Private sector participation in Rwandan micro hydro

The Rwandan Government has launched ambitious plans to improve electricity supply to a satisfactory and sustainable level in the near future. Small hydropower schemes have been identified as a promising option to improve supply to remote rural areas, with privatisation of existing plants identified as an option to improve development.

At present, only 10% of Rwanda's electricity needs are met with existing power plants. The country's capital Kigali and some major province cities currently account for about 95% of the total electricity consumption, with rural villages having no access. The total installed capacity in the country is around 100MW, but demand is estimated at 10 times that figure. The Rwandan government has launched ambitious plans to improve electricity supply throughout the country by 2025. A master plan identified the expansion of the hydropower sector, particularly decentralised small hydropower schemes, as hydropower is one of the main natural renewable energy resources of Rwanda. Over 300 sites have been identified for the development of small and micro hydropower potential, with generating capacity ranging from 50kW to 2MW per site. A few sites benefit from topographic and hydrological conditions that allow a higher installed capacity up to 5MW each.

The Ministry of Infrastructure (MINFRA) selected the following five sites to serve as pilot plants:

- Rugezi (2.2MW) – Northern Province
- Nyamyotsi I (100kW) – Northern Province
- Nyamyotsi II (100kW) – Northern Province
- Mutobo (200kW) – Northern Province
- Agatobwe (200kW) – Southern Province

GIZ (Deutsche Gesellschaft für Inter-nationale Zusammenarbeit) was contracted to carry out an assessment study of the projects as an initial step in pursuing privatization of micro hydropower (MHP) in Rwanda.

The selected five plants lack robust data or records regarding water flow, hydrology investments, daily electricity production, customer situation, total consumption, revenues, operation and maintenance costs, potential rehabilitation costs as well as ownership and operation responsibility. Consequently the audit and assessment focused on fact finding and analysing the present status under the prevailing circumstances.

Methodology

The five selected sites were visited to gain first hand information of physical measurements and conditions, economic status and future development potential. Structured questionnaires were prepared obtaining consumer data, electricity production records, maintenance costs, revenues and required rehabilitation expenses. However it was not possible to obtain all sufficient information as records about actual running costs and revenues were not available. Compensating for the lack of drawings, general measurements of visible and accessible structures were undertaken on site. All structures below ground are further points of uncertainties. The lack of initial investment costs was overcome by taking unit rates from various comparable sources. The rates were validated narrowing down the spread and suggesting rates that might be reasonable.

Consequently, evaluation of the present viability of the sites were only possible based on a limited and rudimentary database.

Table 1: Main features of the pilot plants

Characteristics	Rugezi	Nyamyotsi I	Nyamyotsi II	Mutobo	Agatobwe
Installed capacity	2.200 kW	100 kW	100 kW	200 kW	200 kW
Type of Turbine	2 Francis	1 Turgo	1 Turgo	1 Turgo	1 Francis
Net head	138m	156m	100m	123 m	24 m
Penstock length	436 m	394 m	1.050 m	223 m	50 m
Penstock diameter	1.000 mm	250 mm	300 mm	300 mm	700 mm
Construction		01/06 – 08/06	01/09 -	07/07 – 10/09	07/07 – 10/09

The plants, characteristics & data

The main features of the plants are listed in table 1. Privitisation approaches can differ depending on the plant characteristics. Nyamyotsi I+II operate as cascade plants serving households and small shops in rural and remote communities. Matubo and Agattobwe operate as single units serving households and small shops. Rugezi is much bigger than the others and operates as single unit serving the national grid only. Grid extensions means it may be possible to connect Mutobo, Agatobwe and Nyamyotsi I+II in the future.

Financial aspects

As in-situ surveys of accessible structures and components were limited and robust unit rates or cost records were not available, cost estimates and financial analysis was difficult. After intensive discussions and verifications of available data the following approach was applied filling the data gap with a practical solution.

It is commonly known that small hydropower schemes have similar breakdowns in terms of percentages of the investment costs of the various components. The breakdown structure shown in figure 1 was applied to the five sites.

Data from various sources as well as international publications were evaluated and the percentages of costs for components are as follows: civil structures (26%); weir (10%); headrace canal (6%); forebay (2%); powerhouse (5%); access road (2%); site clearance (1%); penstock (15% including supports); electromechanical (25%); distribution system (15%); valves & gates (5%); Contingencies (10%); engineering & fees (4%).

Except for turbine/generator (25%) and engineering fees (4%) all other components or 71% of the total should be measured using as much accurate data as possible.

As Rugezi is relatively new, records were available and the plant delivers the entire electricity production into the national grid. As a result, the main focus for assessment were the other four projects. The measurable percentages for these

Table 2: Tariffs

Households	118 RWF/kWh
Business	105 RWF/kWh
National grid feed-in tariffs	Rugezi: 55 RWF/kWh Nyamyotsi I 92 RWF/kWh Nyamyotsi II 92 RWF/kWh Mutobo 87 RWF/kWh Agatobwe 87 RWF/kWh
Levy	1% of revenues
Obligatory reserves	5% of revenues

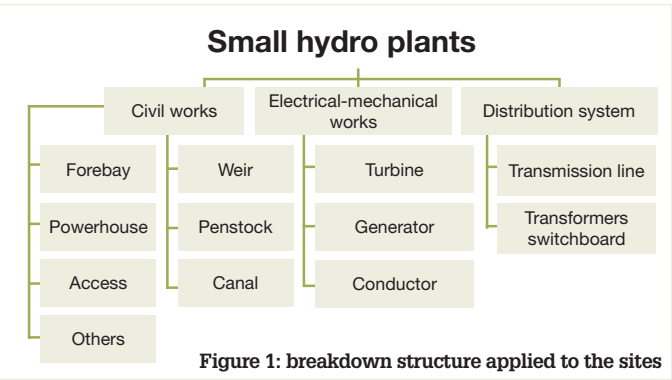

Figure 1: breakdown structure applied to the sites

Table 3: Rugezi

Rugezi 2,200 kW		Investment Costs (.000.000RWF)		
		100% Cost Estimate	85% Cost Estimate	115% Cost Estimate
		3.018	2.565	3.470
Years of Operation	Discount Factor	Net Present Value (.000.000RWF)		
10 years	15%	506	992	19
	17%	253	937	231
	20%	74	902	556
15 years	15%	1.087	1.580	595
	17%	720	1.209	231
	20%	265	749	220
20 years	15%	1.377	1.852	881
	17%	933	1.424	442
	20%	401	867	85

projects are: Nyamyotsi I – benchmark (71%), measurable (10%), unclear (61%); Nyamyotsi II – benchmark (71%), measurable (9%), unclear (62%); Mutobo – benchmark (71%), measurable (15%), unclear (56%); Agatobwe – benchmark (71%), measurable (15%), unclear (56%).

This demonstrates that a survey afterwards determined only 10-15% of the components whereas about 60% remained unclear. A further important indicator assessing the costs of the sites is the physical conditions of the components in relation to their specific cost portions. A ranking from 1- very poor to 5 – very good was applied. The ranking multiplied with the components individual percentages makes the benchmark of 4.8 of the total or 1.3 of the civil structures.

The over all scoring based on benchmark 4.8 is as follows, with the civil structure scoring based on benchmark 1.3 shown in bold: Nyamyotsi I – benchmark (4.8, **1.3**); score (2.14, **0.54**); percentage of quality (45%, **42%**); Nyamyotsi II – benchmark (4.8, **1.3**); score (1.88, **0.58**); percentage of quality (39%, **45%**); Mutobo – benchmark (4.8, **1.3**); score (2.86, **1.01**); percentage of quality (60%, **78%**); Agatobwe – benchmark (4.8, **1.3**); score (2.98, **1.03**); percentage of quality (62%, **79%**).

These four plants serve village customers only and their revenues rely solely on the consumption of households and small shops. Nyamyotsi I and Nyamyotsi II are two sites with extreme poor utilization factor and both need extensive rehabilitation efforts. Nyamyotsi I utilizes about 34% of the installed capacity and Nyamyotsi II 4% only.

Mutobo and Agatobwe are both overall in good physical condition but the customer side is not favourable as they only consume electricity during two to three evening hours only. Both sites need more anchor customers that consume electricity during daytime or connection to national grid in order to increase the utilization factor substantially.

Based on fixed tariffs the final financial analysis for each plant depends on five pa-rameters, which all have considerable uncertainties as detailed above: investment costs; utilization factor; operation and maintenance costs; period of amortization; and economic market conditions expressed with the discount factor.

The Electricity Law of Rwanda commits the national electricity supplier to take on fixed tariffs for all electricity produced by small hydropower plants not used by consumers in the villages. Consequently wby connecting to the national grid the utilization factor of each plant can be substantially improved.

The financial analysis is based on this situation and considers the following variation of parameters.

Table 4: Nyamyotsi I

Nyamyotsi I 100kW		Investment Costs (.000.000RWF)		
		100% Cost Estimate	85% Cost Estimate	115% Cost Estimate
		148	126	170
Years of Operation	Discount Factor	Net Present Value (.000.000RWF)		
10 years	15%	202	230	174
	17%	177	204	150
	20%	145	171	118
15 years	15%	260	289	231
	17%	223	252	195
	20%	178	206	151
20 years	15%	289	318	260
	17%	245	273	216
	20%	192	219	164

Table 5: Nyamyotsi II

Nyamyotsi II 100kW		Investment Costs (.000.000RWF)		
		100% Cost Estimate	85% Cost Estimate	115% Cost Estimate
		229	194	263
Years of Operation	Discount Factor	Net Present Value (.000.000RWF)		
10 years	15%	4	47	39
	17%	13	29	55
	20%	35	7	76
15 years	15%	42	86	2
	17%	18	61	26
	20%	12	30	55
20 years	15%	61	106	16
	17%	32	76	12
	20%	3	39	46

Table 6: Mutobo

Mutobo 200kW		Investment Costs (.000.000RWF)		
		100% Cost Estimate	85% Cost Estimate	115% Cost Estimate
		291	247	334
Years of Operation	Discount Factor	Net Present Value (.000.000RWF)		
10 years	15%	346	396	296
	17%	300	350	250
	20%	290	290	192
15 years	15%	451	502	400
	17%	385	435	334
	20%	302	352	253
20 years	15%	503	555	451
	17%	423	474	372
	20%	327	377	277

Table 7: Agatobwe

Agatobwe 200kW		Investment Costs (.000.000RWF)		
		100% Cost Estimate	85% Cost Estimate	115% Cost Estimate
		305	259	350
Years of Operation	Discount Factor	Net Present Value (.000.000RWF)		
10 years	15%	196	249	144
	17%	160	212	108
	20%	114	165	62
15 years	15%	279	332	225
	17%	227	280	174
	20%	162	214	110
20 years	15%	320	374	266
	17%	257	310	203
	20%	181	234	129

- Investment costs as estimated 100% and +/- 15% range of variation
- Utilization factor 75%
- O&M costs 1.5% - 5% of the total in-vestment, depending on the size of the plant
- Period of amortization (operation period) 10 / 15 / 20 years
- Discount rate 15% / 17% / 20%

Beside the utilization factor it is the discount rate that also has an impact on the results of the financial analysis. In the case study the discount rate is a parameter that covers the bank's interest rates, inflation factor, perception of market developments, business risks and some compensation for the money spent. In this regard. the discount rate should range between 15% and 20%.

Technically the life span of a SHP can easily last 30 years and more. But this is not relevant for a financial analysis, as a serious investor will ask about a manageable amortization period, which is usually much shorter than the life span. According to national law the tariffs shown in table 2 apply.

Results and conclusions

The case study with cost estimates; operational costs, maintenance costs and expectable revenues came to the spread of results shown in tables 3-7 (numbers in red are losses).

The financial analysis carried out during the course of the case study suggests that privatization of the five plants could be a promising option.. In terms of financial viability the ranking of the plants is:

- Mutobo and Agatobwe are favourable as both tariffs – 118 RWF for households and 87 RWF for national grid – offer good income sources.
- Rugezi suffers from the relatively low national grid tariff of 55RWF but can operate profitably. If the plant connects households and delivers a considerable portion of 20-30% for the higher tariff it will become more profitable.
- Nyamyotsi I is also profitable as the national grid tariff is 92RWF, which is quite close to the household tariff.
- Nyamyotsi II is definitely on the bottom line for two main reasons. Firstly the plant suffers from very poor physical conditions (penstock) and secondly it also needs upgrading in terms of sedimentation facilities. Nyamyotsi II is also the only plant where the final investment sum (to date value plus rehabilitation costs) is higher than the initial investment costs.. Considering Nyamyotsi II as a single unit the project will break even after ten years of operation with a discount rate of 17%. This is a long-term investment for a small 100kW hydropower plant. Nyamyotsi II must operate with Nyamyotsi I and consequently an investor must consider both plants as one unit.

In terms of feed-in tariffs the smaller plants are more favourable than the larger ones as the smaller the plant the higher the feed-in tariff per kWh.

However the financial analysis still provides a range of results depending on the parameters. For a very first assessment the following question should be answered: How much electricity (percentage) must be taken by the national grid from the start of operation to ensure profit after five years of operation under unfavourable market conditions (discount rate 20%)? The answers are:

- Rugezi –127%. The plant will need a longer period to become profitable, approximately eight years.
- Nyamyotsi I – 55%. The plant will become profitable even if the national grid contribution is limited to 55%.
- Nyamyotsi II – 119%. Similar to Rugezi the plant needs more than five years. As around 6% of the electricity will go to households the national grid portion would be limited to 94%.
- Mutobo – 14%. Mutobo delivers almost 75% of the electricity to households and taking this into account the plant would become profitable after 4-5 years even without feeding electricity to the national grid.
- Agatobwe – 84%. The household portion of Agatobwe is very low but the plant would become profitable even if the national grid contribution were limited to 84% of the total.w

At first this seems pretty academic but such rapid assessments have a very practical benefit. The figures provide a good indication of the robustness of the overall conditions.

Without an assessment and on a first view the Rugezi plant seems to be the most beneficial. It is the biggest, the newest and delivers 100% of the electricity into the national grid. But the limited tariff of 55RWF/kWh and the fact that the national grid is the sole customer are considerable restrictions in terms of privatization.

According to the figures above Nyamyotsi I seems profitable with less risks for a private operator than Agatobwe. Also a very interesting outcome of this assessment is Agatobwe is in much better physical conditions than Nyamyotsi I. But the size of Nyamyotsi I allows a better utilization in terms of available customers than Agatobwe.

Subject to privatization plans of the five sites the case study brought two main aspects to the investors attention: sufficient utilization factors and substantial records about revenues and costs.

The utilization factor relies on two important indicators: balanced electricity consumption over 24 hours; and satisfied customers. Balanced electricity consumption needs anchor customers using electricity during day-time and satisfied customers require good service and professional operation and maintenance of the plants. The latter is costly and those costs have a substantial impact on the profitability of the small hydropower plants.

The case study comes to the conclusion that decentralized small hydropower plants are favourable options in Rwanda and privatization is an attractive option for all parties concerned ■.

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