian Government's Emergency Program, following the detailed reconnaissance studies, hydropower potential sites within Tekeze, Gojeb and Abbay River Basin had been identified and accordingly the selected sites, one in each basin, are now being looked into in detail in order to clear ground for effective implementation. The hydroelectric potential of Ethiopia is very considerable and is presented in Table 2.

Table 2 Hydropower Potential of Ethiopia

Name of River Basin	**Number of Potential Sites**					
	Small Scale 40 MW	**Medium Scale 40-60 MW**	**Large Scale > 60 MW**	**Total**	**Technical Hydropower Potential (GWh/year)**	**Percentage Share of the Total %**
Abbay	74	11	44	129	78,800	48.9
Rift Valley Lakes	7	-	1	8	800	0.5
Awas	33	2	-	35	4,500	2.8
Omo – Gibe	4	-	16	20	35,000	22.7
Genale – Dawa	18	4	9	31	9,300	5.8
Wabi Shebelle	9	4	3	16	5,400	3.4
Baro Akabo	17	3	21	41	18,900	11.7
Tekeze – Angereb	11	1	8	20	6,000	4.2
Total	**173**	**25**	**100**	**300**	**159,300**	

2. Hydropower Development in Ethiopia

The agency responsible for electric power in Ethiopia is the Ethiopian Electric Light and Power Authority (EELPA and recently renamed EEPCO). This Authority is responsible for the investigation, development and subsequent construction of power generation schemes. It is also responsible for the transmission and distribution of electrical energy.

At present EELPA distributes electrical power to 365 towns, which represent 92% of the total energy produced. The remaining small power generation facilities are installed by the previous Rural Infrastructure Development Department of the Ministry of Agriculture (MOA)

The EELPA presently operates two systems, the interconnected (ICS) and the self-contained system *(SCS)* The ICS has an Installed capacity of 360 MW with six hydropower stations arid two-diesel stations formerly contributing 6.5 MW which are now retired. The total energy output capacity of the ICS is about 1600 GWH/year. The ICS now supplies demand centers within an approximate radius of 400 kilometers around Addis Ababa.

Supply in the SCS is dominated by diesel generators although there are some small hydropower stations dispersed here and there. The current generating capacity of the *SCS* is about 30 MW and the load centers served are dispersed mostly in the border power schemes were commissioned in Ethiopia is shown in Table 3. The schemes presented in the table were commissioned during the last 50 years

Ever since hydropower development started in Ethiopia, a total of 366.2 MW capacity in the ICS and 16.5 MW (Tis Abay and Sor) in the SCS had been installed. Besides small stations such as Dembi, Yadot and Chemoga have also been in operation.

The Aba Samuel plant has been inoperative since 1970. In addition three small hydropower stations around Jimma, Debre Birhan and Dire Dawa were abandoned due to old age at various points of time.

The present installed and dependable capacity in the ICS is 360.2 MW and 351.5 MW respectively, while the average energy production is 1614.1 GWH/year with a firm energy capability of 1607.5 Gwh/year. Two diesel-generating stations in the ICS at Alemaya and Dire Dawa with a total installed capacity of 6.5 MW are still operational.

Though efforts are presently directed towards the development of medium scale hydropower plants in response to a policy decision that electrical capacity deficit would best be addressed by concentrating initially on medium projects, the Gilgel Gibe (180 MW capacity) projects construction program which has long been delayed has now come into the picture. The tunneling works are presently out for tender whilst the major components of the project works are awaiting the outcome of the pre qualification of potential contractors.

3. Projects Identified for Power Development

3.1 The Hydropower Potential of Ethiopia

Ethiopia has a vast hydropower potential, which is estimated to be about 15,000 - 30,000 MW. So far very little percentage (less than 2%) of the vast potential has been harnessed. In order to develop this vast potential of power several projects have been initiated to generate more and more hydroelectric power.

Some 300 hydropower plant sites in the whole eight river basins of the country with a total technical power potential of 159,300 Gwh/year have been identified. Out of these potential sites, 102 are large scale (more than 60 MW) and the rest are small (less than 40 MW) and medium scale (40-60 MW) hydropower plant sites (See Table 1.2).

3.1.1 Large Scale Hydropower Projects

The favorable sites for Large Scale Hydropower Development Scheme within nver basins of Ethiopia number 102 and are fairly distributed throughout the width and breadth of the country. As the development of these schemes requires huge investment, they are not in the priority list by the government. Nevertheless, projects like

Gilgel Gibe (180 MW) hydropower projects are presently under construction, and it is assumed, when commissioned, would alleviate the current critical power shortage to a certain degree.

3.1.2 Medium Scale Hydropower Projects

The promising and candidate sites for the development of Medium Scale Hydropower Development number 25. From these potential sites three in Tekeze, three in Gojeb and one in the Blue Nile Basin had been selected for studies.

Table 3 Development of Hydropower in Ethiopia

Name of Hydropower Scheme	**Year of Commissioning G.C.**	**Installed Capacity (MW)**	**Energy Production GWh/Year** **Energy**	
			Average	Firm
Aba Samuel*	1932	6	1.5	-
TisAbay	1953	11.5	68	55
Koka	1960	43.2	110	80
Awash II	1966	32	165	120
Awash III	1971	32	165	120
Fincha	1973	100	617	613
Melka Wakena	1989	153	560	440
Sor	1990	5	60	48
Smaller Stations		1.15	5	4
			1,705	1480

* Inoperative since 1970.

In 1995 a reconnaissance level study on the hydropower potential of the rivers Tekeze and Gojeb were carried out for the selected sites in each basin. The study evaluated the three schemes in response to a policy decision that the electrical capacity deficit would best be addressed by concentrating initially on medium scale projects. In the study, the three schemes were ranked according to the unit energy cost which in turn were based on estimate of construction and environmental costs and of the comparative value of the energy benefits. The report finally recommended that two sites in each basin be selected for further studies.

Presently, following the outcome of the pre-feasibility and feasibility reports conducted in September 1996; detail designs are being conducted for one best-recommended site in each river basin.

The Tis Abbay II (67 MW) hydroelectric project was also studied to a reconnaissance level among other medium capacity hydroelectric projects which are considered for an urgent development, as a means to quickly solve the need for additional generation capacity in the interconnected power system. Tis Abbay II was identified by preliminary reconnaissance studies as the project to be developed as a first priority, due to its economic attractiveness, and to its short expected duration of construction.

The Tis Abbay II power plants take the advantage, as much as possible of the recently completed regalating Chara - Chara Weir which is capable to discharge around 110 m3/sec for the minimum operating level. This weir which is 2 to 3 meter high is used for establishing a permanent pond in which the water is taken for feeding the power plant through inlet channel.

And thus, Tis Abbay II project, because no darn is required to regulate flows or to provide the generating head, is likely to provide electrical energy at a lower unit cost than other potential schemes in the program. For this reason, and also because of its strategic location with respect to the northern electrification program, Tis Abbay II is likely to be the most attractive of all the schemes and the first to be constructed and commissioned.

Presently, the Tis Abbay II Project Construction works are out for tender and construction is expected to commence in November 1997.

3.1.3 Small Scale Hydropower Projects

The potential for small Scale Hydropower development are immense and amount to 173 in number. The development of these potentials needs also to be given special attention and encouraged along with the Medium Scale Hydropower Schemes especially in the rural areas of the country. Ways and means should, therefore, be sought and facilitated in harnessing small hydropower resources in Ethiopia even if it is not encompassed within the top priority lists. These are areas where private participation should be filly supported and encouraged in developing these untapped resources without any limitations.

3.2 Geothermal Power Potential

Many locations within in Ethiopia's Rift Valley may provide natural super heated steam may be obtained through drilling. The potential of this steam for generating thermal power has been recommended and proved to be attractive.

The geothermal potential of Ethiopia been estimated at about 4000 MW. This is said to be the highest potential for any country identified so far in Africa. The economic contribution that this resource might make to the energy economy of Ethiopia is expected to be great but needs to be studied and looked into in detail in a coordinated manner with other forms of energy.

4. Power Generation of Ethiopia

4.1 On Going Programs and Future Plans

4.1.1 Present Power Generation

Ethiopia has not made significant progress in the field of water resources development during the past four decades. In particular, the exploitation of hydropower potential was not noticeably successful.

The total existing installed power capacity (EELPA) is 417.75 MW, of which 377.75 MW is in hydropower plants and 40 MW in thermal plants (Table 1.1)

About 10% of the electric energy consumed in the entire country are generated by diesel fuel engines thus draining the meager foreign exchange of Ethiopia.

Table 4 On-going and Planned Hydropower Programs

Name of Project	**Proposed Years of Service**	**Energy (GWh/year)**		**Remarks**
		Average	**Firm**	
Gilgel Gibe	1997 - 2002	**864**	**670**	Under Construction
Chemoga Yeda	**1998 – 2015**	**3031**	**2526**	Pre-feasibility level
Upper Beles	1998- 2015	**1617**	**1100**	Advanced identification
Halel *I* Werabessa	1998 - 2015	**1475**	**1180**	Identification level
Aleltu	1998 - 2015	**3550**	**3484**	Pre-feasibility level
Tekeze	1998 – 2002		**981**	Design level
Gojeb	1998 – 2012		**364**	Works out for tender
Tis Abay II	**1998 - 1998**		**359**	
Total			**10,664**	

4.1.2 Future Plan For Hydropower Developments

The annual consumption of electricity in 1995. was 1670 Gwh, equivalent to 30 kwh/capita. The installed capacity is currently 417.75 MW (377.75 MW + 40MW) of which 90% is provided by hydropower. The present capacity deficit is estimated to be about 300 MW. This indicates that power generation needs to grow at an

annual rate of about 10% to reach an approximate target of around 1600 MW by the year 2000, an increase in capacity of some 600 MW, to sustain economic development and to fulfill the domestic needs of the Ethiopian people. Lists of on-going and future plan for hydropower development of Ethiopia through 1997-20 15 are presented in Table 4.

This program should be taken seriously because it is strongly contended that the country could face severe shortage of hydroelectric energy for many years to come. To transform this program into reality all the required supports should be provided to achieve tangible and practical results.

5. **Recommendations**

Hydroelectric power is the cheapest source of power whenever the natural resources are readily available. Ethiopia has plenty of favorable sites where hydroelectric power can be economically generated. The exploitation and development of these untapped hydropower resources of the country need careful planning (short and long term), proper timing, coordinated efforts among all relevant government bodies, technical assistance, and most of all financial resources in order to transform the hydropower potentials into reality.

The wealth of experiences gathered during the reconnaissance studies, pre-feasibility studies and feasibility studies of all the hydropower potential sites within Tekeze, Gojeb and Abbay River Basin would, no doubt, very much facilitate and benefit all concerned bojies and need to be recorded and documented for ease of reference in future use for projects coming in the pipe line. This is a very important aspect that needs to be given special attention.

As discussed above, the government has given priority to the development of Medium Scale Hydropower potentials in the range of 40-60 MW in view of the urgency to fulfill the shortage of energy presently encountered, observed and experienced in the country. Typically, schemes of this size are considered to be more rapidly and easily brought to fruition as they require only modest investment and are likely to be appropriate for setting in rural areas to serve a number of communities.

Nevertheless, since significant water resources are found in the rural areas, harnessing the power of falling water by means of small scale hydropower plants (less than 40 MW) as one way of providing affordable energy for the development of rural areas needs also to be looked into in detail along with the development of Medium Scale Hydropower Schemes and included in the top priority lists.

Any energy source that can ‘be viably implemented in rural setting would contribute to the attractiveness of rural areas. Electric power would encourage the establishment of government offices and associated services in the more remote areas, improve the quality of educational, health and other services and enable individual rural households to have access to amenities which were formerly restricted to urban areas. The source of energy would also encourage the establishment of agro-processing and cottage industries, which would contribute to employment opportunities in rural areas.

Small Scale Hydropower has also several advantages in common with large and medium hydropower schemes:

- It relies on a renewable, non-polluting, indigenous resource that can displace petroleum - based fuels.
- It can be integrated with irrigation and water supply projects to maximize the benefits.
- There exit well-proven technology, generally well beyond the research and development stage.
- However, there are other factors that have reduced the attractiveness of small-hydropower:
- The significant cost and sophistication of the turbo generating equipment have been a barrier.
- The involvement of government in the implementation of these schemes (generation, transmission, and distribution) has resulted in draining large resources for a relatively small contribution to the national electricity supply.
- The high costs and difficulties of central government agencies operating and maintaining plants in remote areas further discourage the development of these plants. Still, it is increasingly recognized that the development of small-scale hydropower schemes holds out more promise for contributing to rural

development than for significantly increasing a nation's indigenous energy generating capacity. Experience has proved that the success of small-scale hydropower entirely depends on active private sector involvement. A number of private companies in some countries have also proved and 'demonstrated their ability to cost effectively implement small-scale hydropower plants.

It is, therefore, recommended that the subject matter needs to be looked into in detail so as to allow private individuals to be free in generating and selling electric power generated by small scale hydropower plants if development of urban areas are to be upgraded to an acceptable standard.

There are also areas of critical nature to be tackled in order to strengthen and clear ground for conducting project studies in hydropower development. The rich experience gained from the Tekeze, Gojeb and Tis Abbay hydropower plants studies need to be built upon. The following are the major points that need to be properly treated and looked into in detail prior to any commencement of hydropower project studies:

- Availability of topographic maps of the project areas and dam sites to a scale of 1:50,000 and 1:500 respectively;
- Stream flow data of the catchment area;
- Metrological data (rainfall; wind speed, evaporation etc.);
- Sediment inflow rate;
- Accessibility of the project areas;
- Geological map of the sites;
- Availability of alternative forms of transport, such as helicopters etc.

Last but not least, the success of any project entirely depends on the structures and freedom of the Project Implementing Unit (PIU) to be established for running the day-to-day activity of the project works.

The PIU needs to be established as an autonomous body in nature so as to avoid any bureaucratic bottle necks for the smooth operations of the project works, If any hydropower scheme in Ethiopia is expected to successfully come into the picture, the PIU needs to be' restructured to fit all the requirements of an independent office.

A start has already been made to develop the hydropower potential in the country especially on large and medium scale hydropower plants. In line with this, the development of small-scale hydropower needs also to be looked into as it could make a substantial impact in the country where significant waterpower resources exist and where economically viable alternatives are few.

References

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