# HYDROELECTRIC POWER PRODUCTION AS AN APPROPRIATE PRIORITY FOR DRAINAGE BASIN ORGANIZATIONS

by

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## INTRODUCTION

The appropriateness of hydroelectric power development as a priority for basin organizations must be conceived against the background of three major factors:

(i) The primary objectives of the basin organizations

(ii) The role of energy and hence power in meeting those objectives

(iii) The comparative advantages and disadvantages hydropower over other sources of electricity.

## I. FIRST ORDER OBJECTIVE

The first order objective of basin organization is to develop the *in situ* natural resources within their jurisdictions so as to improve the well-being of the local population. This is done within the framework of national policy guidelines. Hydropower potential is one of the basic natural endowments which will receive attention primarily on the basis of the stated objectives. Other resources are, land, water, forests, vegetation, climate and human beings.

## II. HIGHER ORDER OBJECTIVES

Energy is essential for an integrated and a systematic development of the above mentioned natural endowments. It is required to achieve both first order and higher order objectives. In this role energy is a very critical input to, and base for, a number of socio-economic activities using other natural resources for development. Primarily energy would be needed to support irrigation, industrialization, mining, water supply and to sustain and improve social facilities. Clearly, an energy resource which can be tapped within a jurisdiction of a basin organization ranks high in the list of development priorities.

## III. COMPARATIVE ADVANTAGES AND DISADVANTAGES

How appropriate hydropower development is as a priority for basin organizations largely depends on the advantages it has relative to the alternative sources of energy which could be substituted for it. Electricity is the primary energy produced by hydropower plants. This type of energy is usually converted into heat, light, mechanical and sound energies depending on the end uses. However, electricity can be produced via a number of processes, such as burning hydrocarbon fuels, reacting fissile materials and utilizing wind and solar power. Due to technical, economic and environmental issues, fissile reactors as sources of energy are inappropriate not only for the basin organizations but also for most national economies in the developing world. For the bulk of applications for which electricity would be required, hydrocarbon fuels would be the most viable alternatives to hydropower within the jurisdictions of developing countries' basin organizations. The hydrocarbon fuels used for this purpose are gas, diesel, fuel oil, and coal. Of these only coal is not a product of crude oil. In essence, the appropriateness of hydropower as a source of energy appropriate for development within a basin organization's jurisdiction would largely depend on how it compares with gas, diesel, fuel oil and coal.

### Advantages

A number of characteristics make hydropower a preferred source of energy in a number of applications. These factors and their implications are reviewed below:

(a) Efficiency. Whereas conversion of hydrocarbons involves a loss of approximately two-thirds of the energy in the form of waste-heat, hydropower has an efficiency approaching 90%. Thus, on a unit energy output basis, hydropower may be three times cheaper than hydrocarbons.

(b) Renewability and cost sensitivity. Unlike hydrocarbons water is virtually free and renewable on a short term basis. This makes hydropower a renewable source of energy which is unlikely to be subject to escalating prices.

(c) Longevity. Hydroelectric power plants have double the operational life of coal-fired power plants and three times the life of diesel or gas-fired plants. For a basin organization which would depend largely on imported technologies for electric power generation this characteristic of hydropower stations would be favourable as it implies that the frequency of using scarce resources just for maintenance, would be reduced.

(d) Technical simplicity. This characteristic of hydropower stations contributes to relatively low operating and maintenance costs. This derives from the fact that relatively small amounts of foreign exchange and scarce resources otherwise needed for development, would be diverted to purchasing spare parts for operating and maintaining hydropower plants. Thus, it is ideal for the development context.

(e) Local resource. Hydropower is a local energy resource. However, in a majority of cases African basin organizations would depend on foreign sources of hydrocarbon fuels as their bases of supply. The above points imply that dependence on hydropower would both lead to saving foreign exchange and ensure a high degree of energy supply security.

(f) Flexibility of supply for peak demand. Hydropower is able to meet peak demand for electricity, because water behind the dams can be released to create an almost instantaneous surge of power. This is a common constraint for conventional thermal plants.

(g) Pollution. Environmental impact due to discharges of water, air and soil pollutants from hydropower plants is minimal. However, use of hydrocarbons would entail discharging gases, solids and heat which would subsequently affect the quality of water, air and soil as well as climate and vegetation.

(h) Multi-purpose facilities. Hydropower systems facilitate multi-purpose strategies. Hydropower is not only suitable for generating electricity but also offers a wide variety of applications in multi-purpose projects. It is a particularly good foundation for development in irrigated agriculture which does not depend entirely on flood waters.

It is noted here that in Kenya the Lake Basin Development Authority (LBDA) commissioned a feasibility study on the Sondu-Miriu River Multi-Purpose Project. The purpose was to facilitate decisions regarding taking advantage of the multi-purpose characteristic of hydropower systems[1]. The viability of even a medium-scale hydropower plant as a base for multi-purpose projects has been demonstrated in a number of developing countries. For example, in Argentina a hydropower system with a generating capacity of about 102 MW is providing irrigation facilities for more than 110,000 hectares of land[2]. Furthermore, the reservior also facilitates flood control, commercial fishing and opening of the surrounding forests for development[3].

Kiambere and Turkwell hydropower stations in Kenya, which are to be constructed within the jurisdictions of the Tana River Development Authority (TRDA) and Kerio Valley Development Authority (KVDA) are of the same capacity as stated above.[4] Also, installed capacity for the planned Rusumo hydropower station is close to this capacity.[5]

(i) Divisibility of hydropower technology. This technology is viable on a small scale. It enables the decentralization of electricity supply to rural areas from mini-hydropower stations. Thus, by utilizing mini-hydropower technology basin organizations can tap power from small (low-head) facilities to supply rural centres and small agro-activities. The major implication is that the consumers of small-scale hydropower facilities would be less dependent on national grid systems, or even completely independent. For a rural market, power from national grid systems is usually relatively expensive due to high costs for transmitting power for long distances and transforming it for small isolated markets.

Regarding viability and suitability of small scale hydro-power plants the European Economic Community Commission made the following remarks: "... Use of small scale hydropower is indispensable in some developing countries if they have to increase their electricity by any appreciable extent. Even waterfalls offering only a low head (five to ten meters) with small through-flow, could be used to produce electricity *in situ* on an economic basis for small industrial enterprises and villages..... the main issue is how to use them on a more systematic and commercial basis and develop small-scale planning at this level."[6]

As the foregoing remarks indicate, for developing countries, and for the basin organizations, the critical issue is not technical or comparative appropriateness, but is with respect to planning and policy.

It may be noted that the suitability and viability of small scale hydropower plants are by no means confined to developing countries. Fritz made the following remarks regarding their contribution to power supply in some industrialized countries:

> "In the 19th and early 20th centuries most of New England's commercial power came from small hydro facilities. Even now such installations are economically competitive and have been used for at least 15 years in France, Germany and Japan..."[7]

Regarding the actual exploitation of the small-scale hydropower potentials in the Third World, the People's Republic of China seems to be the only country which has intensively used her potentials. However, a number of countries have recognised the opportunities for hydropower.[8] According to Fritz,[9] 80,000 small-scale hydropower plants are operating in rural areas in China and they account for 25% of the total hydroelectric output in the country. Average capacity is about 42 KW, although most stations are less than 25 KW, with the smallest having a generating capacity of 0.4 KW.

Wind power and solar energy have generally been considered appropriate for providing low wattage power in basin areas as well as in rural areas. However, where available, hydropower would offer a better alternative. This is mainly because availability of wind and solar power depends on weather conditions. Utilization of these sources also depends heavily on costly imported technologies, with higher maintenance and operating costs.

<u>Disadvantages</u>

Exploitation of hydropower potentials can precipitate some problems. In some cases these problems have been used to fight installation of hydropower facilities in some industrialized countries. The problems are associated primarily with construction of dams for hydropower exploitation. These problems are categorized as environmental and socio-economic.

(a) Environmental problems. These result from controlling river water flow, including holding back the water. This leads to reduction or elimination of water usable for flood irrigation, to silting, limited release of soil-nutrient downstream and reduction of water levels in lakes and rivers to a degree which may affect the aquatic flora and fauna.

Environmental consequences of controlling and retaining river water are already evident in the Aswan Dam project in Egypt. The irrigation enlarged Egypt's cultivable areas by several thousand hectares, allowed two additional harvests, and made it possible to cultivate new types of crops. This was a result of fertile mud being deposited upstream of the dam, with about 100 million tons of mud lost to cultivable land downstream annually.[10]

In the case of the hydropower station to be built at the Turkwell Gorge on River Suan, Kenya, the concern over the possible environmental consequences has motivated a call for an environmental impact study to supplement the technical and economic studies which have been already done.[11] It is recognized by the Government of Kenya that a considerable degree of water diversion, as well as control of water flows and sediment, are necessary for maximization of hydroelectric power production. However, the Government of Kenya has also recognized that these measures would create problems for agricultural areas downstream which rely on flood irrigation, as well as the fishing activities in Lake Turkana. Thus, the Generation and Economic Study for the Turkwell dam project has strongly recommended that investigations be made in order to establish the existing environmental issues before beginning any major work at the dam site.

In the case of the Sondu-Miriu Multi-Purpose Project, the preliminary environmental impact analysis has been made. This task was done in response to increasing concern by the Government of Kenya over environmental impacts associated with major projects.[13]

(b) Socio-economic problems. Socio-economic problems associated with exploitation of hydropower arise primarily from the need to resettle the people displaced through the creation of reservoirs. According to Okidi,[14] concern over the displaced families and loss of agricultural land was the major basis for objection by Rwanda and Burundi of exploitation of the 129 MW hydropower potential at the Rusumo site, even though the Rusumo dam was considered central to the Rusumo agreement. Rwanda alone anticipated a displacement of 22,000 families and a loss of 17,300 hectares of land.[15] This reflects the extent to which human and land-use displacement can be major issues in exploitation of hydropower potentials.

(c) Other negative impacts. Other impacts of constructing reservoirs associated with hydropower exploitation are: displacement of wildlife, damaging natural vegetation, including forest, and creating habitats for malaria mosquitoes and bilharzia vectors (snails) thereby increasing health hazards.

(d) Negative impacts: Summary. The negative impacts are few in number and usually ignored in major technical and economic analyses. However, they can considerably affect the appropriateness of hydropower as source of energy, as well as the priorities attached to the development of hydropower by a basin organization. Strong consumer-oriented lobbyists and conservationists can delay hydropower projects too long to be worthwhile or they can stop them altogether. Concern by governments and awareness of the bulk of the population with respect to their rights under environmental statutes and regulations have been increasing. This would dictate that the issues of negative impact be addressed in an appropriate fashion in the developing countries.

(e) Negative impact is an appropriate planning issue. It is widely believed that the major problems associated with hydropower exploitation are not insurmountable.[16] Their solutions require appropriate and timely integrated planning and willingness to learn from experience. Fritz[17] quotes, as an example, a situation where this approach had been used in order to solve the problem of hydropower exploitation. In Guyana, the Government made a timely decision to appoint a Resettlement Committee as part of a large scale hydroelectric project on the Mazaruni River to ensure that:

"(i) Culture of people affected is respected;

(ii) People will have the choice of selecting resettlement areas;

(iii) Advantages accruing to displaced persons e.g. better housing, health and social facilities will far outweigh disadvantages;

(iv) Just compensation will be made for any loss incurred."

Electric power pricing, as well as fertilizer use and pricing policies, can be formulated and implemented within an integrated planning framework. These can be effective measures in addressing issues ensuing from losses of flood irrigation opportunities and soil nutrients due to control of water flow and sediment.

Electric power generated from upstream stations can be transmitted and distributed downstream. This may facilitate the establishment of those irrigation schemes targeted at farming activities affected by losses of flood irrigation water. Besides, the power generated may in some cases be used to produce fertilizers, to compensate their farmers affected by losses of soil nutrients.

In some cases the production of fertilizers will not be viable or comparative advantages will favour importation of fertilizer into the basin area. In such situations suitable procurement, distribution and supply practices and policies, as well as price structure, should be considered.

Certain factors must be considered for affected basin communities and activities to benefit fairly from these arrangements. The price structures for electric power and fertilizers must internalize relevant negative impacts in costing and in price determination. This requires deliberate policies to address those special needs resulting from the negative impacts. Very often the hydropower generation is tied to national grid systems and demands. System power transmission and distribution are usually performed by a national monopoly company, which, as in the case of Kenya, is protected by exclusive bye-laws. As a result the price structures and behaviour are often a reflection of national demand on the one hand, and the monopoly power and protections enjoyed by the national power companies on the other hand. Similarly situations may arise with respect to fertilizers. Procurement, distribution, storage and supply are commonly performed by state organizations. The prices are commonly subject to government interventions based on national considerations.

Thus basin planning must include policies which ensure availability of hydropower and fertilizers to the affected farming activities. These must be made available at prices which are sufficiently low, not because of subsidies, but because of the internalization of negative consequences arising from controls of water flow and sediment contents.

It is imperative to observe that whereas solving environmental problems associated with hydropower utilization is merely planning and policy "intensive" solving those associated with utilization of hydrocarbon fuels is both capital and technology intensive. The latter involves handling dangerous chemical waste products which must be converted and/or disposed of in a safe way. Solutions may require purchasing conversion facilities which depend on complex technologies and deployment of personnel trained in chemical processes and waste disposal techniques. Here again, to adhere to strict environmental regulations, high dependence on expensive foreign technologies and experts may be a necessity.

## IV. SUMMARY AND CONCLUSION

Energy is a critical input for integration and diversification of basin developments. Acquisition of energy therefore becomes a priority task. But energy must be acquired in an optimal manner. Because hydropower is a natural resource which can be readily tapped, it becomes an easy target for basin organizations. It is a resource which may immediately be exploited to fulfill the primary objective of improving the welfare of people in their jurisdictions. Thus development of hydropower potentials is a high priority task not only because it is a local energy source, but also because it has many advantages over its closest alternative sources of energy. Hydropower production is therefore an appropriate priority for basin organizations.

Notes

1. Republic of Kenya, Lake Basin Development Authority (LBDA). 1985. Sondu River Multi-Purpose Development Project, Vol. I-V.

2. Fritz, M. 1984. Future Energy Consumption of the Third World. p. 80.

3. Ibid, p. 81.

4. See Republic of Kenya (LBDA). 1985. Sondu River Multi-Purpose Development Project, Vol.II. Table 6.4.

5. Okidi, C.O. 1986. "Development of Environment in Kagera Basin Under the Rusumo Treaty". I.D.S. Discussion Paper No. 284. p. 42.

6. European Economic Community Commission. Statement on Cooperation with the Developing Countries in the Energy Field, EG-DoK Nr. R/2140/78 (ENER 52). pp. 52-53.

7. See Fritz, M. 1984. Future Energy Consumption of the Third World, p. 82.

8. Ibid. p. 81.

9. Ibid. p. 82.

10. Ibid.

11. See Government of Kenya. 1984. "Generation and Economic Study for the Turkwell Gorge Project", Draft Final Report, Vol. 1984, pp. 8.1 - 8.10.

12. Ibid.

13. See Republic of Kenya (LBDA). 1984. Sondu River Multi-Purpose Development Project, Vol. II, p. 33.

14. See Okidi, C.O. 1984. "Development of Environment in Kagera Basin Under the Rusumo Treaty", IDS Discussion Paper No. 284, p. 42.

15. *Ibid.*

16. Fritz, M. 1984. Future Energy Consumption of the Third World.

17. *Ibid.*