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MICRO HYDROELECTRIC POWER PLANT DEVELOPMENT IN THE WEST REGION OF CAMEROON.

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ABSTRACT

The objective of the present work is to characterise the state of ten Micro Hydroelectric Power Plants (MHPPs) installed in the west region of Cameroon, in preparation for their modernization. The work was carried out between January 2006 and December 2008. Each site was visited at least once a month. During these visits, data related to the background and to the development structures of the MHPPs were collected by the use of questionnaires, direct interviews, site observations and measurements. The main results show that there are ten MHPPs in the west region of Cameroon. The first one was built in the town of Dschang in1944. Since the installation of the pilot MHPP in Bamougoum village in 1997 with the involvement of local craftsmen, the average increase speed is one MHPP per year. Also 60% of MHPPs are funded locally and 80% managed by development committees and individuals. On 100% of sites, annual mean discharges vary from 1.10 to 0.30 m^3. On 80 % of MHPPs gross heads are between 32 and 2 m. Civil engineering structures are built by local craftsmen using as much maximum local materials as possible. This is to minimize costs but they do not master very well the MHPP technology. This is often a source of malfunction. Thus funding of local craftsman training by the government or other agency can render that technology sustainable in the west region of Cameroon.

KEYWORDS: Problems, micro hydroelectric, funds, craftsmen, Cameroon

INTRODUCTION

Energy from Water streaming down the mountains has been exploited since antiquity to replace muscular effort (Bessac, 2000). The perfection of devices used results today in hydroelectric turbines, which produce about 14% of the electrical power generated in the world and represents only 16.6% of the world hydroelectricity potential (Lejeune and Topliceanu, 2004). According to Dandekar and Sharma (1979), energy is the tool necessary to forge the economic growth of a nation. The industrialized countries are characterized by high levels of energy consumption used in all domains of activity. However, according to Kameni (2008), 75% of sub-Saharan African population does not have access to electricity and in rural areas less than 10% of households have access to electricity (Tagutchou *et al*. 2004). The economic crisis that rages in this region does not permit an improvement of energy situation with large hydroelectric power or thermal plants. Thus numerous rural areas are still without electricity, because of the remoteness and/or the cost of connection to the national grid (Tagutchou *et al*. 2004). However, in many of these regions, some rivers exist and possess sufficient flow rates and auspicious topographic conditions, which if water structures and electrical equipment are well designed and installed, the rivers could constitute interesting alternatives to electricity production from Micro Hydroelectric Power Plants (MHPPs). This type of energy is renewable and safe, unlike the fossil energy which is non-renewable and polluting. Such experiences exist in numerous regions of Canada and Asia (Tondo,2002). Cameroon possesses enormous hydroelectric potential (UNDP, 1993). Although MHPPs were started in the west region of Cameroon since 1944, its evolution does not seem to have progressed in a decisive way to facilitate any real development. The understanding of their respective experiences must be taken into consideration for future projects of MHPPs. The main objective of this study is to characterise ten MHPPs installed in the west region of Cameroon with a view to modernizing them and using the experience for future projects. Specifically the study intends to collect data related to the development of ten MHPPs, to evaluate rivers and civil engineering works of MHPPs.

2.0 MATERIAL AND METHODS

2.1 Physical environment

The survey took place in Central Africa, in the mountainous zone of the west region of Cameroon, with the following geographic coordinates: latitude 4°55' and 6°13' north; longitude 9°51' and 11°18 ' east. It covers an area of 13.894 km^2 (MENOS, 2004). The altitude

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varies between 1200 m (Bamoun plateau) and 2740 m (Bamboutos Mountain) with an average of 1500 m (CEPMAE, 1976). The mountainous relief and the rainfall (1600 to 2000 mm) are auspicious to hydroelectricity (Helvetas, 1981; Kuété *et al.,* 1993).

2.2 Socio-economic environment

The population of this region is about two millions inhabitants with a yearly growth rate of 2.87% (NIS,). The average density is 500 inhabitants /km^2 and may attain 600 inhabitants /km^2 in some areas (Menoua and Mifi). The main economic activities are agriculture, handcraft, livestock rearing, some industrial units of transformation (soap factories and brewery) and the commercial exchanges with the other provinces. At least, each village possesses a market place, a development committee, basic public services such as schools and health centres.

2.3 Data collection.

The study was carried out from January 2006 to December 2008. During that period the main technical characteristics of the MHPPs were studied on each of 10 sites in the West region of Cameroon; the components concerned are rivers and civil engineering works. The above characteristics and data were obtained on each site by direct observations and measurements. Also data were collected by interviews of the maintenance technicians and the members of the development committee and all people susceptible to provide reliable information on the MHPPs in the villages. Furthermore, all accessible documentations were exploited.

2.3.1 River characteristics.

The river characteristics were the following:

-The static head H is the difference between the elevations in the headwater in the forebay and the water in the tailrace (Krivchenko, 1986; Lejeune, 2000). It was estimated twice a month using a theodolite.

-The river flow rates: they were measured at the same period as the static head using the float method (République française, Ministère de la Coopération, 1978)

-The theoretical power, P_t in kW was calculated from the following expression: (Lejeune and Toplicéanu, 2004)

$$P_t = 9.81QH \quad (1)$$

Where: Q: is the discharge in m^3/s

H: is the static head in metres

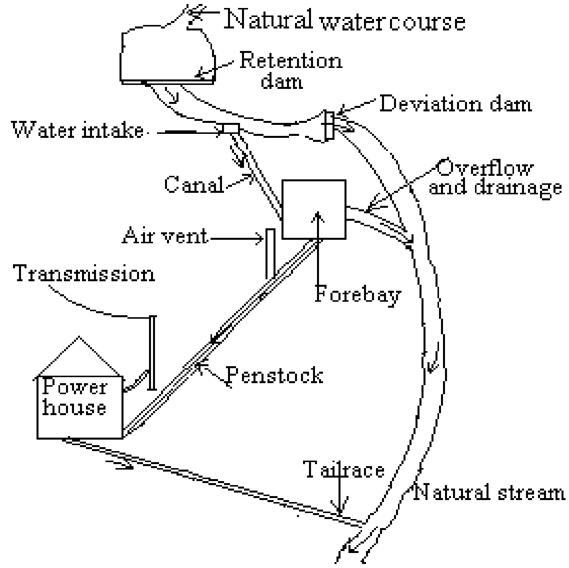
-The net minimal power, P_{mnet} in kW, is the value of the power computed by the equation: (Lejeune and Toplicéanu, 2004)

$$P_{mnet}=7.26Q_{100}H \quad (2)$$

Where: Q_{100} = minimal flow rate observed in m^3/s

2.3.2 Civil engineering work characteristics.

The Civil engineering works are shown on the general diagram of MHPP in figure 1. Each component was observed and characterized on the site. Main dimensions were measured using a tape.



(Source: Compiled from Linsley and Franzini, 1972;Dandekar and Sharma, 1979; Lejeune Toplicéanu and 2004).

Figure 1: schematic diagram of MHPP development structures

a) Storage dams. According to Dandekar and Sharma (1979), the storage dam function in a hydroelectric power project is mainly for storing water to be used during the dry season or peak load period. Its suitable site is where the water course valley has a bottle neck. Such a site reduces costs. Earth embankment dams are commonly used in small projects having heights of a few metres. They have over flow sections called spillways. Also they are usually equipped with an intake structure in their body. The main features of that dam intake are a trash rack and a control gate operated from the top of the dam (Dandekar and Sharma, 1979).

b) Deviation dams. They are built perpendicularly to the water course to raise the water head and to divert a part into the canal or penstock (République française, Ministère de la Coopération, 1978). They are overflow dams, the site of their implantation is where the length of water conveyance is reduced (Helvetas, 1981).

c) Intakes. Besides the dam intakes, other main types of intakes for rural projects are run-of-river intakes and canal intakes. Run-of-river intakes filter and lead water to forebays and are designed for run-of-river power plants. Canal intakes clean water before it enters into the deviation canals. Both intakes clean water with devices such as trash rack, inlet sill, silt trap and skimmer wall. They are also provided with control gates and stop log grooves for discharge control (Ministère de la Coopération, 1978; Dandekar and Sharma, 1979).

d) Canals. Canals convey cleaned water from intakes to forebays. They are non-pressure pipes or open canals with gentle slopes if the topography of the site is moderate. But if the terrain is steep with obstacles, supported steel pipes or pressure PVC pipes are suitable for small projects (Dandekar and Sharma, 1979).

e) Forebays. Forebays are regulating reservoirs. They store water when the load on the plant is reduced and provides it when the load increases. Forebay inlet is provided with trash rack and sill to prevent debris which may damage turbines (Linsley and Franzini, 1972; Dandekar and Sharma, 1979). For rural hydroelectric power plants, forebays can be created by the construction of stone masonry or concrete chamber. They are provided with a sill to eliminate rolling particles, an overflow to pass safely excess water and drainage at the bottom for cleaning.

f) Penstocks: Penstocks are the pressure pipes fabricated from steel, reinforced-concrete and wood staves. PVC pipes are also used on small projects. Penstocks supply water from forebays to the turbines. The choice of materials is mainly related to the head, the discharge and the topography of the site. Penstocks may be buried, uncovered on the ground surface or supported on piers. Sharp bends are not admitted to avoid head losses and large forces to anchor the pipe. (Dandekar and Sharma, 1979). Sudden discharge changes in penstocks due to governor control or fast turbine gate operation can cause water hammer pressures. These phenomena may damage the penstock. Long penstocks are protected with surge tanks while for short penstocks it is more economical to use heavier pipe walls. Gates at the forebay outlets permit repair on the penstocks. Also to avoid penstocks collapsing at the closing of gates, air vents equip the penstock inlets (Linsley and Franzini,1972). In addition, appropriate depth of water is required above the penstock inlets to prevent air entering; because air in the pipes reduces water power. For short distances from forebays to power houses, each turbine is supplied with one penstock. In case of long distances; a long penstock with a manifold at the lower end, feeds each turbine with one branch (Lejeune, 2000)

g) Tailraces. Tailraces are the waterways from power houses back to the rivers. These canals must be lined to avoid degradations.

h) Power houses. Power houses are structures that house mechanical, hydraulic and electrical equipment. Their dimensions depend on the equipment enclosed. Lighting and ventilation by means of openings on the walls are very important to avoid rust of equipment (Dandekar and Sharma, 1979).

3.0 RESULTS AND DISCUSSIONS

3.1 Evolution of MHPPs. The first MHPP in the west region of Cameroon was built in 1944 in the town of Dschang by French colonialist**.** Despite the existence of an auspicious hydrographic network, the technical and financial conditions constitute a major handicap to the evolution of MHPPs in this area. In 1997 the World Bank financed the MHPP pilot in the Bamougoum village that was constructed with the involvement of the population and local craftsmen (Harvey *et al.* 1997). This installation accelerated the creation of other MHPPs in the west region of Cameroon (figure 2). The average installation rate from 1997 to 2007 is one MHPP per year. This growth shows the advantages of MHPPs over other sources of energy used in the region such as thermal generators, kerosene lamps and firewood. The use of MHPPs can help to reduce emissions of greenhouse gases, prevent savannah deforestation. In addition they can improve the living conditions in the villages by allowing electrification of homes and services.

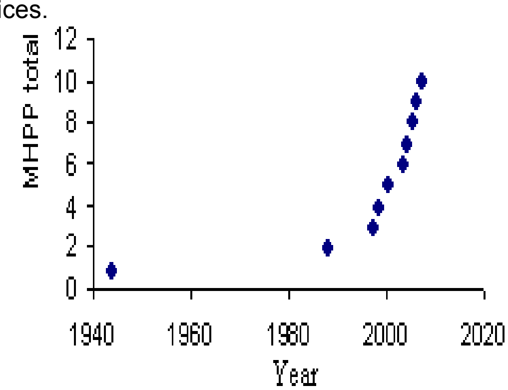


Figure 2: Evolution of MHPPs in the west region of Cameroon

3.2 Funding sources.

Depending on funding, MHPPs can be classified into two categories as this funding is ether external or local. Their classification is shown in table 1. The percentages are defined as the ratio of the number of MHPPs to their total number

Table1: Classification of MHPPs according to their funding

MHPP Sites	**Funding Sources**	**MHPPs**	
		Number	%
Dschang ; Fonjumetaw; Bapi; Bamougoum	External (France, Germany and Canada)	4	40
Belleh ; County I	ADEID*	2	20
Batotcha;Bangang; Mamarem; Foto	local (Development committees, private)	4	40
Total		10	100

*ADEID (Action pour un Développement Intégré et Durable) is a Bafoussam based NGO

Table 1 shows that 60% of MHPPs are funded locally, which is an important indicator for the development of MHPP technology in the west region of Cameroon.

3.3 MHPP builders.

Considering the builders, MHPPs can be grouped into 3 categories according to whether they are expatriates, expatriates associated with local craftsmen or local craftsmen only as indicated in Table 2.

Table 2: Classification of MHPPs according to the builders

MHPP Sites	Builders	MHPPs	
		Number	%
Dschang; Fonjumetaw	expatriates (French ; German)	2	20
Bapi ; Bamougoum	expatriates(English)+local craftsmen	2	20
Batotcha;Bangang; Mamarem; Belleh ; Foto ; County I	local craftsmen	6	60
total		10	100

Table 2 shows that 80% of MHPPs in the west region of Cameroon were built by local craftsmen. That is an asset to the development of this technology in the region. This means that maintenance and repairs can be made easily, rendering this source of energy sustainable.

3.4 MHPP management.

The management of MHPPs in the west region of Cameroon is given in Table 3. It shows that 80% of MHPPs are managed by development committees and individuals. This demonstrates once again the capacity of villagers to contribute to their socio-economic development and environmental protection.

Table 3: Classification of MHPPs according to management structures

MHPP Sites	Management structures	MHPPs	
		Number	%
Dschang	AES SONEL*	1	10
Fonjumetaw	Catholic mission	1	10
Bapi; Bamougoum ; County I,; Belleh	Development committees	4	40
Batotcha; Bangang; Mamarem; Foto	private	4	40
Total		10	100

* AES SONEL: American company in charge of national grid

3.5 Initial distances of the sites of MHPPs to national grid.

The distribution of MHPPs according to the initial distances to national grid at the time of installation is given in table 4.

Table 4: Distribution of MHPPs according to the distances to national grid at the time of implantation

MHPP Sites	Distances D (km)	MHPPs	
		Number	%
Dschang	D =300	1	10
Fonjumetaw; Bapi ; Mamarem ;County I; Belleh	$18 \geq D \geq 14$	5	50
Batotcha ; Foto; Bamougoum	$10 \geq D \geq 2$	3	30
Bangang	D = 0	1	10
Total		10	100

Table 4 indicates that only Bangang MHPP was installed under the national electricity network. According to MINMEE (2003), 209.74 km of medium voltage lines and 238.7 km of low voltage lines were achieved by the state and HIPC funds. With this extension of the national grid, other sites are now within the national but high connection charges still make the use oh MHPPS more attractive.

3.6 Technical characteristics of MHPPs in the West region of Cameroon

3.6.1 River characteristics.

River characteristics as shown in table 5, group the MHPPs of the west region according to beds, annual discharges, and gross heads.

Table 5: Grouping of MHPPs according to beds, annual discharges, and gross heads characteristics of rivers

MHPP Sites	**River characteristics**	**MHPPs**	
		Number	%
All sites	**1-Beds** - Rocky with waterfalls	10	100
	2-Annual discharges (m^3/s)		
	- Maximum (Q_M)		
All sites except Batotcha	$4.18 \geq Q_M \geq 3.12$	9	90
Batototcha	$Q_M = 2.10$	1	10
	- mean (Q)		
Bangang ; Bapi ; Fonjumetaw; Dschang; Belleh	$1.10 \geq Q \geq 0.65$	5	50
Bamougoum; Batotcha; Mamarem ;Foto; Conty I	$0.54 \geq Q \geq 0.30$	5	50
	- Minimum (Q_{100})		
Mamarem; Bapi ; Belleh	$1.29 \geq Q_{100} \geq 0.40$	3	30
Bamougoum ; Bangang ;Fonjumetaw;Dschang	$0.35 \geq Q_{100} \geq 0.20$	4	40
Batotcha ; Foto ; County I	$0.18 \geq Q_{100} \geq 0.15$	3	30
	3-Gross heads H (m)		
Fonjumetaw; Dschang	$70 \geq H \geq 60$	2	20
Bamougoum ; Bapi ;Batotcha; Mamarem; Belleh	$32 \geq H \geq 25$	5	50
Bangang; Foto; County I	$3 \geq H \geq 2$	3	30

It appears from table 5 that 100% of MHPPs in the west region of Cameroon have rocky sites. This is an important factor for the implantation of civil engineering works needed by MHPPs. First of all one notes that 100 % of MHPPs have low annual mean discharges within the range of 1.10 and 0.30 m^3/s. Secondly 80% of MHPPs have gross heads less than 32m. These conditions justify the present installation of 80% of Pelton turbines in the West Region of Cameroon.

3.6.2 Synthesis of MHPP main technical characteristics of civil engineering works.

The summary of MHPP main technical characteristics (civil engineering works) are as follows.

a) Main characteristics of retention dams. The retention dams (table 6) are only on 10% of sites (Dschang). In addition to the role of flow control, the dams contribute to the mildness of the local microclimate and feeding of ground water. The dams also serve for leisure activities as well as fishing. For other sites without retention dams, the gross head can be increased by constructing a new deviation dam upstream.

b) Main characteristics of deviation dams. Main characteristics of deviation dams are iven in table 6. Lengths on 80% of sites are less than 1.50m and heights are less than 0.80m. On Dschang and Fonjumetaw sites, the deviation dams have stone masonry walls. During the rainy seasons excess water passes over weirs. On other sites the deviation dams are made of stop logs or clay bag. These materials are partially or totally removed to avoid flooding during heavy rain periods and to clean deposits.

Table 6: Distribution of MHPPs according to the main characteristics of retention dams and deviation dams

MHPP Sites	**Work characteristics**	**MHPPs**	
		Number	%
	1-Retention dams		
Dschang	- Earth dam : 119 m long, 8 m high - Water reserve: 1 km long - Gate : two slide gates; 3 m wide eac	1	10
Other sites	No retention dam	9	90
	2- Deviation dams		
	- Construction materials		
Dschang ; Fonjumetaw	Stone masonry	2	20
County I; Foto; Batotcha; Bamougoum	Clay bags	4	40
Belleh; Bangang; Mamarem; Bapi	Stop logs	4	40
	- Height H (m)		
Dschang ; Fonjumetaw	$3 \geq H \geq 1{,}40$	2	20
Batotcha; Bamougoum; Bangang; Belleh; Mamarem; Bapi; County I; Foto.	$0{,}80 \geq H \geq 0{,}20$	8	80
	- Length L (m)		
Dschang ; Fonjumetaw	$64 \geq L \geq 3$	2	20
Bamougoum; Bangang; Mamarem; Bapi; Foto; Batotcha; Belleh; County I	$1{,}50 \geq L \geq 1$	8	80

c) Main characteristics of intakes. The main characteristics of intakes (table 7) indicate that two types of intake are used in the MHPPs in the West Region of Cameroon; run-of-river intakes are on 30% of sites and canal intakes on 70% of sites. Wire nettings on 80% of sites are often clogged by accumulations of leaves and other trash from agricultural fields. These accumulations reduce MHPP efficiencies or stop their functioning. To solve that problem, each site of MHPP should have a trained technician to take care of daily problems. He should be paid by the village development committee.

Table 7: Distribution of MHPPs according to the main characteristics of intakes and canals

MHPP Sites	Work characteristics	MHPPs	
		Number	%
	1- intakes		
	- type		
Fonjumetaw ; Foto; Bangang	Run-of-River intakes: width W (m) 1.50 ≥ W ≥ 0	3	30
Bamougoum; Batotcha; Mamarem;	Canal intakes:		
Bapi ; Belleh ; County I;	W ≤ 0.50	6	60
Dschang	W =1.20	1	10
	- intake structure		
Dschang ; Fonjumetaw	Control gate, trashrack set on silt trap	2	20
Batotcha; Bamougoum; Bangang; Belleh; Mamarem; Bapi; County I; Foto	Wire netting	8	80
	2- Canals		
	- Length L (m) - Diameter D (mm)		
Bamougoum; Batotcha; Mamarem; Bapi ; Belleh ; County I	5 ≥ L ≥ 1 150 ≥ D ≥ 63	6	60
Dschang	L = 404 D = 1000	1	10
	-Type		
Bamougoum; Batotcha; Mamarem; Bapi	PVC Pipe	4	40
Belleh ; County I	Galvanized steel pipes	2	20
Dschang	Reinforced concrete ducts	1	10
	- Supports		
Bamougoum; Batotcha; Mamarem; Bapi; Belleh ; County I;	Ground surface and Y tree branches	6	60
Dschang	Underground ; concrete piers	1	10
Fonjumetaw ; Bangang ; Foto	No canal	3	30

d) Main characteristics of canals. The main characteristics of canals presented in table 7 show that 100% of canals in the West Region of Cameroon are pipes or ducts to avoid infiltrations and undesirable trash or debris in water. They are made of non- pressure PVC pipes on 40% of sites. These pipes are manufactured in the region, they are cheap with respect to other conduit types, also light and easy to use, but they are deteriorated by sun rays and bush fires. On 30% of sites galvanized steel pipes or reinforced concrete ducts are used. They are expensive but minimize the inconveniences mentioned earlier. In the West Region of Cameroon, 60% of canals are supported by Y tree branches and other materials where the topography is very steep and rugged. Where the terrain has gentle slope, pipes are embedded or uncovered. This is to reduce MHPP costs, but the conveyance system is not reliable.

e) Main technical characteristics of forebays. Main technical characteristics of forebays, are summarised in table 8.

Table 8: grouping of MHPPs according to main characteristics of forebays, penstocks and tailraces

MHPP Sites	**Work characteristics**	**MHPPs**	
		Number	%
	1- Forebays		
	Type		
Dschang ; Fonjumetaw	Concrete walls	2	20
Bamougoum ; Dschang ; Bangang ; Bapi ;Batotcha; Belleh; Foto ; County I	Stone Masonry walls	8	80
	volume v (m^3)		
Dschang ; Fonjumetaw	$120 \geq v \geq 60$	2	20
Bamougoum ; Dschang ; Bangang ; Bapi ;Batotcha; Belleh; Foto ; County I	$3.2 \geq v \geq 0.3$	8	80
	2-Penstocks		
	- Type		
Dschang ; Fonjumetaw	Cast iron pipe	2	20
Bangang; Belleh ; County I	Galvanized steel pipe	3	30
Bamougoum; Bapi ; Foto ; Mamarem	pressure PVC pipe	4	40
Batotcha	Non pressure PVC pipe	1	10
All sites	- supports	10	100
	- Length L (m)		
Bamougoum; Batotcha ; Foto ; Bangang	$150 \geq L \geq 20$	4	40
Dschang ; Fonjumetaw ; Mamarem; Bapi ; Belleh; County	$360 \geq L \geq 225$	6	60
	- Number of turbines fed		
Dschang	2	1	10
Other sites	1	9	90
	- Diameter D (mm)		
Bamougoum;Bangang;Mamarem ;Bapi ; Batotcha; Foto; Belleh, County I	$150 \geq D \geq 125$	8	80
Dschang ; Fonjumetaw	$1000 \geq D \geq 600$	2	20

f) Main characteristics of forebays. The main characteristics of forebays shown in table 8 indicate that 80% of forebays have stone masonry walls. They are built by local craftsmen who use as much maximum local materials as possible to minimize costs. On these sites forebay volumes are small, less than 32m^3. They also are not equipped with trash racks and sills. Hence the nozzles of Pelton turbines used are often choked up. Very often sediments fill up the reservoirs and prevent water from entering the penstocks. The removal of these sediments is painful because there is no drainage. Further more, excess water in forebays flows anywhere since they are not equipped with overflow pipes. This leads to environmental degradation.

g) Main characteristics of penstocks. The main characteristics of penstocks are given in table 8. On 30% of sites, galvanized pipes are recovery used pipes. They have been used in banana plantations for sprinkler irrigation. Very often there are leaks which lower the plant efficiencies. Cast iron pipes are used on 20% of sites (Dschang; Fonjumetaw). The projects on these sites were designed, funded and built by expatriates. Cast iron pipes are imported, expensive, heavy, and difficult to use at village level. These pipes are not appropriate for rural areas. Pressure PVC pipes can replaced cast iron pipes at village level because they are locally made, light, inexpensive and easy to handle. Also they are durable if they are not exposed to direct sun rays. At the penstock inlets for the Dschang and Fonjumetaw projects there is a good water level, a gate and an air vent. Other 80% of sites possess only an air vent to protect the penstock from water hammer due to sudden discharge variation. Non pressure PVC pipes used on 10% of sites (Batocha) are very often broken by water pressure. The broken pipes are attached by rubber or other types of ropes at many places to minimise water leaks which reduce water power. Only 10% of sites (Dschang) use one penstock to feed two turbines by a bifurcation; other sites have a single turbine in the power house. In case of turbine maintenance, the village will have no electricity since there is no alternative power source. Penstocks are straight on 100% of sites and this enhances power generated.

h) Main characteristics of power houses. The main characteristics of power houses are given in table 9. On 50% of the sites a vehicle can enter the plant. This is very important for transportation of heavy equipment to the site. On 70% of sites, the power houses have a single room and the floor areas are small and between 8 and 15 m^2. These power houses contain a mill whose mechanical energy is obtained from the turbine shaft by means of a belt. There are many mill users in the room and accident risk is high. For security measures, it must be planned a room for the mill users. It is separated from the mill room by a wall of 1.40 m high. The mill functions during the day when the electricity demand is low. On 50% of MHPPs there is no ventilation; hence all metal parts of equipment are rusted because of humidity. All these defaults resulted from poor design of the structures.

Table 9: Grouping of MHPPs according to the main characteristics of power houses and tailraces

MHPP Sites	**Work characteristics**	MHPPs Numbe r	%
	1- Power houses		
	- access: distance road to the factory d (m)		
Dschang; Fonjumetaw; Bangang ; Belleh, County I	d = 0 (cars can enter the factory)	5	50
Mamarem;Batotcha; Bamougoum	$20 \geq d \geq 10$	3	30
Bapi; Foto	$100 \geq d \geq 80$	2	20
	- Floor area a (m^2)		
Dschang; Fonjumetaw; Bangang	$200 \geq a \geq 100$	3	30
Bamougoum; Batotcha; Bapi; Mamarem; County I; Belleh; Foto	$15 \geq a \geq 8$	7	70
	- Equipment housed.		
Dschang	2 turbine alternator units; 2 governors; a control board ; 1 thermal unit	1	10
Fonjumetaw	Turbine alternator unit; governor; switch board	1	10
Bamougoum; Batotcha; Bapi; Mamarem; County I; Belleh; Foto; Bangang	1 Turbine alternator unit; 1 switch board; 1 mill	8	80
	- Lighting and ventilation		
Dschang; Fonjumetaw; Bangang; Belleh; County I	Openings for day light and ventilation	5	50
Bamougoum; Batotcha; Bapi; Mamarem; Foto	No opening except the door.	5	50
	2- Tailraces		
	-Type		
Bamougoum;Bangang;Mamarem ;Bapi; Batotcha; Foto; Belleh, County I	Earth	8	80
Dschang ; Fonjumetaw	Concrete	2	20
	- Length L (m)		
Bamougoum; Bangang; Batotcha; Belleh	$6 \geq L \geq 2$	4	40
Dschang ; Fonjumetaw ; Mamarem; Bapi ; County I ; Foto	$15 \geq L \geq 7$	6	60

i) Main characteristics of tailraces. The main haracteristics of tailraces (table 9), indicate that 80% of tailraces are earthen canals. Vegetation growth in these water ways prevents flow and creates environmental problems. To remedy tailraces must be stone masonry, possess suitable slopes and also be regularly cleaned.

CONCLUSION AND RECOMMANDATIONS

Physical environment in the West Region of Cameroon is suitable for the installation of Micro hydroelectric plants. Funding of the MHPP in the Bamougoun village by the World Bank and its construction by expatriate technicians with the involvement of the local craftsmen boosted MHPP technology in the West Region of Cameroon. Because of this, the functioning of the structures is still not mastered and this is often the source of the MHPP malfunction. The MHPPs can contribute efficiently to sustainable development of the region if craftsmen devoted to that technology in the rural areas are trained. Training can be financed by government or other funding agency. The MHPP technology is simple, clean and can be easily mastered by local craftsmen.

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