Using small low cost, robust and easily maintained decentralized hydraulic power stations in Central Africa

Prof. Patrick Hendrick

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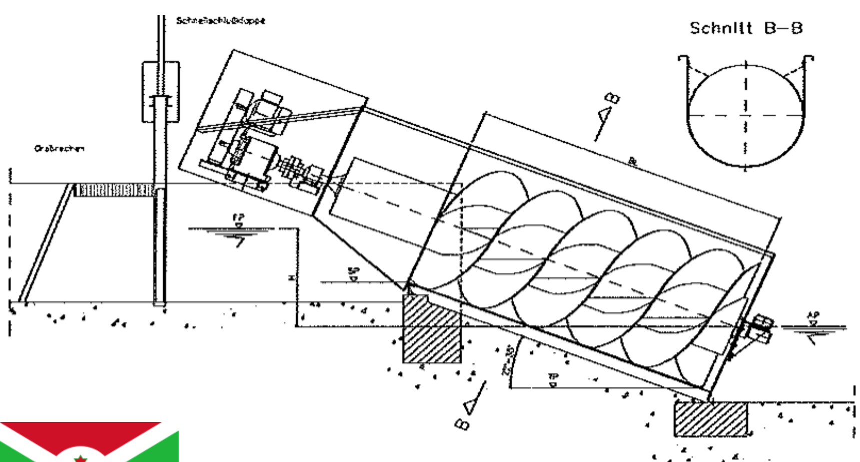
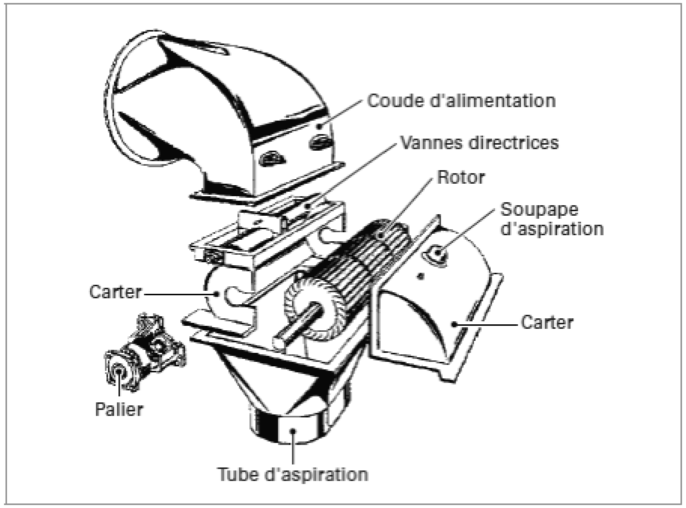
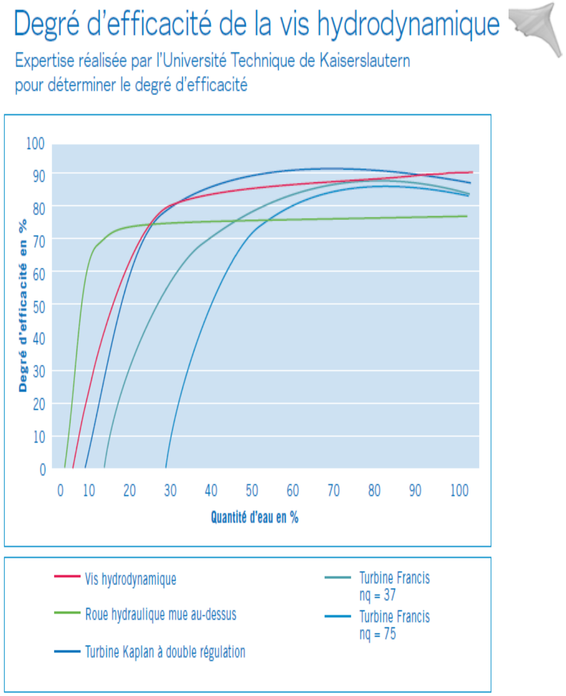




Problem



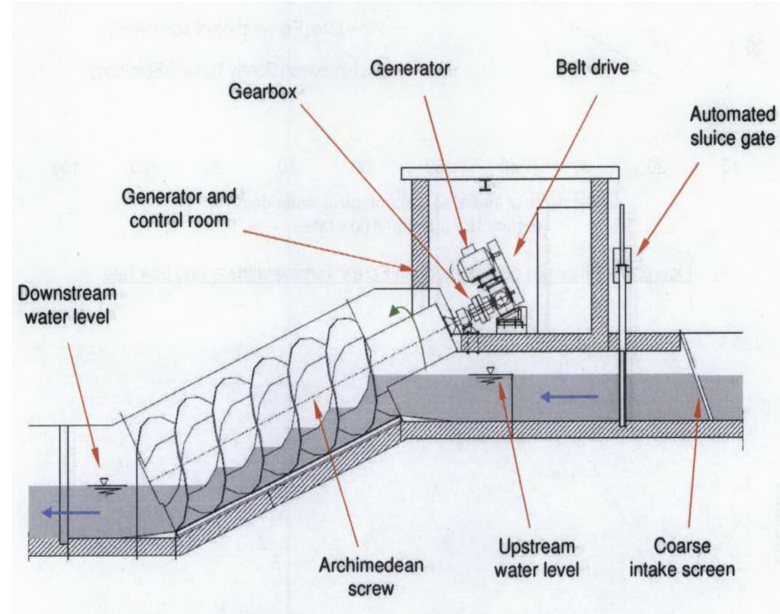
Key criteria to success of projects using Small Hydro Plant (SHP) in Developing countries:

1° Cost-reduction in manufacture of equipment
2° Cost-reduction in maintenance
3° Reliability
4° Robustness
5° Simplicity, ease of use

Archimedean turbine appears to be an appropriate solution to these requirements

- Proposal for a turbine technology "simplified" screw can be manufactured in workshops locally
- Tests and obtain characteristic curves for 6 operating configurations (combination of slope and pitch of the screw) ,
- 2 optimized models used (p45H22 and p45H30) and determination of their speed limit

Archimedean screw turbine



Advantages of the screw turbine

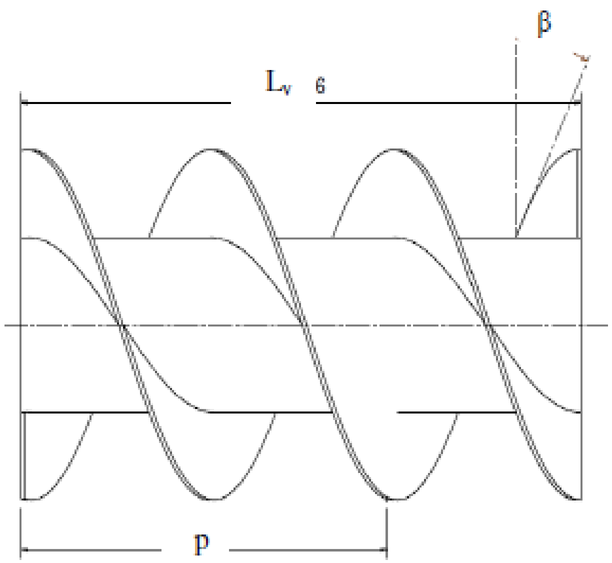
1. Design, construction and maintenance are simple
2. Significant reduction in civil engineering, therefore the initial capital (civil engineering may represent up to 40% of SHP budget)
3. Screw tolerates many impurities without its functioning affected => coarse grids
4. Ecological technology / fish-friendly

Archimèdes screw
(Luxemburg)

P : 30 kW
ηt : 86 %
De : 2,6 m Nt = 26 tr/min
3 screws
Inclination 22°
« Standard installation »

Tests, results, and laws obtained / Test bench

Parameters of screw turbine



Parameters of test bench

N= 2 srews

Pitch p for β: 30° and 45°

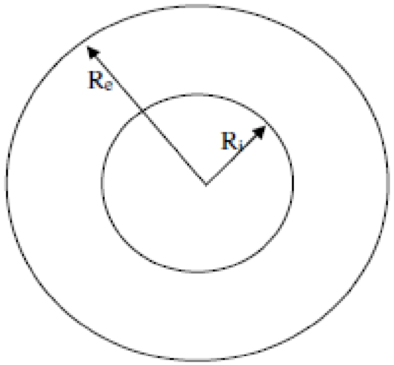
Slope α of 22,5° , 30° and 37,5°

a. External parameters

1° Outer radius Re of the screw

2° Length of the screw L

3° The slope α (Head)



b. Internal parameters

1° Inner radius Ri of the screw

2° Number of helices N = 1, 2, ...

3° Pitch of helix (β) or period p

Tests, results, and laws obtained

Model

Diamètre		Rayon		Pas p		L_{vis}
Extérieur	Intérieur	extérieur	intérieur	$\beta = 30°$	$\beta = 45°$	
0,6250	0,3125	0,3125	0,1563	$p_{30} = 1,13$	$p_{45} = 1,96$	1,56

$\mathbf{H_{22}}\ (\alpha_{22,5°}) = 0,60$ m; $\mathbf{H_{30}}\ (\alpha_{30°}) = 0,78$ m; $\mathbf{H_{37}}\ (\alpha_{37,5°}) = 0,95$ m

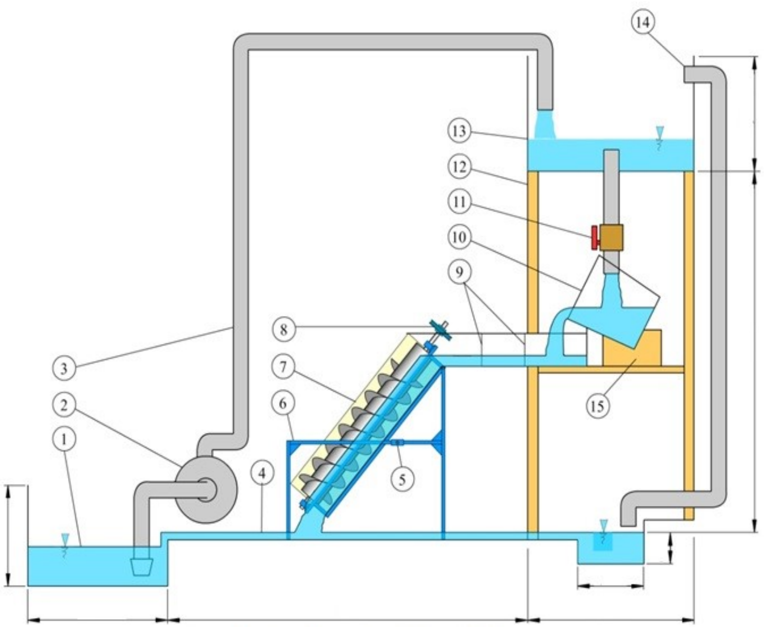
Mesurements

Q : Flow

N : Rotation speed

T: torque

Test bench



- Plan global banc d'essai vis d'Archimède JPK

$$\eta_t = 2.\pi.\ N.\ T_{mec}\ /\ \rho.\ g.\ Q.\ H$$

Example in Lubumbashi DR Congo

Power : 18 kW

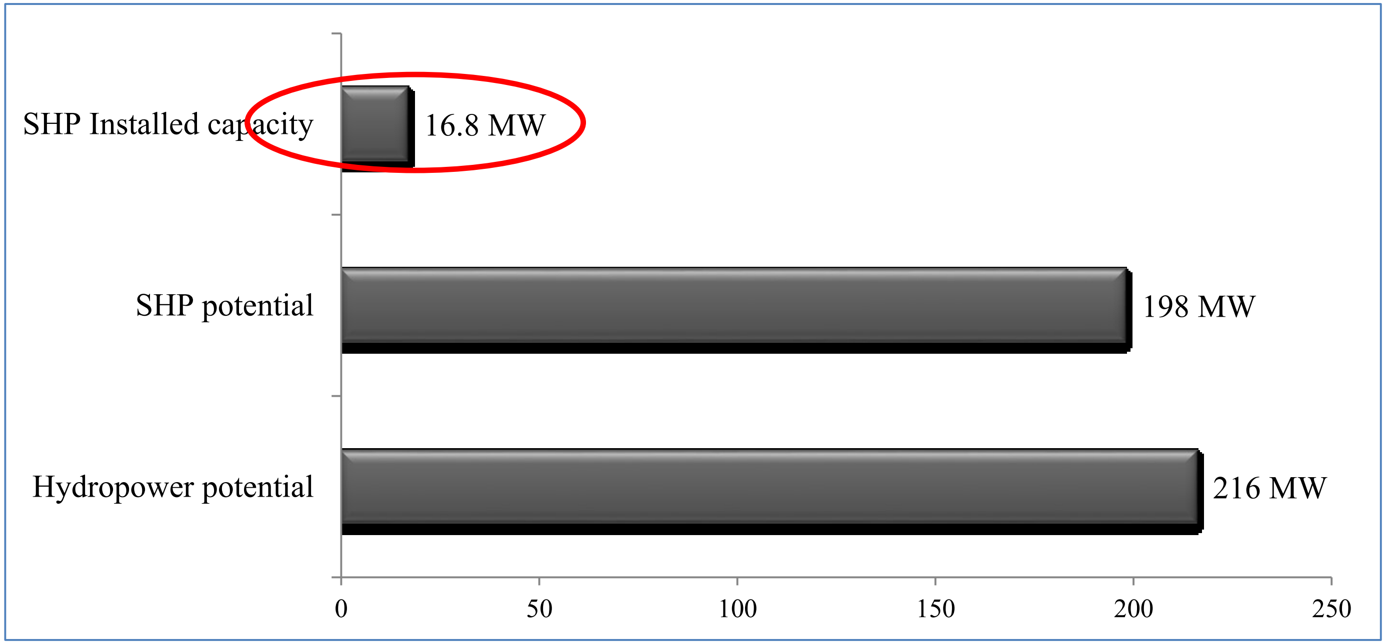
Length : 4,5 m

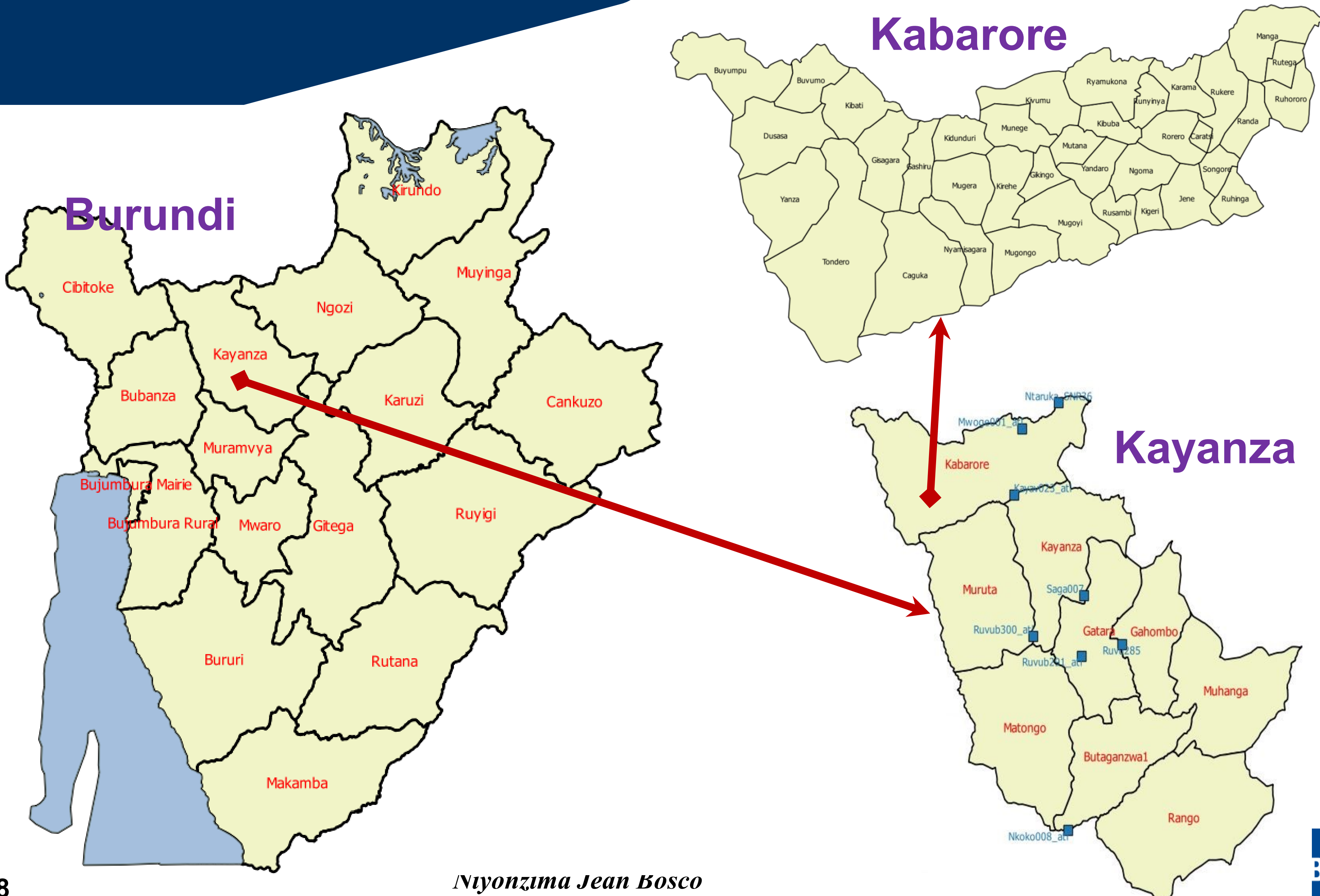
Ext Diameter : 1,9 m

Nbre blades : 2

Burundi

- Lahmeyer (1983): **294 MW**
- Sher engineering conseils sa (2013): 414 MW




Burundi
Kirundo
Cibitoke
Ngozi
Muyinga
Kayanza
Bubanza
Karuzi
Cankuzo
Muramvya
Bujumbura Mairie
Bujumbura Rural
Mwaro
Gitega
Ruyigi
Bururi
Rutana
Makamba
Kabarore
Buyumpu
Buvumo
Kibati
Dusasa
Yanza
Tondero
Gisagara
Gashiru
Kidunduri
Munege
Kivumu
Ryamukona
Karama
Rukere
Manga
Rutega
Ruhororo
Kunyinya
Kibuba
Mutana
Rorero
Carata
Randa
Gikingo
Mugera
Kirehe
Yandaro
Ngoma
Songore
Jene
Ruhinga
Rusambi
Kigeri
Mugoyi
Nyamisagara
Mugongo
Caguka
Kayanza
Kabarore
Kayanza
Muruta
Saga007
Gatara
Gahombo
Ruvub300_at
Muhanga
Matongo
Butaganzwa1
Rango
Nkoko008_at

Province Kayanza

Atlas Hydroelectricity

- River Mwogere: Mwoge001
- 2 sites: Munege & Ryamukona

Dénivelé / Head

- Ryamukona: 33 m
- Munege: 29 m

Niyonzima Jean Bosco

Site selection

- Remote zone from national grid of electricity: reducing the socio-economic situation of the population
    - Small activities of the population: lighting, hairdresser, grain mills , freezer, TV (cinema) …
- Deposit of Coltan: Mining craftsmen are grouped together to look for job, they need electricity for their daily lives




- Public services : Sheltered healthy and public school

Velocity sensor

Flowatch Impeller Probe

Daily discharge variations

	Date: 03/01/2017					Site Ryamukona 1																	
	Hour: 9h40 to 10h24					Width: 10 m																	
Width [m]	0	0,4	0,8	1,2	1,6	2	2,4	2,8	3,2	3,6	4	4,4	4,8	5,2	5,6	6	6,4	6,8	7,2	7,6	8	8,4	8,8
Depth [m]	0,15	0,18	0,16	0,26	0,29	0,27	0,26	0,24	0,22	0,21	0,21	0,24	0,22	0,2	0,18	0,2	0,2	0,19	0,18	0,18	0,2	0,2	0,2
Velocity at 0,2H [m/s]																							
Velocity at 0,6H [m/s]	0,4	0,6	0,9	1	1	1	1,1	1,1	1,1	1,1	0,6	0,9	0,7	0,9	0,7	0,6	0,7	0,9	0,8	0,6	0,7	0,6	0,3
Velocity at 0,8H [m/s]																							
Segment discharge [m^3/s]	0,01	0,04	0,06	0,10	0,12	0,11	0,11	0,11	0,10	0,09	0,05	0,09	0,06	0,07	0,05	0,05	0,06	0,07	0,06	0,04	0,06	0,05	0,01
Total discharge [m^3/s]	1,5																						
	Hour: 12h 36 to 13h																						
Width [m]	0	0,4	0,8	1,2	1,6	2	2,4	2,8	3,2	3,6	4	4,4	4,8	5,2	5,6	6	6,4	6,8	7,2	7,6	8	8,4	8,8
Depth [m]	0,14	0,18	0,25	0,25	0,27	0,24	0,22	0,22	0,22	0,22	0,19	0,21	0,2	0,18	0,18	0,18	0,18	0,18	0,18	0,18	0,21	0	0
Velocity at 0,2H [m/s]																							
Velocity at 0,6H [m/s]	0,4	0,6	0,9	1,1	0,8	0,9	0,8	0,9	0,8	1	0,9	1	0,8	0,6	0,6	0,4	0,4	0,7	0,5	0,5	0,4	0,2	0,1
Velocity at 0,8H [m/s]																							
Segment discharge [m^3/s]	0,01	0,04	0,09	0,11	0,09	0,09	0,07	0,08	0,07	0,09	0,07	0,08	0,06	0,04	0,04	0,03	0,03	0,05	0,04	0,04	0,03	0	0
Total discharge [m^3/s]	1,3																						
	Hour: 15h9 to 15h32																						
Width [m]	0	0,4	0,8	1,2	1,6	2	2,4	2,8	3,2	3,6	4	4,4	4,8	5,2	5,6	6	6,4	6,8	7,2	7,6	8	8,4	8,8
Depth [m]	0,14	0,2	0,25	0,26	0,25	0,26	0,25	0,23	0,23	0,22	0,2	0,22	0,2	0,2	0,2	0,19	0,16	0,14	0,16	0,16	0,17	0	0
Velocity at 0,2H [m/s]																							
Velocity at 0,6H [m/s]	0,5	0,9	0,9	0,8	1	0,9	0,7	1,1	0,9	0,9	0,8	0,7	0,6	0,8	0,9	0,9	0,6	0,3	0,7	0,4	0,4	0	0
Velocity at 0,8H [m/s]																							
Segment discharge [m^3/s]	0,01	0,07	0,09	0,08	0,1	0,09	0,07	0,1	0,08	0,08	0,06	0,06	0,05	0,06	0,07	0,07	0,04	0,02	0,04	0,03	0,03	0	0
Total discharge [m^3/s]	1,3																						

Discharge variations along the day

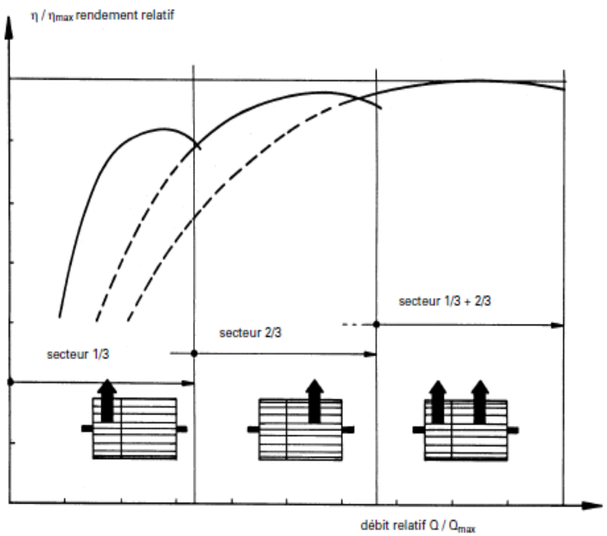
Test bench (JLA)

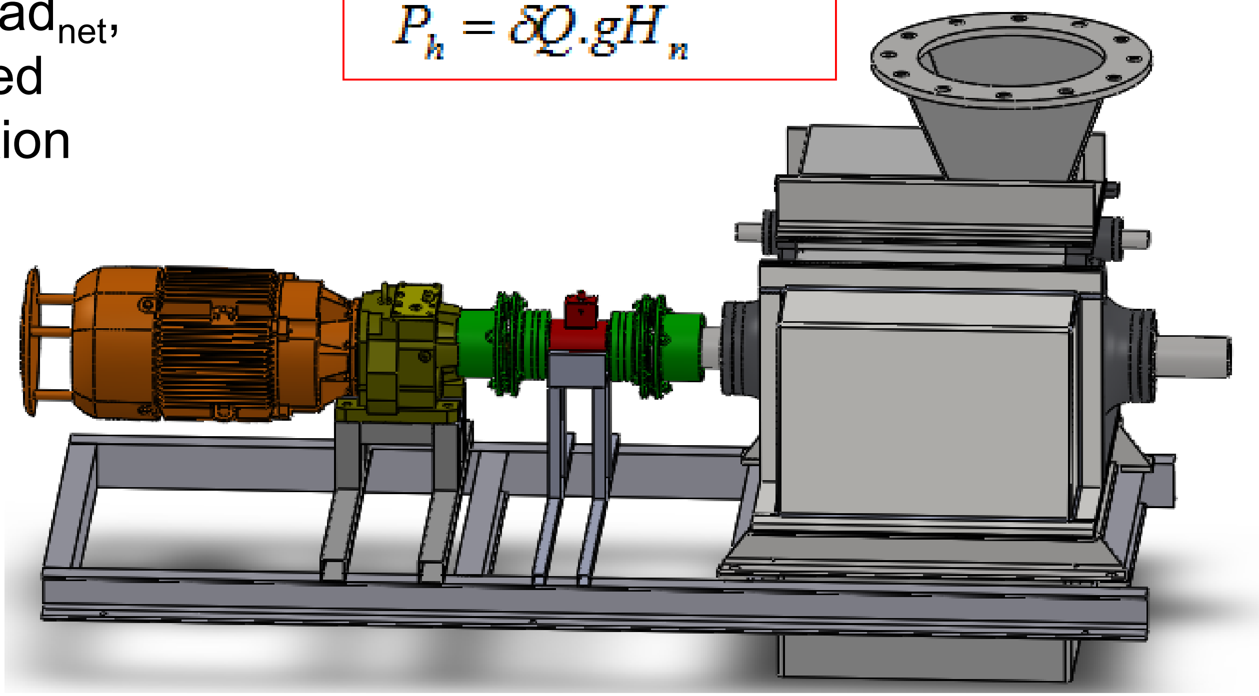
$$\eta_t = \frac{P_m}{P_h}$$

$$P_m = T.\omega = \frac{T.2\pi n}{60}$$

$$P_h = \delta Q.gH_n$$

- Reservoir: hydraulic canal & Piping
- B-M turbine: JLA
- Load: gear motor
- Measurements: flow, head$_{net}$, torque and rotational speed
- Control: frequency variation

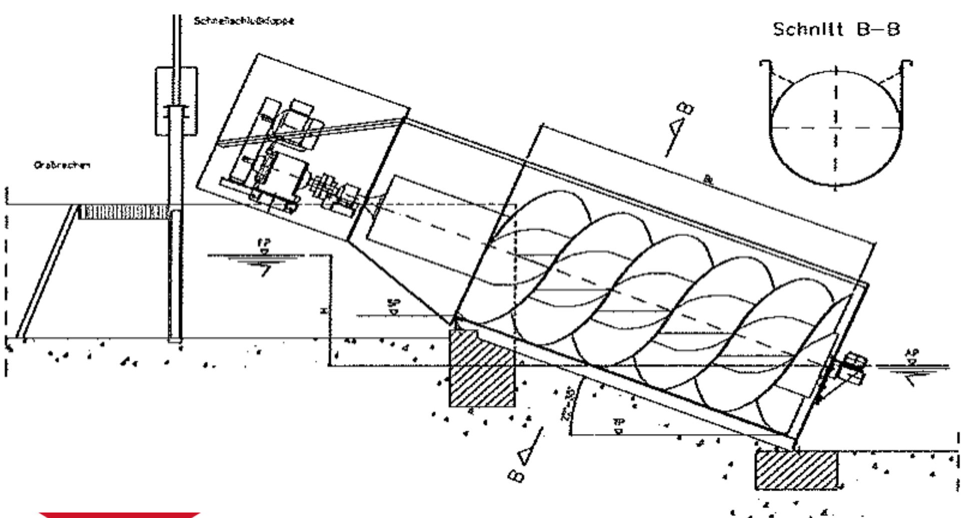


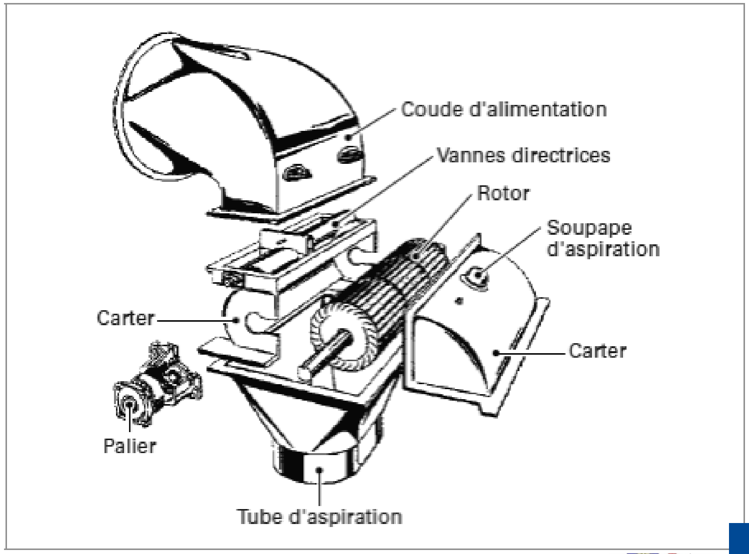


Goal: test if turbine operates at real conditions of Mwogere river

Conclusions

- Solutions exist for small low cost, robust and easily maintained decentralized hydraulic power stations for Central Africa
- 2 proposed here ...





Thank you

jpkatond@polytechunilu.ac.cd

jpkatond@hotmail.com

Jean.bosco.niyonzima@ulb.ac.be

patrick.hendrick@ulb.ac.be