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CONSTRAINTS OF MICRO HYDROELECTRIC POWER PLANTS IN THE WEST REGION OF CAMEROON

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ABSTRACT

The objective of the present work is to study the constraints of Micro Hydroelectric Power Plants (MHPPs) installed in the West Region of Cameroon. The study was carried out between January 2005 and December 2008 and is related to water conveyance structures, production facilities; transportation and distribution networks, management and maintenance of the MHPPs. Data were collected using questionnaires, direct interviews and site observations and measurements. The main results show that the poor working condition on 60% of power plants is due to lack of previous survey before setting up the facility. Deteriorations and silting up of structures exist on all sites and result from their poor maintenance. Machine vibrations and bad weather also contribute to the deteriorations. On 50% of the sites, water conduits of diversion works consist of low pressure pipes which break down very often. On 80% of sites, power houses are single narrow rooms that house the machinery. On 80% of sites, the current produced is single phase and the power is lower than the demand of the population. On the transportation and distribution networks, electric conductors on 43% of sites are within reach of inhabitants. On 80% of sites, grounding and neutral wires do not exist or are poorly installed. For maintenance and repairs, problems exist on all sites because of the lack of spare parts, the lack of capable technicians and poor management of funds.

KEYWORDS: Constraints; craftsmen; funds; highlands; hydroelectric.

INTRODUCTION

Energy is an essential tool for the economic growth of a nation. Africa is the least equipped continent in the domain of energy; less than 5% of the inhabitants of countries in south of the Sahara have access to electricity (Sokon and Thomas, 1997). The economic crisis that rages in this region does not permit an improvement of energy with large hydroelectric power or thermal plants. Thus numerous rural areas are still without electricity, because of the remoteness and/or the high costs of connection to the national grid (Tagutchou *et al*., 2004). However in many of these regions, some rivers exist and have sufficient flow rates so that well designed water structures and electric equipments, followed by their implementation, could constitute interesting alternatives of electricity production from the MHPPs. Such experiences exist in numerous regions of Canada and Asia (Tondo, 2002). Cameroon possesses enormous hydroelectric potentialities (UNDP, 1993). This potential remains almost unexploited for the meantime. The technology of the MHPPs can favour the electrification of the farming zones where water-resources and topography conditions are favourable and improve the standard of living and work conditions of the populations and, thus facilitate real development. Furthermore the MHPPs can constitute a

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complementary network to the existing national network. Experiences with MHPPs in Cameroon started since 1944, unfortunately their evolution did not continue. Also no assessment survey has been carried out, and the understanding of their respective experiences needs to be taken into consideration when planning future projects on MHPPs development in the West Region of Cameroon. This is why the objective of the present study is to make up for this short coming. Specifically we intend to study the main problems linked to the planning of civil engineering works, generation facilities, transportation and distribution networks, management and maintenance of MHPPs in the West Region of Cameroon.

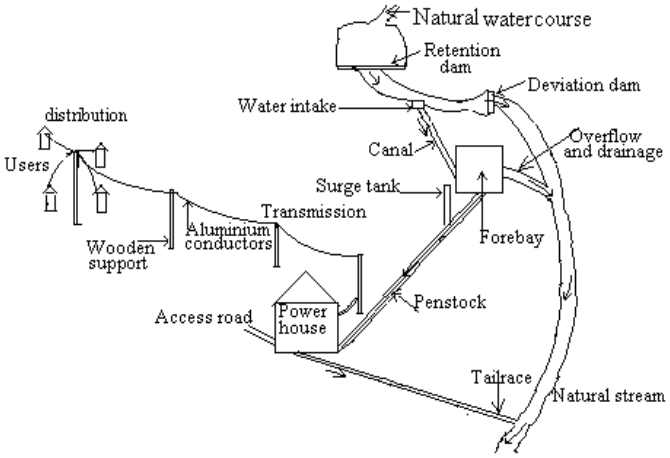
MATERIAL AND METHODS

1.1 Physical environment

The survey took place in Central Africa, in the mountainous zone of west Cameroon, having the following geographic coordinates: latitude 4°55' and 6°13' north; longitude 9°51' and 11°18 ' east. The altitude varies between 1200m (Bamoun plateau) and 2740m (Bamboutos Mount) with an average of 1500m (CEPMAE, 1976). The mountainous relief and the rainfall (1600 to 2000mm) are auspicious to hydroelectricity (Helvetas, 1981; Kuété *et al*., 1993). The population is about two million inhabitants with a yearly growth rate of 2.87% (NIS, 2001). The average density is 500 inhabitants /km^2 and may attain 600 inhabitants in some areas (Menoua and Mifi). The main economic activities are agriculture, rearing, livestock breeding some industrial units of transformation (soap factories and brewery) and the commercial exchanges with the other provinces.

1.2 Data collection.

The study was carried out from January 2005 to December 2008. During that period, the main problems of MHPP development structures were studied: dams, water intake, canals, forebays, penstocks, tailraces and power plants. Also, the main constraints linked to production, transmission and distribution of electric energy were studied (turbines, alternators, transformers, conductors, poles, safety devices and watt-meters). These works and facilities are shown on the general diagram of MHPP development in figure1. Furthermore, the main problems related to the management and to the maintenance of MHPPs were studied. The above data were collected on each site at least once a month, by using questionnaires, interviews and site observations. All people susceptible to provide reliable information were interrogated and all accessible documentations were exploited.



Source: compiled from Linsley and Franzini, 1972; Dandekar and Sharma, 1972; Lejeune and Topliceanu, 2004

Figure 1: General scheme of MHPP development structures

RESULTS AND DISCUSSIONS

2.1: Implantation dates of ten MHPPs in the West Region of Cameroon

The commissioning dates of ten MHPPs in the West Region of Cameroon are listed on the table 1 and show that the first MHPP was built in Dschang in 1944. The implementation of the pilot MHPP in Bamougoum village in 1997 by the World Bank with the involvement of the local craftsmen boosted the realizations of MHPPs in other villages (Adam and Associates, 1997).

Table 1: Sites and installation dates of MHPPs in the West Region of Cameroon

Sites of MHPPs	commissioning dates
Dschang	1944
Fonjumetaw	1988
Bamougoum	1997
Bapi	1998
Batotcha	2000
Bangang	2003
Mamarem	2004
Foto	2005
County I	2007
Belleh	2007

2.2: Main constraints of the MHPPs linked to development works in the West Region of Cameroon

The main constraints of the MHPPs are summarized in table 2. The poor functioning of the structures on 100% of the sites is related to poor maintenance, and poor design without feasibility study that lead to the system being abandoned. The broken conduits on 30% of sites (Bamougoum; Bapi; Batotcha) are due to the use of non-pressure PVC pipes. The silting up of water intakes on 20% of sites (Bamougoum; Dschang), results from the neglect of systems. One also notes the silting up of forebays on 30% of sites (Bamougoum; Bangang; Bapi); this is because of their small storage capacity and also because their watersheds are intensely exploited for agricultural activities. The power houses on 30% of sites (Bamougoum; Bapi; Batotcha) show deteriorations of floors, walls and metallic parts .This is probably due to internal humidity and vibrations of the machines. On 40% of sites (Bamougoum; Bapi; Batotcha; Mamarem), the power houses have narrow interior spaces hindering some activities. On the site of County I, water very often escapes from the air vent because of its short height and sudden variation of discharges from the turbine. Access to the power house by vehicle exists only on 20% of sites (Dschang; Fonjumetaw); this constitutes a major handicap in case of transportation of heavy materials.

For better functioning of MHPPs in the West Region of Cameroon, hydraulic structures should be sized according to the maximum flow to convey. The materials for their construction must be resistant. The design of the power station is function of machines and activities taking place. Factory must be constructed of durable local materials. Aeration and ventilation are provided through secured openings. The engine room must have a slope and a drain to evacuate water. Each MHPP must have a technician for the daily maintenance of the system. Access to the plant is important, but the topography may prevent, the road should be as near to the plant as possible.

Table 2: State of the development works of the MHPPs in the West Region of Cameroon.

Sites	State of hydraulic works									
	Retention dam	Deviation dam	Water intake	Canal	fore bay	Over flow	Pens tock	Air vent	Factory	Tailrace
Dschang	silt[1]	silt	rusty	+	negl[4]	-[2]	+[3]	+	+	silt
Fonjumetaw	-	+	silt	-	+	+	+	+	+	+
Bamougoum	-	silt	bro[5]	bro	negl	-	bro	+	nar[6]	silt
Bapi	-	bro	bro	bro	silt	-	bro	+	nar	silt
Batotcha	-	+	rusty	bro	+	-	bro	+	nar	silt
Bangang	-	+	+	-	silt	-	+	+	nar	silt
Mamarem	-	+	+	+	+	+	+	+	nar	silt
Foto	-	+	+	-	silt	+	+	+	nar	silt
County I	-	+	+	+	+	+	+	sh[7]	nar	silt
Belleh	-	+	+	+	+	+	+	+	nar	silt

1silt: silted up structure 2- : structure does not exist. 3 +: good structure 4 negl: neglected 5 bro: broken 6 nar: narrow 7sh: short

2.3 Main constraints linked to equipment, to maintenance and to management in the West Region of Cameroon.

2.3.1 Constraints linked to equipment. Equipment constraints exist on all sites and the main problems are given in table 3.

Table 3: Main constraints linked to equipment of the MHPPs in the West Region of Cameroon.

Sites	State of equipment on the Sites			
	Turbine alternator unit	Current conductors	Poles	Circuit breaker
Dschang	- power < needs	good	- concrete pole	exist
Fonjumetaw	- power < needs	good	- good	exist
Bamougoum	- power < needs - no synchronism	- clearance < 3m - stripped - section not uniform - no grounding wire	- wooden pole np[1] - depth < 1.2m -span › 45m	not exist
Bapi	- power < needs -no synchronism	- clearance < 3m - stripped - section not uniform	- wooden pole np - depth < 1.2m -span › 45m	not exist
Batotcha	- power< needs -no synchronism	-clearance < 3m -no grounding wire	- wooden pole np -depth < 1.2m -span › 45m	not exist
Bangang	- power< needs -no synchronism	-clearance < 3m -no grounding wire	- wooden pole np -depth < 1.2m	exist
Mamarem	-no synchronism	- clearance < 3m	- wooden pole np - depth < 1.2m	not exist
Foto	- power< needs -no synchronism	- clearance < 3m -no grounding wire	- wooden pole np - depth < 1.2m	exist
County I	good	good	- wooden pole np	exist
Belleh	good	good	- wooden pole np	exist

1 wooden pole np: wooden pole not protected

The main constraints of the MHPPs summarized in table 3 indicate that, on 70% of sites, power stations are equipped with inappropriate hydro turbine alternator units; the installed powers are low with respect to the population needs. Also, the coupling of the local manufactured turbines to the imported alternators is not well done; and the alternators are not functioning at the synchronised speed on 60% of sites (Bamougoum; Bapi; Batotcha; Bangang; Foto; Mamarem). This reduces the efficiency of the unit. There are no axle alignments and the rotating part protection is lacking, which enhances wear and may cause accidents. The transmission conductor sections are not uniform on the whole length on the sites of Bamougoum and Bapi. This non uniformity of sections hinders current passage. On 50% of sites, there is no grounding wire on the transmission and distribution lines and also on other electrical systems (Bamougoum, Bangang, Batotcha, Bapi, Foto). This situation is aggravated by the fact that the distribution networks don't have fuses or circuit breakers. According to AAVIM (1981), grounding makes an electrical system safer for users and prevents damage to equipment and to property. Because of lightning danger on the installations of electrical networks, Lamadieu (1977) recommends that the neutral should be connected to the grounding wire at the top posts every three hundred meters in areas like the west region of Cameroon where lightning occurs very often. The distribution network conductors not insulated in Dschang often cause accidents. In Bamougoum, Bapi, and Mamarem, the electrical wires overhang, cross or border the roads which are used by vehicles, have minimum clearance less than three meters and even touch the ground at some parts in the fields. At other parts conductors are stripped off; these conductors pass through for agricultural fields; all this constitutes a permanent danger for people and livestock and also contributes to default current. For poles, most of wooden poles have heights less than four metres; they are not protected and are not numbered on four sites (Bamougoum; Bapi; Fonjumetaw; Mamarem). This does not facilitate the mastery of the networks. The lack of top protection for the wooden pole such as zinc belts, zinc or rubber hats and slanted top (Bamougoum; Bapi; Mamarem), provokes their deterioration. Some of these poles fall because the planting depth is less than one metre, and there is erosion and other actions at the pole foundations. The meter pole which is a central distribution point to all dwellings exists only on the Dschang and Fonjumetaw sites. The other six sites have distribution networks that do not have meter pole (Bamougoum, Bapi, Belleh; County I; Foto; Mamarem), and a short circuit in one building can disrupt the whole system and even damage the generator in the power house. In addition to that, the detection of faults in the networks is difficult and this renders maintenance operations more complicated.

The likely solution to these problems is the training of the local craftsmen to the MHPP technology. They should be aware of the functioning of each component: deviation dam, water conveyance system, current production unit, and transmission systems; also the government and NGOs should facilitate the importation and installation of small turbine alternator units to familiarize local craftsmen to their technique.

2.3.2 Constraints linked to maintenance.

The main constraints linked to maintenance are given in table 4. Maintenance problems are due to the lack of the spare parts but especially because technicians are not paid regularly although there has been clear increase in the use of the current supplied by MHPPs in the villages. Mamarem, Belleh and County I are the sites where MHPPs operate in good conditions, probably because of their private management and especially because they were recently installed. The trained technicians will be in charge of maintenance of MHPP systems. Each beneficiary village will take care of its MHPP through the Development Committee. The transparent management of funds collected by the Development Committee can afford to pay the salaries of technicians and maintain the system in the normal conditions.

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Table 4: Main constraints linked to maintenance of the MHPPs in the West Region of Cameroon

Sites	Maintenance constraints		
	Presence of a technician	Stock of spare parts	Existence of appropriate tools
Dschang	yes	no	no
Fonjumetaw	yes	yes	yes
Bamougoum	no	no	no
Bapi	no	no	no
Batotcha	no	no	no
Bangang	yes	no	yes
Mamarem	yes	no	yes
Foto	no	no	no
County I	no	no	no
Belleh	no	no	no

2.3.3 Constraints linked to management.

The constraints linked to the management are indicated on table 5. They are present on almost all the sites, mainly on Bapi, Bamougoum, County I, and Belleh sites where the management organ is the development committee. On these sites, the beneficiaries do not contribute because of the non transparency on funds collected. Also there is the absence of a wattmeter to control energy consumption per house, and households consume more than their quarter in power (40W/households), and this leads to poor functioning of the networks at peak periods, resulting in the unhappiness of the beneficiaries. This situation is aggravated by the non respect of the contribution method fixed by the development committee (monthly payment of an amount equivalent to the cost of three litres of oil consumed by a household per month). On all the sites, the population is not informed on the use and the safety of electricity. This information can help them to be more implicated and to work properly on their MHPPs.

The problems here are technical and social and can be solved by good design and execution of MHPP by qualified technicians. Thus energy generated will be reliable and used by many households. The funds raised will remedy the salaries of technicians and the proper functioning of MHPP systems.

Table 5: Main constraints linked to management of the MHPPs in the West Region of Cameroon.

Sites	Management constraints			
	Management organ	Use of funds collected	Energy meter	Payment method
Dschang	AES SONEL	no transparency	yes	kWh
Fonjumetaw	Missionary group	-	no	no payment
Bamougoum	Development committee	no transparency	no	price of 3 litres of oil / month
Bapi	Development committee	no transparency	no	price of 3 litres of oil / month
Batotcha	individual	no transparency	no	no payment
Bangang	individual	no funds collected	no	no payment
Mamarem	individual	no funds collected	no	no payment
Foto	individual	no funds collected	no	no payment
County I	Development committee	no transparency	no	price of 3 litres of oil / month
Belleh	Development committee	under consideration	no	under consideration

CONCLUSION AND RECOMMENDATIONS:

At the end of the survey on the constraints of the Micro Hydroelectric Power Plants in the West Region of Cameroon, the main conclusions are as it follows:

The variations of constraints from one site to the other are related to the executions of the projects without feasibility studies, to the non-transparency management of funds collected from beneficiaries and to the lack of maintenance that leads to the deteriorations of the structures.

There is the need for the training of local craftsmen to the techniques of setting up and the manufacture of the MHPPs components. This can be supported by the government and/or other organisations in the West Region of Cameroon.

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REFERENCES

AAVIM (American Association for Vocational Instructional Material), 1981. Electrical Wiring, Residential, Utility Buildings and Service Areas. 2nd Edition. Engineering Center. Athens, Georgia 30602 USA. Pp34-69

Adam H. and Associates, 1997. Pico-hydro in Cameroon. On behalf of ESMAP, World Bank, Washington DC, USA. 8 South moor Rd, Oxford OX2 6RD, UK. Tel/fax 00865 55 27 96; Email adamharvey@compurserve.com, Pilot project Yaoundé. Cameroon. Pp35

CEPMAE (Centre d'édition et de production de Manuels et d'Auxiliaires de l'enseignement. Géographie du Cameroun), 1976. CEPMAE BP 808 Yaoundé République du Cameroun. pp264

Dandekar M. M. and Sharma, K.N., 1979. Water Power Engineering. Vikas Publishing House PVT LTD. New Delhi, Bombay, Bangalore, Calcutta, Kanpur. India. Pp185-388

Helvetas, 1981. Manuel technique pour l'Approvisionnement en Eau des Zones Rurales. Yaoundé/Zurich, édition française. Cameroon.183 pp

Kuété M., Menlingui A., Mounkam J., Nguoghia J.et Nofiele D., 1993. Nouvelle Géographie du Cameroun, édition EDICEF, 58, rue Jean Bleuzen, 92178, Vanves Cedex. France. Pp318

Lamadieu, 1977. Electrification Rurale. EIER Ouagadougou, Burkina Faso. 66pp

Lejeune A. and Topliceanu, 2004. Energie hydroélectrique et barrage. « Energies Renouvelables et Cogénération pour le Développement Durable en Afrique » p1-20. Ecole Nationale Supérieure Polytechnique, Université de Yaoundé I, Cameroun. 246pp

Linsley R.K. and Franzini J.B, 1972. Water-Resources Engineering 2nd edition. Mc Graw-Hill Book Company New York, USA. Pp191-467

NIS (National Institute of Statistics), 2001. Cameroon Statistical Yearbook 2000, Yaoundé, Cameroon. 637pp

Sokon Y. and Thomas J.P., 1997. Programme d'énergie d'enda-tm. 54 Rue Carnot, BP 3370 Dakar, Sénégal. 278pp

Tagutchou, Tanawa, Djeuda, Tchapanga and Ngnikam, 2004. Gasification of Biomass for Power supply in tropical humid areas: case study of Cameroon, Colloque International, EREC 2004 University de Yaoundé I; Cameroon. 246pp

Tondo B. L., 2002. Inventaire des sites hydroélectriques en République Centrafricaine, Séminaire Atelier, Université de Yaoundé I, République du Cameroun. 226pp

UNDP, 1993. Rapport sur le développement humain au Cameroun. Yaoundé, Cameroon. 91pp