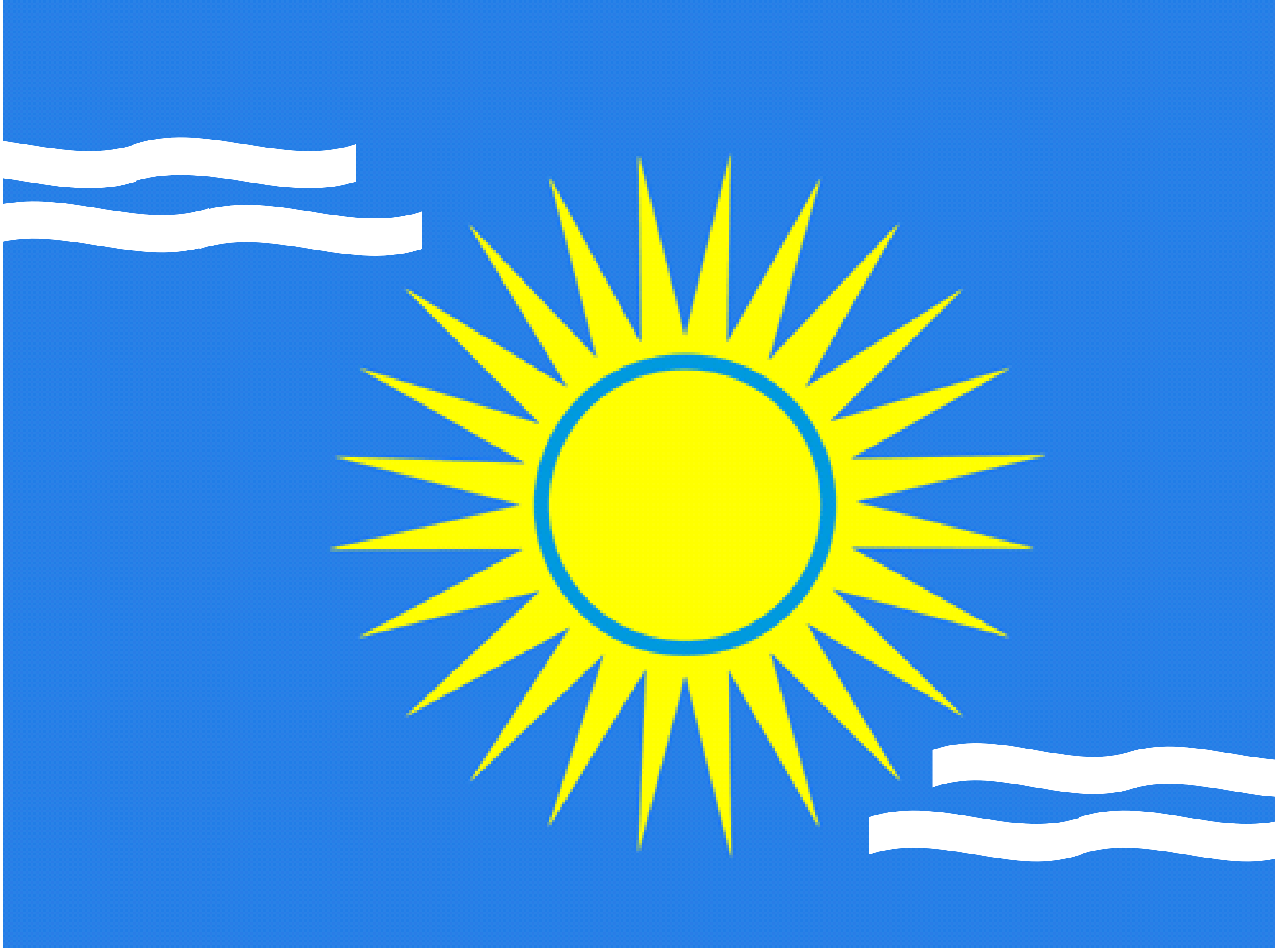

PSP Hydro

Private Sector Participation in Micro-hydro Power Supply for Rural Development, Rwanda

Baseline Study Report

gtz

rwi

Project Name: Private Sector Participation in Micro-hydro Power Supply for Rural Development, Rwanda

Project Number: PN 56.3021.5-001.02

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Abbreviations

ADENYA Association pour le Développement de Nyabimata (Association for the Development of Nyabimata)
BA_c Base, control site with Électrogaz grid
CV Control Village
CY_c Nyanga/ Cyanika, control site with Électrogaz grid
DHS Demographic and Health Survey (conducted in 2005)
EICV Enquête Intégrale sur les Conditions de Vie des Ménages (Household Living Conditions Survey)
EICV1 First EICV (conducted in 2001)
EICV2 Second EICV (conducted in 2006)
ENNy Energie Nyaruguru (Nyaruguru Energy)
EnDev Energising Development
EUR Euro (average exchange rate of EUR/FRw in mid 2007 = 1:750)
FHI Family Health International
FRw Francs Rwandaises (Rwandan Francs)
GA_c Gasarenda, control site with Électrogaz grid
GDP Gross Domestic Product
GTR Groupe des Travaux Ruraux (Rural Development Group)
GTZ Gesellschaft für Technische Zusammenarbeit (German Technical Cooperation)
ha hectare = 10,000 m^2
HS Household size
ICT Information and Communication Technology
KA Kavumu, site exploited by RES
KI_c Kibangu, control site
kw kilo watt
kwh kilo watt hours
lm Lumen
lmh Lumen hours
LV Low Voltage
MDG Millennium Development Goal
MHP Micro-Hydro Plant
MINALOC Ministère de l'Administration Locale (Ministry of Local Government)
MINECOFIN Ministère des Finances et de la Planification Economique (Ministry of Finance and Economic Planning)
MINEDUC Ministère de l'Éducation (Ministry of Education)
MININFRA Ministère des Infrastructures (Ministry of Infrastructure)
MINISANTE Ministère de la Santé (Ministry of Health)
MP Mpenge, site originally intended to be exploited by GTR
MSE Micro and Small Enterprise
MV Medium Voltage
MU Musarara, site exploited by SOGEMR
mw mega watt
N_H Number of electrified households
NI_c Nyamyotsi, control site exploited by UNIDO
n/k not known
NY Nyaruguru, site exploited by ENNy
PD Project Developer
PSP Private Sector Participation
PSP Hydro "Private Sector Participation in Micro-hydro Power Supply for Rural Development, Rwanda"
PV Project Village
PV_m Matched Project Village Households
RES Rural Energy Solutions
RU_c Rutsiro, control site with Électrogaz grid
SHER Société pour l'Hydraulique, l'Environnement et la Réhabilitation (Company for Hydraulics, Environment and Rehabilitation)
SOGEMR Société de Gestion de l'Electricité et de l'Eau en Milieu Rural (Rural Electricity and Water Management Company)
UNIDO United Nations Industrial Development Organization
UNDP United Nations Development Programme
VHF Very High Frequency

Acknowledgements

We would like to thank everyone involved in the baseline for the unanimously very cooperative and sympathetic way of working together. Beginning with the teams at the GTZ offices in Kigali and Ethiopia, we want to show appreciation to their quick support and patience with the organisational unpredictabilities constantly faced during the survey. Thanks also to Mario Merchan, the project coordinator of PSP Hydro, to his predecessor Maurice Pigaht, the Project Developers and the Ministry of Infrastructure for always being supportive in case of need for information. A warm thank you goes to the whole team of interviewers of IBC Kigali for the very *franche collaboration* and their remarkable commitment to the study through reliable assistance and helpful discussions. We are also grateful to those people contacted during the field study in Rwanda. For the very most part, they did not bother to provide us on the spot with helpful insights. This especially holds for those persons interviewed in Kigali and the control villages Kibangu, Gasarenda, Nyamyotsi, and in the regions of Nyanga/ Cyanika, Rutsiro and Base who cooperated in the same way though not directly benefiting from the ongoing intervention.

Furthermore, we would like to thank Florian Ziegler, Robert Heine, Robert J. van der Plas, Marcel Raats, Edith Bernhard, Andreas Michel, Rixa Schwarz, Manuel Frondel and Colin Vance for valuable and inspiring remarks and discussions. Last but not least, we are grateful to Marek Harsdorff for making available the questionnaire he prepared for a baseline survey in Benin.

Foreword

Energising Development (EnDev) is a Dutch-German partnership implemented by GTZ with the aim of promoting sustainable access to modern energy services for 5 million people in developing countries. In this context, the Directorate-General for International Cooperation (DGIS) at the Dutch Ministry of Foreign Affairs and the German Federal Ministry for Economic Cooperation and Development (BMZ) have been first-movers in setting specific, quantified targets to measure the provision of sustainable access to modern energy services. EnDev includes the following types of modern energy services: (i) Lighting and household applications; (ii) cooking; (iii) social infrastructure, and (iv) productive uses.

This output-based commitment is a contribution to the achievement of the MDGs. The assumption behind this is that sustainable access to modern energy services fosters economic and social development, leads to improvements in the quality of life, and minimizes the negative external effects on the environment on both local and global scales. Furthermore, EnDev accountability measurement requirements are in line with the idea of the MDGs: Every project under EnDev is committed to report reliable, trustworthy, and comparable figures about the number of people provided with modern energy.

The Energising Development programme has proven the feasibility of reaching its output target. Two and a half years after it commenced in 2005, 95 per cent of the first phase target has been achieved, i.e. nearly 3.1 million people have been led out of energy poverty and served with a form of modern energy services.

In order to represent interests of the cooperating partners and political decision-makers, GTZ, as the implementing organisation, is obligated to maximise the impacts of interventions with given funds. For that purpose, it also has to verify the appropriateness of the above assumption about the contribution of access to modern energy to poverty reduction. This is substantiated, inter alia, by summarizing experiences and lessons learnt to form a basis for political decision-making.

The target group's needs have been the focus of many discussions between GTZ and the partners on the political level as well as other actors of the development community. The question is whether the people without any access to energy services should be targeted exclusively or whether people with existent but deficient access should be included equally. These discussions reflect the different approaches towards improving the global effectiveness of development initiatives.

Effectively, however, these two approaches are complements rather than substitutes. The reason is that moving from a situation in which a person lives without any lights and fuelling his/her fireplace with dung, to a situation with a solar lantern and an improved fuel wood stove could induce the same poverty impact as someone whose already existent electricity access is improved by e.g. enhanced grid reliability. As a matter of course, the magnitude of impacts evoked by climbing the so called energy ladder differs among countries and environments.

The scale of this energy ladder is not the calorific value of energy consumption. The beneficiary is interested in lighting during the evening hours at certain brightness, or heating to a certain temperature during the cold season. The scale can therefore rather be expressed in terms of the energy services consumed – be it cooking with dung, lighting with kerosene, or watching TV with grid electricity. At the same time, it is imaginable that access to a certain service is an improvement for one group while it would be of little use for another. As an example, one might consider the case of fishermen in Eastern Africa, among whom portable solar lanterns are much more required than grid access.

These considerations illustrate that the simple application of technology parameters or prosperity indicators for the energy ladder scale may not be appropriate. Instead, it seems to be useful to define technological indicators as an intermediate step for individual interventions. For initiatives or fund allocation in general, they are, however, too restrictive and would lead development aid out of its frame of reference, i.e. to contribute to the MDGs and development dynamics.

Energising Development has therefore started an initiative to evaluate energy access projects in a way that is strongly impact oriented. In addition to the indicators defined in the MDGs, the impacts are measured through an assessment of economic benefits, thereby including conceivable impacts on the individual household level as well as benefits for the national economy.

In this context, RWI Essen implemented a survey in the target villages of the EnDev component Rwanda (Private Sector Participation in Hydro-power for Rural Economic Development, PSP Hydro). This survey should initially portray the socio-economic conditions in the first four chosen project sites before project implementation, thereby providing a basis for future ex-post impact evaluation in the sense of a baseline study. In addition, the expected impacts were assessed by including cross-sectional control villages that already have access to grid electricity. This so-called ex-ante impact analysis compares living conditions in those control villages to those in the target region. The study was implemented in close cooperation with the main developing partners, the Rwandan Ministry of Infrastructure and GTZ.

This comprehensive survey and all lessons learned in the context of further impact evaluation are used to improve the planning of development measures, to improve advice to political decision-makers, and to increase the efficiency of development aid.

Energising Development is not yet able to provide area-wide figures on the costs and level of impact improvement of any given incremental impact step. GTZ, its development partners, and highly acknowledged research partners like RWI Essen are trying constantly to improve survey methodologies and the database. The ultimate goal is well defined risk management on the political level for output-based development initiatives.

Florian Ziegler
Programme Manager, Energising Development

Executive Summary

Background to the Study

This report presents the findings of the baseline study for an upcoming rural electrification project supported by GTZ. The basic characteristics of this development measure already become clear through the project title: "Private Sector Participation in Micro-Hydro Power Supply for Rural Development, Rwanda" (PSP Hydro). Concretely, PSP Hydro envisages supporting five private Rwandan Project Developers financially and with ongoing training. The intervention is realized under the umbrella of the Dutch-German Energy Partnership "Energising Development" (EnDev). The baseline study serves to portray the socio-economic conditions in the project areas, which will constitute the yardstick for the monitoring and a future impact assessment of the intervention. Due to the explicit output-based commitment of EnDev, special attention has been put on reliable estimates of the prospective project beneficiaries. Predefined counting rules for the relevant potential beneficiary groups of households, social infrastructure institutions and micro and small enterprises (MSE) have been applied and partly adapted to the concrete conditions in Rwanda.

Due to a sequence of project selection phases, the baseline was conducted at two points of time: between April and July 2007 and in November and December 2008. In total, 741 households have been visited, gathering information about a total number of 4057 household members. Furthermore, 107 rural enterprises have been interviewed as well as 100 social infrastructure institutions comprising schools, health centers, administrative offices and churches. While most of them were located in five target regions of PSP Hydro, around 45 percent of the interviews were held in six comparable, already electrified villages in rural Rwanda. This control group has been included in the baseline approach in order to allow cross-sectional comparisons, thereby substantiating the impact assessment even before project implementation. According to the sampling design, households have been selected irrespective of being clients or non-clients of the electricity utility so as to gain insights both on electricity use and on bottlenecks concerning grid connection. In addition, impacts of electrification on both household types can be assessed using modern evaluation techniques. In order to make the survey and its interpretation as transparent as possible, this report provides for detailed descriptions of the current status quo, maps and photographs of the project sites and the respective potential customers.

Expected Project Beneficiaries

Baseline information can be provided on all five project sites. Yet, the original project of the site in the outskirts of Ruhengeri has been cancelled in the meantime and a business plan by a new Project Developer is yet in progress. A second site, the rehabilitation project in Murunda is already reliably electrified. It still remains to be seen, in how far the intervention positively impacts the energy situation of the local population. It is, furthermore, unclear how new EnDev guidelines on the countability of project beneficiaries will treat such a case. These new guidelines shall be applied to all EnDev projects starting operations from 2010 on, which will probably the case for the PSP Hydro projects. According to the current counting guidelines, the Murunda project in its present setup cannot be counted. Therefore, data on potential beneficiaries is given only for the other three project sites. According to the current level of information, some 40,000 people can be expected to benefit from the intervention at these sites in the North, North-East and South of the country. They can be divided up according to the number of people provided with

- lighting/household energy: 1,500
- energy in social infrastructure: 28,500
- energy for productive use: 11,000.

These aggregate figures have to be carefully appreciated. As mentioned above, the calculation formulae are not yet definite. EnDev already expressed its interest in an overhaul of these formulae. Due to the early stage of implementation and unpredictabilities stemming from the market-based approach of the development measure, these estimates had to be based on a range of assumptions and were partly calculated using probability weights. The two main suppositions are (i) the connection probability and (ii) the probability of grid coverage. On the one hand, based on the impressions gleaned from visiting both the project and electrified control villages, it is expected that every third household in the surrounding of the grid will connect to the grid. The expected connection rates of MSEs are type-specific (for example, every fifth shop is supposed to electrify). Apart from primary schools, all social infrastructure institutions are expected to connect to the project grids. On the other hand, the physical electricity grid is not yet established and it will probably not reach at all sites the extension presented in the Project Developer's business plans. Some regions have therefore been included in the beneficiary counting with a reduced weighting.

Existing Energy Sources

Since EnDev, moreover, only counts newly provided modern energy access, the existence of electricity sources like generators, solar panels and car batteries before the intervention has to be investigated. Especially health centers, secondary schools and sector offices often already possess either a generator or solar panels. These panels are generally old and therefore perform poorly or are even out of order. Since the change to grid electricity can be considered a significant improvement of electricity supply for these institutions, it is proposed to include generators and solar panels into the counting with a reduced weight of 0.25 and 0.5, respectively. The weight of 0.5 shall as well be applied to car batteries. Among MSEs, the predominant alternative electricity sources are generators found with mills and barbers. Altogether, the percentage of pre-electrified MSEs among the customer MSEs of the project grids is expected to be 75 among mills and barbers and ten percent among the others. Among households, only five percent by now have a modern energy source, including car batteries.

Household Energy Use

Correspondingly, energy is delivered in the project village households predominantly by traditional energy sources. More than 85 percent of these households use kerosene and firewood and still two-thirds use batteries; less than every fifth consumes candles or charcoal for lighting and cooking. On average, 3,850 FRw (5 EUR) per month are spent on energy, which corresponds to less than a fifth of total expenditures. While this share gets smaller the richer the household is in non-electrified villages, the opposite is the case in connected households. The most considerable improvement at the household level can be expected in terms of lighting. Outstanding 91 percent in connected households see lighting as the main advantage of electricity. Among these connected households, three out of four switched totally from traditional to modern, electric lighting sources. They benefit through (i) more convenience thanks to the presence of a light switch and the ceasing of the need to fetch kerosene; (ii) better quality – connected households consume 7 times more lighting and 300 times more Lumen hours than non-connected ones; (iii) less indoor smoke and (iv) lower unit costs – e. g. savings amount to 40 percent if kerosene is substituted by incandescent light bulbs, 85 percent if substituted by compact fluorescent bulbs. Apart from kerosene for lighting, resource savings can be expected from substituting batteries for radio use and generator fuel. Cost savings in the range of 50 to 60 percent for each are attainable. Cooking and thereby the consumption of cooking fuels will not be affected by electricity.

Concerning electrical appliances, radios and mobile phones are quite common in both project and control villages. Despite the lack of electricity and lower network coverage, already 20 percent own a mobile phone in the non-electrified project villages. Yet, electrification goes along with much higher rates of mobile phone possession (over 55 percent). Apart from that, in the control villages only irons and television sets can be found in significant quantities of 16 and 11 percent respectively. In the project villages, most kinds of electrical appliances are lacking. Since only a minimal proportion of the population uses these appliances outside their home (e.g. at a bar or a neighbours' place), little experience with electricity and electrical appliances exists. Without explicit efforts from external sources, productive uses of electricity do not emerge substantially. Among connected households in the control villages, eight percent actually developed any novel activity for which energy is required, such as commerce or welding.

The high up-front grid connection costs are the main access barrier for households in electrified regions. These would further rise substantially if the household would need to move house in order to come into reach of the electricity grid. In the very dispersed Rwandan settlements, such relocations are, however, necessary in order to reach the targeted connection rates. Only few households see themselves capable or willing to do so.

Energy Use in Social Infrastructure Institutions

Three of the five health centers in the project villages possess irreparable solar panels. Necessary operations and rounds at night have to be lit unhygienically by means of kerosene hurricane lamps. Patients arriving at night must wait until morning to receive care. Microscopes can only be used at sunlight. The other two health centers currently possess solar panels that perform poorly. Here, power is not reliable enough to maintain the cold chain. Kerosene-run refrigerator/ freezer combinations have to be run instead. Hence, the relevant question for health centers to connect to one of the project grids will be the reliability of the electricity provided. Power is neither sufficient to allow for the usage of computers and printers. Apart from electric lighting, another main difference to the other group of health centers is the existence of a television set for sensitization purposes. Electrical sterilization devices for hygiene are lacking in all visited centers.

Primary schools currently seem to neither have the resources nor an elevated need for electricity. Even in electrified regions, electricity is only used, if at all, for the installation of the headmaster's office. Secondary schools, on the other hand, do have significant electricity needs. Three of the five schools in the non-electrified project regions already own a generator, another one possesses solar panels. The secondary school in the already electrified project village Murunda is connected to the grid. On a daily basis, students study during night at school. Commonly two thirds of them are boarders, staying in nearby dormitories. Many schools already have computers and television sets, but due to the high fuel costs, they can use them only sporadically. It therefore is quite probable that these schools will substitute grid electricity for their present electricity sources.

Sector offices would use electricity for administrative purposes, i. e. computers, printers and a telephone. Lighting is used only in exceptional cases, since offices usually shut before sunset. Currently, though, they do not have the necessary budget for grid connection and electricity payments.

Micro and Small Enterprises

The existing Micro and Small Enterprises (MSEs) predominantly belong to one of the following six groups: Bars/ Restaurants, Shops, Barber Shops, Mills, Tailor Shops and Carpenter Workshops. In the control villages, further businesses reliant on electricity were found, such as welding (partly in combination with a bicycle repair workshop), battery charging, one shop with photocopying, film showing spaces, but also more specialised retailers like shoe shops. The main perceived problems of these enterprises in the order of importance are (i) the lack of clients; (ii) financial matters – capital is lacking, but also taxes and non-payments by clients pose problems for the small businesspeople, while poor availability of credits was uttered only by MSEs in control villages, (iii) inputs – machines are either missing or very old and for some MSEs, there is also a shortage of (primary) material like wood and cloth; (iv) electricity – fuel and electricity are either missing or too costly from the interviewee's point of view. MSE will accordingly not automatically connect. Instead, it is anticipated that they will rather connect with a business-type specific probability ranging between 10 percent for tailors and carpenters and 50 percent for barbers and millers. Among the six MSE business types present in the project villages, carpenter workshops equipped with electrical carpenter machinery are considered to have the highest socio-economic impact on the local community. Furniture of considerably higher quality can be produced in less time. Due to a bigger market size of carpenters, effects on revenue and employment can also be sizeable.

Electrification Impacts

Direct electrification impacts on household energy use, such as better lighting and per-unit cost savings, have already been mentioned. The same holds for impacts on social infrastructure institutions and MSEs from which ultimately every individual household benefits – both connected and non-connected. In the case of MSEs, benefits trickle down to households on one hand through an increase in crop transformation, which is, furthermore, bound to become cheaper. On the other hand, people profit from improved income generation opportunities due to efficiency gains and the ability to create new enterprises in need of electricity. These can be for instance welding, battery charging, film exhibition or poultry farming. Evidence from the survey suggests that electrification actually translates into community-wide wealth impacts. In this report we develop a wealth indicator that combines 14 sub-indicators representing assets, expenditure, and income. Project villages do not attain a similar wealth level as the comparable control villages. There is, however, not sufficient evidence on the relevant transmission channels. Furthermore, it remains unclear whether there remain unobservable differences in the compared village types that determine the differences in outcomes as well such as local social capital. It should be mentioned as well that inequality might deteriorate in the short run, since poor households connect eight times less than wealthier households. As the target villages are in less favoured areas of Rwanda, the inter-regional inequality will, nevertheless, improve.

Since pupils spend a lot of time, sometimes the whole day, at school, positive educational impacts of electrification will primarily materialize at the school level. Nevertheless, longer hours of learning in the evening are noticeable at the household level, too: Primary school pupils spend on average 26 percent more time on studying after sunset in connected households than in comparable project village households. Isolating health impacts on household level is much more difficult. There is weak evidence for a lower prevalence of respiratory system diseases in electrified regions. Substantial effects might materialize in case cooking fuels were to be substituted by electricity. This is, however, neither probable nor desirable in light of the limited capacity of the micro-hydro plants.

Electrification impacts on workload – especially that of women – could not be convincingly analysed by means of the present dataset. The relevant transmission channels provide little indication on significant impacts to be expected. The relief from household duties is negligible. On the other hand new job opportunities for women in the service sector emerge where hours worked tend to be higher.

Recommendations

In order to facilitate the achievement of the final goals that the Project Developers run their micro-hydro plants in a sustainable way and that households benefit persistently from electricity, complementary activities should focus at the following:

(i) raising the ability to pay of the population (training courses for selected craftsmen on the use of electric appliances for familiar activities and on new activities conditional on electricity such as poultry farming or juice production; facilitating micro credits or grants for productive electrical appliances in cooperation with the GTZ private sector development programme EcoEmploi; analysing the potential of home businesses; supporting local organisations like cooperatives in their efforts to improve the working conditions and income generation options of subsistence farmers);
(ii) reducing the up-front and current costs of electricity (dissemination of energy saving bulbs, elaboration of pro-poor strategies, e. g. grid electricity alternatives like car batteries and rechargeable);
(iii) optimizing the customer-provider relationship (building up trust among the population through better communication; insisting in the introduction of pre-paid meters);
(iv) consumer education (sensitisation about what can realistically be expected from electricity and how people can best benefit from it);

(v) technical support (seeking to guarantee a dependable and continuous electricity supply by the Project Developers from the beginning).

An exchange of experiences concerning consumer behaviour with the Rwandan national biogas programme is also recommended. Furthermore, this report includes a set of Monitoring Instruments proposed to accompany the development measure.

In conclusion, the baseline provides a broad socio-economic profile of the target regions of PSP Hydro, also through comparing data with other, electrified villages in Rwanda. The questionnaire, the survey and the data analysis were designed to easily conduct further surveys, e.g. on complementary sites or in an endline survey. The very low grid coverage in Rwanda's rural areas hampered the selection of a sufficient amount of control villages for an optimal cross-sectional comparison. The cross-sectional approach, nevertheless, generated reliable and illuminating impact assessment information and substantiated a wide range of development hypotheses concerning electrification. Households benefit primarily through improvements in the quality of life. The potential of electricity as a driving force for local economic growth does require complementary measures.

1 Introduction

This chapter provides a concentrated description of the national, sectoral and technical cooperation environment in which the development measure PSP Hydro has been established.

1.1 Country's State of Affairs

Rwanda is a country in the Great Lakes region of east-central Africa, a few degrees south of the Equator. Similar to Belgium in terms of dimension and population, Rwanda supports the densest human population in continental Africa.

Since its administrative reorganisation in 2006, the Republic of Rwanda is subdivided in 5 provinces, 30 districts and 415 sectors, areas comprising on average 15,000 to 20,000 people. These are further subdivided in cells and so-called “imidugudus”. Imidugudus are centres being established to gather the traditionally dispersed settled rural households around basic infrastructure like schools, health centres, markets and roads.

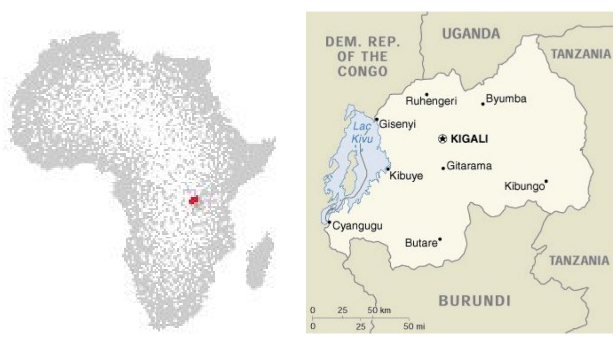
After a long and difficult process of recovery from one of the worst atrocities in Africa that devastated the country’s human, physical and social capital in 1994, Rwanda is now firmly on the path of resurgence and economic development. Primary export goods are coffee and tea, with the addition in recent years of minerals and flowers. Tourism is a growing sector as well, notably around ecotourism and the unique mountain gorillas in the Virunga Park.

In its “Vision 2020”, the government has set a framework of key policies for Rwanda’s development based on good governance and leapfrogging. Growth rates have averaged 4.9 percent per annum since 2000, making Rwanda one of the top performers in Africa. Progress could also be observed in areas such the access to education and health, gender equality and democratic governance. Its achievements in establishing an aid coordination, harmonisation, and alignment framework are being recognised by OECD as international best-practice. As mentioned by UNDP in its latest Rwanda National Human Development Report (UNDP 2007b) agriculture, demography and income distribution pose major problems on a sustained growth path. Moreover, Rwanda as the majority of Sub-Saharan Countries faces a serious lack of electricity supply, which is part of a general energy shortage.

Box 1: Synthesis of Main Socio-economic Indicators and Map of Rwanda

Year	2000	2007
Land Surface (km^2)	24,948	
Population (millions)	8.0	9.7
Population Density (per km^2)	321	389
Ann. Pop. Growth Rate (%)	6.8	2.7
Urban Population (%)	14	19
Real GDP Growth Rate (%)	6.0	6.0
Life Expectancy at Birth (y.)	41.0	46
Net Enrolment in 1^{ary} Schools (%)	73	86
HDI* Rank among 177 countries	162	161
“GDI-HDI Ratio”-Rank* among 136 countries	n/k	28

Blue colourisation specifies values that are higher than the average for Sub-Saharan Countries, red ones those that are lower while grey represents values that are identical with the Sub-Saharan average.



** The UN Human Development Index (HDI) is comparative measure of life expectancy, literacy, education, and standard of living for countries. The UN Gender-related Development Index (GDI) represents the same measure for women.*

Sources: ADB 2008, CIA 2009, UNDP 2007, WB 2009

1.2 Energy Sector

In Rwanda, energy generation from wood fuels dominates with an estimated 95 percent of the total energy supply. The country lost 50.2 percent of its forest and woodland habitat between 1990 and 2005 which lead to a lack of wood for other economic activities (e.g. construction), soil erosion, and the drying up of rivers and lakes (UNDP 2007b). Replanting and sensitization programmes came up in the last years to address this problem.

Accordingly, only about 5 percent of the households have access to grid-supplied electricity. A more in-depth study by Lahmeyer (LAHMEYER 2004) arrived at an estimate for this figure of mere 2.5 percent, making it one of the countries with the lowest per capita electricity consumption in the world. Furthermore, electricity is almost entirely consumed in the main cities. Only about 1 percent of the rural population is connected, while Kigali alone accounts for over 70 percent of the total low-voltage electricity consumption. One target of "Vision 2020" for the energy sector is defined in terms of per capita electricity consumption. It is due to raise from 30 kwh per year in 2004 to about 60 in 2010 and at least 100 kwh per year in 2020 (MINECOFIN 2000).

Investments in new generation or network capacities have been limited in the past, Energy Sector Reform advances slowly. The supply is provided half by imported and inhouse hydroelectric power and half by extremely costly rented and inhouse thermal power generators, which have been acquired in 2004. Since the national hydroelectric power stations partly operate at only 25 percent capacity, only 50 of the 72 mw installed capacity are available. Annual national electricity production was estimated at 93m kwh in 2004 in contrast to consumption at 196m kwh (EIU 2008). Expectations to solve this electricity shortage are being raised by the vast methane gas reserves in lake Kivu. A first pilot plant was successfully launched in November 2008. Plans for two further projects already exist that shall have a capacity of 50 mw each in the medium term. A further current major project is the recently started construction of a 27.5 mw hydro power plant at Nyabarongo River in Rwanda's Western Province.

Concerning micro-hydro, less than 20 micro-hydro plants existed before 1994. Of these, currently only one is operational. Adding to these supply constraints, traditional energy options in rural areas are even more limited as the extension of the public electricity grid in this mainly hilly country is prohibitively expensive.

1.3 PSP Hydro Rwanda

To account for the persistent problem of rural energy poverty in Rwanda, GTZ has been implementing the development measure "Private Sector Participation in Micro-Hydro Power Supply for Rural Development, Rwanda" (PSP Hydro) since mid 2006. It is part of the Dutch-German Energy Partnership "Energising Development" (EnDev) (see Box 2), which aims at providing 5 million people in developing countries with sustainable access to modern energy, i. e. (reliable) grid electricity, solar panels, generators or – to a limited extent – car batteries. Its advantages over traditional energy (candles, kerosene, batteries, wood, etc.) become manifest in terms of versatility, power and rather lower prices.

Photo 1: Waterfall at Mpenge Site

Box 2: Energising Development

Energising Development (EnDev) is a Dutch-German partnership on access to energy implemented by the GTZ. Its goal is to actively promote and realise sustainable access to modern energy services for 5 million people in developing countries and thereby contributing to the achievement of the Millennium Development Goals (MDGs), as energy is seen as a prerequisite to the achievement of all eight MDGs (cf. DFID 2002). In this context, the Directorate-General for International Co-operation (DGIS) at the Dutch Ministry of Foreign Affairs and the German Federal Ministry for Economic Cooperation and Development (BMZ) have been first-movers in setting specific, quantified targets to measure the provision of "sustainable access to modern energy". Every project under EnDev is required to report reliable, trustworthy and comparable figures about the number of people provided with modern energy. Therefore, standardised rules for calculating the number of people reached, the "EnDev beneficiaries", have been developed. The types of energy services included in EnDev are modern energy for:

(i) Lighting and household applications,
(ii) cooking,
(iii) social infrastructure, and
(iv) productive use,

while only (i), (iii) and (iv) are relevant for PSP Hydro. According to these calculations, the target to reach 3.1 million people during the first phase of EnDev (2005–2009) is achieved. It is planned that the counting rules get overhauled for the second phase of EnDev and then applied to all projects starting from 2010 onwards. Since this is the case for at least part of the PSP Hydro sites, those adaptations are of relevance for PSP Hydro as well. Further details can be found in chapter 2.2.

Apart from rural electrification in Rwanda, PSP Hydro pursues the objective of inciting the development of an institutional environment favourable to private participation in energy provision. It therefore contributes to policies of the Government of Rwanda defined in the "Economic Development and Poverty Reduction Strategy Paper" concerning regionalisation and the productive sector. Concretely, PSP Hydro supports five project developers (PDs) financially (with a maximum grant of 50 percent of investment costs) and with ongoing training. These PDs were chosen after two rounds of Call for Proposals in 2005 and 2007 to build micro hydro power plants and to serve households, firms, and community institutions with electricity. PSP Hydro did not recommend any concrete sites for these plants and in general tried to make the PDs decide on the specification of project-related questions.

The second round of Call for Proposals became necessary as two of the original six PDs had to be replaced. Of the two substituting PDs, again one desisted, leaving five project sites run by private companies, of which two originated from community organisations (SOGEMR and ENNy). This report joins information on all five projects.

Since the first phase of the baseline survey took place in mid 2007 while this second round of Call for Proposals was still ongoing, the site of the last PD, REPRO, has been surveyed only in end of 2008. All four surveyed sites visited in the first phase of the baseline survey in mid 2007 were still in the planning phase at that time. Until the second phase of the baseline survey in end of 2008, construction works at the micro-hydro plant site reached an advanced stage only at SOGEMR and RES. Notwithstanding the later project start, the fifth site, REPRO, is even more advanced and is expected to be the first in starting operation. This is partly due to the fact that it is – in contrast to the other projects – a rehabilitation of an abandoned micro-hydro site.

The project grid design is not yet definite at any site, and therefore possibly subject to modifications. Since the project grids determine the beneficiary centers and are therefore crucial for the survey, this baseline as well analysed the feasibility of the electricity grids outlined in the business plans of the PDs.

2 Baseline Approach

This chapter offers background information on why, how and which data has been gathered.

2.1 Objectives

As one of the last steps of the pre-implementation phase of the development measure, the Baseline Survey pursues mainly six aims:

1. Portray the socio-economic conditions in the project regions.

   The accountability of socio-economic change to the provision of electricity access is a matter of complex investigation. It is therefore required to document conditions at the beginning of the programme in order to provide a picture of the status quo, a baseline from which to measure progress.

2. Serve as a data basis for monitoring activities.

   The Baseline Survey is also part of a broader Monitoring and Evaluation Process which is carried out throughout the project. Accordingly, all applicable indicators of EnDev Impact Monitoring (cf. GTZ 2007) shall be considered. In particular, estimations of the probable number of beneficiaries in 2010 are elaborated according to EnDev Counting guidelines (cf. chapter 2.2).

3. Investigating the development effect of the intervention through with-without comparison.

   In order to inform stakeholders of the expected consequences of interventions, international development organisations set out to implement ex ante poverty impact assessment processes (cf. OECD 2007). In this case, both descriptive and econometric analysis of the linkages between energy availability, energy use and economic development is conducted. This is done by visiting – apart from PSP Hydro project sites – another four villages in Rwanda, which show similar basic characteristics but are yet electrified.

4. Provide benchmark data for a potential ex-post Impact Evaluation of PSP Hydro.

   Apart from the effectiveness of a specific intervention type, of course, the success of the specific project is of interest. For that purpose, data collection and analysis shall be conducted such that they facilitate a straightforward implementation of a potential ex-post study.

5. Reducing uncertainty about demand assumptions in the target regions.

   For a successful project implementation and a transparent estimation of expected "EnDev beneficiaries" (cf. Box 2), a thorough investigation of key information is crucial. This key information comprises among others the number of connecting households, affordability issues, current energy consumption and the agglomeration process in the target regions. This analysis is of special interest for PSP Hydro due to the programme setup with GTZ as a main financial contributor not having prepared the business plans.

6. Surveying the anticipated requirements of complementary activities.

   Potential obstacles and bottlenecks on the consumer side concerning grid connection shall be tracked and suitable interventions proposed. At the same time, the target population shall be sensitized to energy consumption decisions and the opportunities provided by electricity.

These objectives pose particular requirements on the methodology applied. This includes not only the general aspects of sampling (see chapter 2.6) and the questionnaire design (chapter 2.4 and 2.5), but also the more specific questions of EnDev counting and with-without comparison, which will be dealt with beforehand in chapter 2.2 and 2.3.

2.2 EnDev Counting

Due to its output-based commitment (cf. Box 2, page 3) and in order to support planning and monitoring, reliable estimates of EnDev's beneficiaries are indispensable. For PSP Hydro, the relevant potential beneficiary groups are households, social infrastructure and micro and small enterprises (MSE). Since so far only rough figures made available by the PDs were considered, the baseline aims at creating a more reliable data basis. Moreover, the baseline is crucial for determining, whether the further EnDev criteria are fulfilled: The access is (i) newly provided, and (ii) additional, i.e. it would not be realized without EnDev intervention. Furthermore, (iii) EnDev can be held accountable for the access. Even the satisfaction of the first criterion can be problematic in special cases where electricity sources existed already beforehand. Applying the energy ladder paradigm, clients may be counted whose former electricity source has been very unreliable. The idea is that a proper step on the energy ladder, i.e. a considerable improvement in the energy provision, has been made – e. g. an old solar panel with poor batteries at a health center is replaced by grid electricity. These special cases have to be taken into consideration individually. Nonetheless, standardised rules for calculating the number of "EnDev beneficiaries" have already been developed in order to achieve comparability among the different EnDev projects. Adaptations in the calculation formula have been announced for the next year. Since these are not yet decided upon, even the existing rules are in part not fully developed and minor adaptation to the specific circumstances that prevail in Rwanda are advisable, this issue shall be discussed in more detail in the following paragraphs.

2.2.1 Households

The number of people provided with modern energy for lighting and household applications is calculated according to EnDev guidelines by multiplying the number of connected households (N_H) with the average household size (HS). While HS can be easily retrieved from the baseline survey (in this case it amounts to 5.6), estimates of N_H will be provided in chapter 5 or – in more detail – in appendix A7.

Table 1: Accounting Shares of Institution Types

Schools	0.35
Health Institutions	0.35
Communal Services	0.30
Social Infrastructure	1.00

2.2.2 Social Infrastructure

A person is counted as having access to social infrastructure if he or she is supplied with schools, health institutions and communal services. The accounting shares of institution type in Table 1 are supposed to reflect the importance of the respective type of social infrastructure. When counting the number of people provided with modern energy for social infrastructure the entire population of the respective institution's catchment area is taken into account. The focus is on potential access, not on actual use.

While health centers in Rwanda do have a clearly defined catchment area (the so-called "zone de rayonnement" or "population cible", i.e. "target population"), this is not the case for schools. A fraction of pupils often come from rather remote areas and school representatives are usually overstrained by estimating the number of people living in the core areas of pupils' provenience. Anyway, this figure can be relatively easily imputed: If one credibly assumes that the proportion of pupils among the catchment area population is the same as the proportion of pupils among the population surveyed by the baseline, baseline survey data yields a plausible catchment area value. It corresponds to multiplying the number of pupils of a school by the total number of people divided by the number of pupils among the surveyed population. A simplified example of this formula is presented in Box 3.

Box 3: Example for How to Derive a School Catchment Area from Baseline Data

A village primary school with 500 pupils is located in a catchment area of, say, 2645 people. This figure for the catchment area is however unknown. In order to reach at a reliable estimate of this figure, a surveyor visits ten families in that region. In total, these families have 50 family members. Among them, ten children go to primary school. According to the explanation given in the text being summarized in Table 3, the catchment area estimate follows by "multiplying the number of pupils of the school (N_{PT}) by the total number of people per pupil among the surveyed population (N_S)/ (N_{SPT})", which is 500 x 50/10 = 2500; a figure which is reasonably close to the true value.

Another problem arises considering the existence of both primary and secondary schools (universities as post-secondary education institutions are not relevant for rural areas). So far the accounting share has been set at 0.35 for each school type. Instead, the sum of the two shares should be 0.35. In light of the respective MDG relevance and expectable electrification impact (cf. chapter 4.7) of the two school types, it seems most adequate to weight them equally with 0.175.

Concerning the third group of social infrastructure, communal services, the weighting proposed in the EnDev Annual Planning 2007 (GTZ 2006: 183) shall be adopted: 0.21 for administrative buildings (i.e. sector offices) and 0.09 for churches (including mosques). The respective beneficiary groups will be defined as the inhabitants of the sector and the members of the church, the people that frequently go to church (the totality of all churches can be seen as the "worshipping infrastructure"). It is also justifiable that other potential communal services (street lighting, cell offices) are completely left out due to their present irrelevance. In the improbable case that they will be connected, readjustments may be considered afterwards.

2.2.3 Micro and Small Enterprises

EnDev intends to include electrifying micro and small enterprises (MSEs) in the beneficiary counting according to their contribution to the local economy. Concretely, it is proposed in EnDev Annual Planning 2006 (GTZ 2005) to multiply the catchment area population by the share of workers in the MSEs served among the total number of workers in enterprises in need of modern energy. Since this is a rather monitoring-intensive approach, we propose an alternative procedure. It encompasses the following generalisation based upon findings from the survey mission: Each Sector with roughly 20,000 inhabitants has four village centers. Hence, 5,000 inhabitants live in the catchment area of one village center. A single village center offers a limited range of specific businesses, each of which can be found in a certain amount given in Table 2. These specific businesses, e. g. bars or carpenters, are relatively homogenous in terms of size and the number of employees.

Table 2: Assumed Number of MSEs per Village Center in Need of Modern Energy

1.	Shops	10
2.	Bars/ Restaurants	10
3.	Barber Shops	2
4.	Mills	2
5.	Tailor Shops	1
6.	Carpenter Workshops	1

The resulting calculation formula (see Table 3) is the product of the share of connected businesses among the respective business type (for example mills) and 1/6 (accounting for the six different business types listed in Table 2) and 5000 (which is the assumed catchment area population). Apart from the easy applicability, this formula has the advantage that businesses are in fact weighted according to their contribution to the local economy (cf. also Chart 19 in chapter 4.5 on MSEs). For example, the weight of a connected barber is five times higher than that of a simple shop and a carpenter weights two times a mill. In case new businesses are established when having electricity, which do not match with any of these six business types, the following two steps have to be taken: (i) The assumed quantity of businesses of this type per village center, which are in need of modern energy, has to be defined as done in Table 2. (ii) The factor 1/6 has to be adjusted to 1/7, or 1/(6+n), in case several new business types are created.

The following table summarizes the considerations of this paragraph:

Table 3: Summary of Calculation Formulas for EnDev Beneficiaries

Beneficiary Group	Calculation Formulas
Households	N_H (Number of Households Connected) x HS (Average Household Size)
Social Infrastructure	
Health Institutions	N_{PC} (Number of People Living in the Catchment Area, i.e. Population Cible) x 0.35 (Accounting Share of Health Institutions)
Primary Schools / *Secondary Schools*	N_{PT} (Number of Pupils of School Type T) x $\frac{N_S \text{ (Number of People Surveyed)}}{N_{SPT} \text{ (Number of Pupils of School Type T Surveyed)}}$ x 0.175 (Accounting Share of School Type T)
Sector Offices	N_I (Number of Inhabitants in the Sector) x 0.21 (Accounting Share of Sector Offices)
Churches	N_W (Number of Worshippers) x 0.09 (Accounting Share of Churches)
Micro and Small Enterprises (MSE)	$\frac{N_{BST} \text{ (Number of Businesses of Business Type T Served with Electricity)}}{N_{BT} \text{ (Number of Businesses of Business Type T per Village Center)}}$ x $\frac{1}{6}$ (Reciprocal Value of the Number of Different Business Types) x 5000 (Catchment Area of a single Village Center)

These calculation formulas mainly represent the concretion of guiding principles defined by EnDev. In the case of schools and MSEs, the formulas show a substantial innovation. Variables that can be replaced by figures of the baseline are the following: HS = 5.55; N_S = 1654; N_{SP1} (primary schools) = 482 and N_{SP1} (secondary schools) = 103. The following example shall illustrate the calculation: Mutete Primary School has 1131 pupils (N_{PT}). In total, a population of 1654 (N_S) was surveyed in the project villages, among which there were 482 primary school pupils (N_{SP1}). The corresponding number of EnDev Beneficiaries would be: 1131 x (1654/482) x 0.175 = 679. For another, simplified example, confer Box 3.

2.3 With-without Comparison

Statistical comparison can be longitudinal (over time, e.g. comparing today's income in Rwanda with the income in Rwanda five years ago) or cross-sectional (at the same time, e.g. comparing today's income in Northern Rwanda with today's income in Southern Rwanda). The usual approach for measuring the impact of an intervention is longitudinal by before-after comparison. One weakness in longitudinal evaluation designs of rural electrification projects has been that the time interval was too short to measure certain benefits of rural electrification. For instance, education of children takes between ten and twelve years. Sustainable effects of electrification may probably only materialize in the long term and will therefore be difficult to capture within a period of three to four years from receiving access (cf. WB ET AL. 2003). It is also to be expected that it will take some time until especially private households will actually connect.

The preferred approach in modern studies is cross-sectional comparison, which has also been applied in this survey. It allows drawing conclusions on the investigated issue in the same way as before-after comparison. Different from before-after comparison, however, it can be carried *ex ante* – this means as early as in the preparatory stage of a programme. Of course, this approach does not rule out a follow-up survey for evaluating the concrete impact of the development measure. The cross-sectional research design includes a “with”-group and a “without”-group. The project sites, yet without electricity, as the “treatment group” and the comparison or “control group” of villages that already live with electricity.

The denomination might be confusing, since in an ordinary quasi-experimental set-up one would refer to the electrified region as the treatment group (the group that underwent an intervention) and to the non-electrified as the comparison group (the group that will undergo an intervention). Yet, in our case the terms “treatment” refers to the target regions of PSP Hydro, i.e. a kind of an inverted scientific control is applied. Moreover, it is acknowledged that the term “control group” should be reserved for experimental settings. For reasons of convenience, it is, though, referred to “control villages” instead of “comparison villages”.

In order to identify causal relationships, the project sites and control villages have to show similar socio-economic characteristics. This comparability is discussed on the basis of the actual control villages in chapter 3.6. The availability of data for comparable electrified and non-electrified villages forms the foundations for applying robust evaluation techniques as outlined in FRONDEL & SCHMIDT 2005 or RAVALLION 2008.

2.4 Questionnaire Design

The questionnaire (see Electronic Annex E2) was designed including both quantitative and qualitative approaches. In order to find an appropriate balance between the two ways, among households a mainly quantitative survey is applied using a formalised questionnaire to gain a distinct picture of the people’s living situation in the target area, including a small range of qualitative indicators. Data from social institutions and rural enterprises is collected by means of a hybrid approach in order to complement household-level data with contextual information about the non-familial economic and social circumstances. In addition, key informants were interviewed in order to verify specific responses (a list of all persons contacted during the baseline survey can be found in appendix A1).

Of particular importance concerning the topics included in the questionnaire is the availability of socio-economic *and* energy-related information. This has been done, since profound statements on interrelations between energy and development issues can only be made if data is available on both issues. To provide the required basic data, the following topics had to be considered in the questionnaire for household data collection:

Component 1: Household structure
e.g. household size and composition

Component 2: Economic situation
e.g. occupation, household income sources and expenditures

Component 3: Social life
e.g. time use, work load, including children’s studying, TV and radio use, health issues, migration

Component 4: Energy
- Energy sources used in the household
- Energy consumption, expenditures and problems
- Energy for Lighting, respective consumption and appraisal
- Productive activities in the household
- Electricity sources and respective use, expenditures and preferences

- Electric appliance ownership and use
- Appraisal of electricity
- Expectations, plans and preferences concerning electricity

For MSEs, the components 1 and 2 were reduced and adapted, the social life component was dropped and the energy component almost completely taken over. Due to the hybrid approach outlined above, some more qualitative, open questions have been added. The same holds for social infrastructure institutions, where the questions rather served as an interview guide than as a formalised questionnaire. Household interviews lasted 60 to 80 minutes, while interviews with the other respondent groups took 30 to 50 minutes.

2.5 The Wealth Indicator

Various variables listed in Annex E3 have been created stemming from the questionnaire information. Most of them are self-explanatory and constructed according to common methodologies. Somehow innovative is the "wealth indicator" generated for the poverty/wealth analysis. Data gathered in rural areas in developing countries typically suffers – in addition to the general shortcomings of quantitative data referred to above – from sporadic inaccuracies due to a lack of recording systems and limited intellectual abilities. Data on income and wealth is further biased, because people tend to state lower values in order not to give rise to jealousy. A fact that is especially true for Rwanda, where distrust is relatively deep-rooted. Therefore, a combined indicator has been created to reduce biases inherent in single variables and to incorporate different facets and proxies of wealth. These comprise assets, expenditure and income elements (cf. Table 4). Income has been defined as shown in Box 4, following the definition of World Bank Living Standard Surveys (WB 1992). The indicator takes on values between 0 and 40, which are categorized into "poor", "middle" and "rich". It is described in more detail in Appendix A2.

Table 4: Components of the Wealth Indicator

Criterion	Subindicator
ASSETS	
Dwelling Conditions	▪ Construction Material of Outside Walls ▪ Flooring Material ▪ Roofing Material ▪ Windows Fitted with Glass
Cattle	▪ Quantity of Cows Owned
Savings	▪ Ownership of a Bank Account
Mobility	▪ Type of Means of Transportation
Education	▪ Education Level of Head of Household
EXPENDITURE	
Nutrition	▪ Food Expenditure per Adult Equivalent* ▪ Existence of Food Shortages
Telecom-munication	▪ Telecommunication Expenditure
Energy	▪ Expenditure on Energy Sources per Adult Equivalent*
Health	▪ Health Expenditure
INCOME	
Income	▪ HH Income per HH Member Able to Work excl. Consumption of Home Production

** See Appendix A3 for a description of the Adult Equivalent.*

Box 4: Income Definition

Income =
Wage Income
\+ Non-Farm Self-Employment Income
\+ Income from Remittances
\+ Farm Income
(*Farm Income = Revenue from Sale of Crops, Transformed Crop Products, and Animal Products - Total Expenditure on Inputs for Growing Crops (Seeds, etc.), Expenditure on Renting Land*)

2.6 Representativity and Sample

The household survey is based on a two-stage stratified sample. The target and control regions form the first-stage primary sampling units (PSUs). The units have been stratified, i.e. grouped into subgroups, with respect to a single characteristic: the distance to future or, in the case of control villages, existing electricity grid. Households represent the second stage sampling units. In total, 741 households and 107 MSEs have been interviewed. Moreover, some 100 social infrastructure institutions (health center, schools, sector offices, churches) have been visited in five project sites and six control villages (Table 5).

Since it is yet unknown who will actually connect to the future mini-grids, complete sampling among project village households was not feasible (Table 6). Instead, a sampling probability of ¼ was applied for target areas defined by the PDs. With a lower probability of 1/6, people living distant to the electricity grid were included in the survey as well, since the impact monitoring aims at recording the changes attributable to the electrification project among the entire village population. For the same reason, households with and without access to electricity in the control villages have been sampled with an identical probability of 1/6. As a result, the control group households are not exclusively grid-connected, but mimic the entire population of "electrified" control villages.

Table 5: Surveyed Entities

	Project Villages	Control Villages
Households	393	348
Social Infrastructure	5……….Health Centers……….6 15…….Primary Schools……..12 6…….Secondary Schools…..10 5………..Sector Offices………..4 19…………Churches…………14	
Micro and Small Enterprises	61	46

As a further peculiarity of the survey, two of the project villages, Murunda and Mpenge are already electrified (see chapter 3.2 and 3.5). Households have therefore been sampled as control village households. The implications for data analysis of the existence of already electrified project villages are delineated in chapter 3.7.

Households were selected in a simple random sampling (WARWICK & LININGER 1975). Lists of potential interviewees (e.g. people living in a certain village or households interested in getting connected), which would have improved the randomness, were available

Table 6: Sampling Probabilities

	Project Villages		Control Villages	
Characteristics	living near the planned electricity grid (< ~ 50m)	living near the possible grid extensions or simply distant to the electricity grid	living near existing grid (< ~ 50m); with electricity	living near existing grid (< ~ 50m); without electricity
Household	1/4 [Stratum 1]	1/6 [Stratum 2]	1/6 [Stratum 3]	1/6 [Stratum 4]
Social Infrastructure	complete sampling			
Micro and Small Enterprises	ad hoc sampling			

only for one site. The areas to be surveyed were divided up according to the number of households they comprised. Even here, the error rate among the listed households was too high. If possible non-present households were revisited. In part, people were visited at their working place, e.g. a shop or school.

Under the prevailing circumstances, the maximum representativity was achieved. At least for the project villages, this representativity holds not only for the surveyed villages, but for the entire rural population in the surveyed Provinces. This is due to the non-selective and random sampling on the second stage of the two-stage stratified sample. The control villages, on the other hand, being rural electrified villages cannot be plausibly representative for their Provinces considering that only about 1 percent of the Rwandan rural population is grid connected. As only households have been interviewed which live sufficiently near the existing electricity grids, which primarily cover commercial centers and their surroundings, people engaged in the service sector are probably more numerous in these areas.

In accordance with standard practise, weight factors used for the statistical analysis were the reciprocal of the sampling probability.

2.7 Baseline Schedule

The Baseline Study includes the following nine steps. Steps 2 to 7 were realised in Rwanda for the first four sites during the period of 23 April until 17 July 2007. Due to the inclusion of a fifth project developer, these steps have been replicated in the second baseline survey phase between 24 November and 6 December 2008.

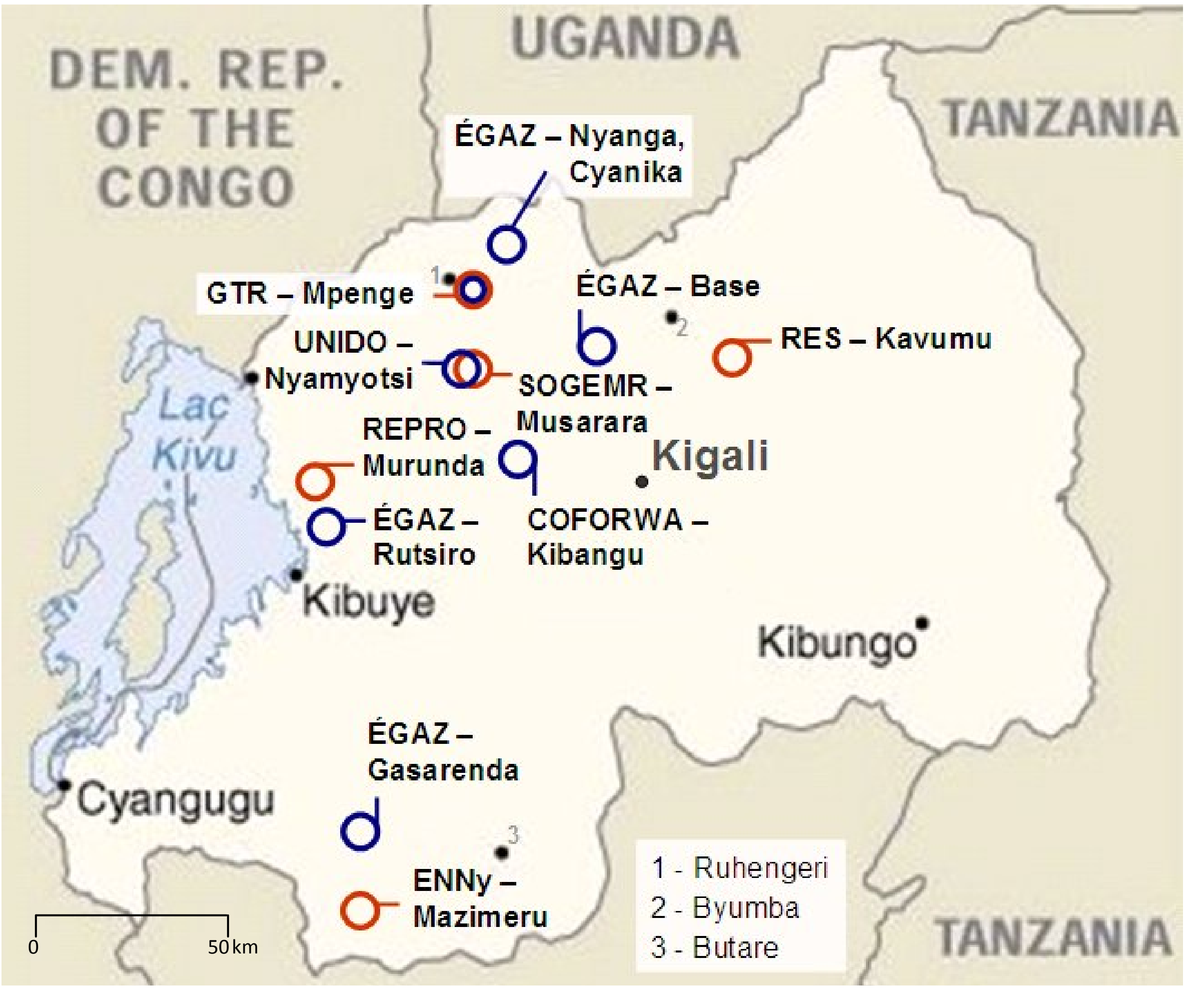
1. Preparatory desk study of PSP Hydro Programme Reports setup of a survey team, and Questionnaire preparation in French, structurally based on a questionnaire used for a GTZ baseline study in Benin. It was developed to be also applicable without fundamental modifications in future impact assessment and monitoring surveys.
2. Desk study of relevant documents, like Business Plans of the Project Developers, results of National Surveys and EnDev Background Papers used for the baseline preparation and the later data analysis.
3. Site visits to the five project villages and potential control sites in order to prepare the baseline schedule and sampling and furthermore to inform and interview local authorities.
4. Pre-tests and following conclusion of the French Questionnaire. This questionnaire was then translated to Kinyarwanda, the language of communication in Rwanda.
5. Three-day enumerator training workshop, partly on-site.
6. During the surveys, in total 741 household interviews have been conducted in five project and six control villages. At least one family member, mostly the head of household was interviewed. Apart from that, 107 MSE and some 100 social infrastructure institutions were interviewed.
7. Presentation and discussion of first results with programme stakeholders.
8. Data processing in Excel and data analysis in STATA.
9. Final report and feeding results back into the planning and implementation of the development measure.

3 Site Profiles

This chapter offers background information on the surveyed project and control villages.

An overview over the sites visited can be taken from Figure 1. Three of the PSP Hydro projects (Kavumu [KA], Mpenge [MP] and Musarara [MU]) are located in the Northern Province, one in the Western Province (Murunda [MD]) and another in the South Province (Nyaruguru [NY]). Due to regional particularities, the control villages of Nyanga/ Cyanika [CYc], Base [BAc] Nyamyotsi [NIc], Rutsiro [RUc], Gasarenda [GAc] and Kibangu [KIc] have been chosen to be first of all located in these Provinces.

Figure 1: Map of Rwanda with Surveyed Sites Marked



Red circles represent project villages, blue ones control villages. The first name in capital letters is the electricity provider (with EGAZ standing for Electrogaz, the national electricity company). The latter name is the site, which may be the village or river name.

The site profiles comprise a short characterisation and a summary of the present status quo. Schematic maps of the villages and surveyed areas can be found in appendix A4. They are included, because the consumer areas are not yet definite and people in the project areas live very dispersed. In addition, names of housing agglomerations are often not consistent and official maps do not exhibit the necessary degree of exactness in many cases. Thereby, the maps contribute to the transparency of the survey and – enriched by photos and descriptive data – to ex-post judgment of project impacts. As the data depict the current state of affairs, they do not necessarily represent figures for the potential beneficiaries, which depend on projects and projections, too. Estimates on these figures will be found in chapter 5 or – in more detail – in appendix A7.

All project sites are located in the middle longitudinal corridor of Rwanda. They exhibit comparable geographical and climatic characteristics, e.g. concerning rainfall. In terms of fertility of land, the Northern sites profit from fertile, mainly volcanic soil, while the acidic soil in the Nyaruguru [NY] region exacerbates subsistence farming. On the other hand conditions for large scale tea plantations, of which three can be found in the region, are advantageous.

Reviewing the activity of donors and non-governmental organisations in the project areas helps to assess the accountability of the intervention, relating to socio-economic development in general and energy provision in specific. It can be regarded as rather low-scaled and dominated by agricultural and social interventions. There are for example ADENYA's own breeding and seed improvement and multiplication center [NY] or the governmental "One Cow one Family" programme which delivers 80 improved breed cows to families at the SOGEMR site [MU]. Alphabetisation, orphan care and women empowerment are main topics of social projects. Concerning the more relevant field of infrastructure, currently only the construction of a modern market in Kamirabagenzi [NY] is worth mentioning. School and health center support is more widespread, also in terms of electrification. Donors are the African Development Bank, Compassion, Family Health International (FHI), GTZ, Global Fund, Save the Children and World Vision.

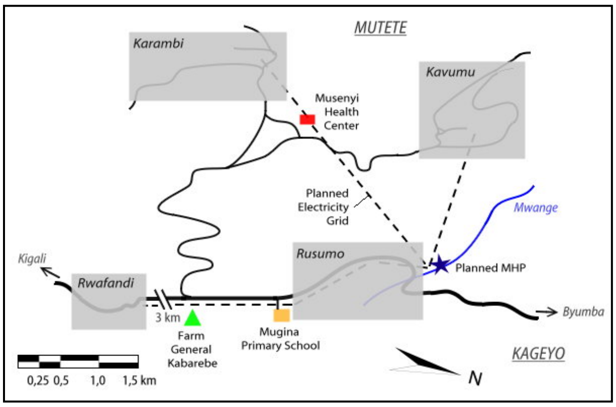
3.1 RES – Kavumu [KA]

The project site of the private company Rural Energy Solutions (RES) is located about 44 km far from Kigali and 9 km from the Gicumbi District capital Byumba. While the plant is located in Kageyo Sector, almost all potential beneficiaries lie in Mutete Sector, along the main transit route between Kigali and Kampala, therefore benefiting from the traffic and well maintained transport infrastructure.

There had been a micro-hydro plant before at the Kavumu site, thus leading to a certain familiarity with electricity among the population. The 25 kw plant was in operation between 1987 and 1993, financed by grants from the German federal state of Rhineland-Palatinate. Usable left-over from this time is only the consumer association "Ingufu z'Amajyambere" ("Power of Development") with currently 186 members.

Table 7 shows figures for the relevant beneficiary groups that currently inhabit the surveyed areas. A bigger project – conditional upon electricity provision – already announced is a dairy at General Kabarebe's farm.

Figure 2: Map of Kavumu Site



Moreover, two other investors expressed their interest in creating new businesses when having electricity at their disposal, one of whom intends to enter the construction industry. The District Development Plan for 2008-2012 is another important source for predicting future developments. In the case of Gicumbi, it states among other things that at the sector office, the secondary school and the health center solar panels will be installed (GICUMBI 2007: 202).

Table 7: Current Figures of Potential Customers for Kavumu Site

Village	Shops	Bars	Restaurants	Barber Shops	Carpenter Workshops	Mills	Tailor Shops	Households	Health Center	Primary Schools	Secondary Schools	Sector Offices	Churches
Rusumo	7	15	8	-	1	1	1	75	-	1	-	-	4
Kavumu	6	30	9	1	1	2	2	50	1	1	1	-	1
Karambi	3	15	2	1	2	-	-	70		1		1	1
Rwanfandi	*4*	*2*	*4*	*2*	*1*	*2*	-	*50*	-	-	-	-	-
Total (S1)	**16**	**60**	**19**	**2**	**4**	**3**	**3**	**195**	**1**	**3**	**1**	**1**	**6**
Total (S 2)	***4***	***2***	***4***	***2***	***1***	***2***	-	***50***	-	-	-	-	-

The location in italic depend to Stratum 2 (cf. Table 5), the areas that will be less probably electrified.

Alternative electricity sources are very rare at Kavumu site: All five mills possess generators. Other generators are used by a barber in Kavumu, the secondary school and the tailor shop in Rusumo (though not for electric sewing machines); the only properly functioning solar panel exists in Rusumo. Some car batteries are in use as well, for example at a bar in Kavumu.

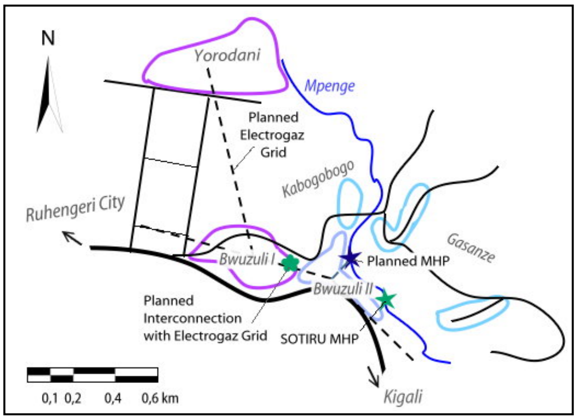
3.2 GTR – Mpenge [MP]

Although the GTR project has been cancelled from the side of GTZ in end of 2008, findings from the survey and data collection in May 2007 shall be presented in the following. First, they are deemed to be of interest for the implementation at the other sites. Second, the same site is intended to become exploited by a new project developer. Although the business plan is not prepared yet the investor already expressed his intention to mainly serve the cement factory PPCT (see Figure A2 in Annex A4.2 or photo MP-E1).

The original plan of the private construction firm GTR was to build a MHP in the peri-urban area around the river Mpenge in the East of Ruhengeri. The city, in 2006 renamed as Musanze, counts 93,000 inhabitants and is thereby the fourth-largest town in Rwanda. It is favourably located in the region where Rwanda meets both Congo and Uganda, and is the closest city to the Volcanoes National Park. Accordingly, the city is prosperous (with economic growth rates similar to those of the capital Kigali) and main parts of the city are electrified. The already electrified part of town that borders the proposed project area was chosen as one control group. During the survey it was found that main parts of the area to be electrified by GTR were already electrified to a more than sufficient extent. For that reason, these areas have been abandoned by the project and added to the control group.

Alternative beneficiary centers had not been proposed. Instead, the survey team chose the most nearby areas whose electrification seemed to be justifiable. Bwuzuli II and Kabogobogo are peripheries of the Electrogaz grid, Gasanze on the other side of the river Mpenge is not yet electrified. Whether Electrogaz intends to extend its grid to these areas is not yet foreseeable neither in how far the urbanisation process will raise the housing density in the agglomerations.

Figure 3: Map of Mpenge Site



Box 5: Overconfident Hypotheses

Apart from gathering information about the potential future beneficiaries, the validity of hypotheses in the PDs' business plans were also checked for during the site visits. In the case of the proposed consumer groups at Mpenge this examination was complemented by a small additional survey among 170 households.

Hypothesis 1: Only small parts of the population in the proposed areas are already connected.

While in Bwuzuli only 4 % of the population are connected, this proportion is 73 % in the Yorodani target region which suggests that this area is saturated.

Hypothesis 2: Many of those not yet connected have made futile attempts to applying for an Électrogaz connection.

Only 9 % of those not connected have already contacted Électrogaz somehow.

Hypothesis 3: People will be attracted by lower prices per kWh of 100 FRw in comparison to 132 FRw for Électrogaz.

Even neglecting that the Électrogaz price includes the value added tax while the price envisaged by GTR probably does not, the price differential on the bill will be substantially lower in the end. This is due to the fact that – for the time being – most of the people in the region have conventional meters. For them they pay a monthly rent of 200 FRw while GTR proposes pre-paid meters for a monthly rent of 500 FRw. With an assumed monthly consumption of 15 kWh the savings would amount to far less convincing 8 % instead of 24 %.

Hypothesis 4: People will be attracted by lower connection fees.

Hardly surprising, connection costs are clearly the obstacle for most of the non-electrified households. 80 % of them mentioned that solely the connection costs hinder them from getting connected (though they probably underestimate the burden of the monthly bill). Furthermore, Électrogaz fees actually seem in some respects overcharged. Nevertheless, it holds also for this hypothesis that making all calculations does not leave the GTR alternative much more appealing. In contrast to Électrogaz, GTR plans to charge the clients for half the purchasing costs of the meter, which would be currently some 15,000 FRw (20.40 EUR).

Hypothesis 5: Some People did not connect to the Électrogaz grid due to a poor service quality.

Only 17 % mention that not being connected has to do with service quality at all.

Moreover 93 % among those who are connected to Électrogaz expressed their interest in going over to GTR. Since electricity provision is sufficiently reliable in Ruhengeri, these households cannot be included in the EnDev counting. The construction of a second independent physical electricity grid would be moreover just like a waste of resources and creates conflict potential not only within this area, but also at its limit.

In all, these findings led to refraining from a large part of the proposed areas, namely Yorodani and Bwuzuli I (cf. Figure 3 or Figure A2).

3.3 SOGEMR – Musarara [MU]

The Musara site exploited by SOGEMR, a rural development association with head office in Ruhengeri, is in a very landlocked region 25 km from the tarmac road and further 7 km from Ruhengeri City. It comprises the villages of Gatonde, Cyinama, Rusasa and Biziba. In Gatonde which is 4 km from the micro-hydro plant the MV/LV-Transformer will be installed from where the other villages will be fed. While Biziba has a small foodstuff market on Wednesday and Sunday, the next bigger market center is Vunga, around 10 km south-west, where e.g. kerosene can be bought.

Current figures for the relevant beneficiary groups of Musarara site can be retrieved from Table 8. Other institutions worth mentioning are the Muzo court house and the communal service building in Gatonde. The latter accommodates the office of the criminal investigation department, a microfinance institution (that functions very irregularly and could therefore not be visited) and an AIDS organisation active in five sectors. This organisation plans to use electricity in order to produce pineapple juice, for poultry farming (with the potential support of the Global Fund) and a mill they already possess. Apart from the 5.6 kw generator newly purchased for the Muzo court house, there is another one in use by a barber in Rusasa and the secondary school at Nkunduburezi. Three buildings in Gatonde are equipped with solar panels: a private house, the health center and the secondary school. Moreover, the primary school possesses a solar panel which is yet unpacked and a handful of car batteries are in use.

While the plans to establish a hospital on the Gatonde hill are vague and questionable, the opportunity came up recently to connect Shyira Hospital in the Mukungwa River Valley via a planned Electrogaz MT line. While it may become an important customer for SOGEMR, no information is available on this facility so far.

Figure 4: Map of Musarara Site

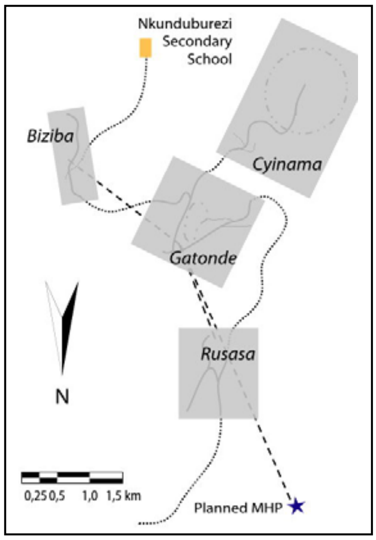


Table 8: Current Figures of Potential Customers for Musarara Site

Village	Shops	Bars	Restaurants	Barber Shops	Carpenter Workshops	Mills	Tailor Shops	Households	Health Center	Primary Schools	Secondary Schools	Sector Offices	Churches
Rusasa	6	5	3	1	2	-	-	70	-	1	-	1	-
- Periphery								*130*	-	-	-	-	*1*
Gatonde	21	7	2	-	1	-	1	120	1	-	1	-	-
Cyinama	-	1	-	-	-	-	1	30	-	1	-	-	1
- Periphery								*40*	-	-	-	-	-
Biziba	4	10	5	2	1	(1)	1	70	-	-	-	-	-
- Periphery								*40*	-	-	*1*	-	-
Total (S1)	**31**	**23**	**10**	**3**	**4**	**0**	**3**	**290**	**1**	**2**	**1**	**1**	**1**
Total (S 2)	-	-	-	-	-	-	-	*210*	-	-	*1*	-	*1*

The locations in italic depend to Stratum 2 (cf. Table 5), the mill in Biziba is damaged.

Box 6: Agglomeration Processes and the Electricity Grid

Though Rwanda is characterised by a high population density, people in rural areas live very dispersed. This dispersion was traditionally bolstered by rules that forbade changing residence without governmental approval. In 1996, a National Habitat Policy was adopted stipulating that all Rwandans living in scattered homesteads were to live in the government created villages called "Imidugudu". The total number of houses constructed under the villagisation programme reached 300,000 by 2004.

For the PDs the agglomeration process is crucial, since in most of the targeted villages the population density is currently low and falls far behind the population necessary to achieve the envisaged client figures.

An example is the main road on Cyinama Hill (cf. photo MU-14, Electronic Annex 0) which is chosen to become an Umudugudu. Currently around 30 people live along the road with a length of 800 meters. According to local residents the path exists since 1940. Hence, the "natural" agglomeration process has already occurred here. Therefore, the possible electrifi-

(continues next page)

cation and the villagisation programme remain to exert a pull.

The structurally very similar control site of Kibangu, which has been electrified since 1987 (cf. chapter 3.6.1), might offer some insights into the **"electrification pull"**. At Kibangu, 175 clients are connected along a low-voltage grid of some estimated two kilometres. It results a satisfactory rate of one client per ten meters of grid. However, looking at the distribution of the houses, one observes concentrations in the village center (see KI-01) and near the association COFORWA. 200 meters further (KI-02) and at a subcenter (KI-03), electrification did not seem to have induced many people to move house towards the grid. It has to be taken into consideration that for a simple family moving in this case would mean constructing a new house for around 300,000 FRw (400 EUR) without being able to sell the abandoned one. Since electricity at their private homes would be used primarily for consumptive reasons, only few households can be expected to make such expenses.

The **villagisation programme** has affected the different districts differently, depending on the eagerness of local authorities, the number and composition of returnees, access to international funding and resistance from the local population. In addition, the absence of promised basic infrastructure in some of the created villages caused displeasure and reluctance. As the directive already exists since ten years, it can be expected that in the years to come more families will feel themselves obliged to move house to an Umudugudu. Young Rwandans who want to move out of their parents' home might cause larger movements towards the Imidugudu. It is however improbable that these movements will increase significantly in the coming three to five years.

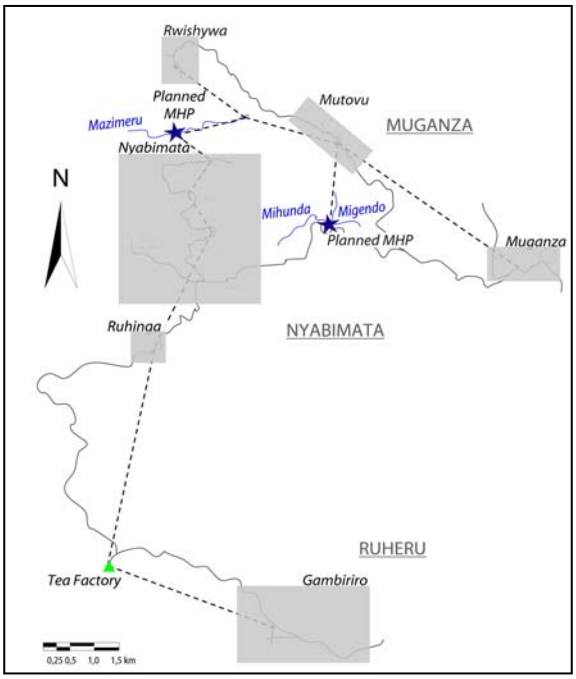
In Cyinama the main road shall moreover be extended to the southern side of the hill, which is yet covered with bean fields, in order to found another Umudugudu there. Though it is unclear when the grid will cover also this place, the local population of around 100 households already held meetings in order to create a consumer association and marked off a budget of 600,000 FRw (815 EUR) for the electrification of this area. The money stems from "Ubudehe", a programme sponsored by the Ministry of Local Government (MINALOC) that follows a participative approach in order to finance local infrastructure projects.

3.4 ENNy – Mazimeru/ Nyaruguru [NY]

Located 35 km west of Butare and some 5 km east of the Nyungwe Forest, with a distance to the nearest electricity line of 13 km as the crow flies, the ENNy site is the most remote among the four project sites. At the same time, the acidic soil hampers subsistence farming, why the World Food Programme (WFP) is active in the region. An important regional institution is the rural development association ADENYA which also promotes the MHP site.

Although a cartographer has already staked out the planned electricity grid (see Figure 5), it is yet more than questionable whether all the targeted agglomerations along this extensively planned grid will be provided. Nevertheless, all the originally targeted regions have been surveyed, though in some cases with a lower sampling probability (cf. Figure A4).

Figure 5: Map of Nyaruguru Site



If realized as planned, the grid would actually have an extension of 25 km. This corresponds to the distance between Mata and the planned Hydro Power Plant Ntaruka A which is also located in this – even for Rwandan conditions – mountainous region. In a recent study, the Belgian consulting engineers company SHER estimated the costs of this interconnection line at two million Euros. It is moreover doubtful whether the planned number of MV/LV-Transformers (in the original proposal between eight and ten) can be realized and hence, whether all the targeted agglomerations can be supplied. Last but not least, the recent revision of the installed capacity from 600 to 225 kw (one turbine at river Mazimeru instead of three) will have an impact on the areas to be supplied.

As for the other sites, Table 9 depicts the current figures for the intervention area. Other enterprises active are four welders and one mechanic in Cyezi, one mechanic in Mpuza and two in Muganza. In Muganza, also the second bank apart from the ADENYA bank is located, a Banque Populaire. A public telephone shop, Terimbere, powered by a car battery charged in Butare and Kibeho (around 20 km away), and the police are established at Mutovu. Apart from the mills and barber shops, which are all equipped, generators are in use at Bigugu secondary school, at the Court house, at some shopkeepers in Gambiriro and at few private households. While the priest in Bigugu uses the parish's generator for a mill as well, the priest in Muganza uses it only for masses and private purposes. The mill they formerly possessed had to be sold because the millers who ran the mill embezzled money. Though the Ruheru Sector Office has been equipped with twelve solar panels last year, not even the one PC in their possession can be used due to a lack of power. Further solar panels are installed at the health centers, the primary schools of Muganza, Gambiriro and Nyabimata (where it is currently not in use) and at a private house in Gambiriro.

In their business plan, ENNy has already listed a range of business ideas conditional on electricity provision. Emphasis is on the one hand put on AMECOBI, an Association with seven carpenters having nationwide clients who plan to move together into a new workshop in Tangabo sponsored by Rhineland Palatinate.

Table 9: Current Figures of Potential Customers for Nyaruguru Site

Village	Shops	Bars	Restaurants	Barber Shops	Carpenter Workshops	Mills	Tailor Shops	Households	Health Center	Primary Schools	Secondary Schools	Sector Offices	Churches
Nyabimata	7	2	1	-	2	1	1	40	1	1	-	- **	1
- Cyezi	11	18	2	-	-	1	-	40	-	-	-	-	1
- Bigugu	8	2	-	1	1*	1	1	30 + 60	-	1	1	-	1
- *Tangabo*	-	-	-	-	*1 **	-	-	*40*	-	-	-	-	-
- Mpuza	10	8	1	-	1	-	1	35	-	-	-	-	1
- Rumenero	10	13	2	1	1	1	2	35	-	-	-	-	-
Ruhinga	-	-	-	-	-	-	-	*30*	-	*1*	-	-	-
Gambiriro	33	3		3	2	6	4	70	1	1	-	1	1
Muganza	6	15	1	-	-	1 + (1)	-	60	1	1	-	-	1
- Kamirabagenzi	30	25	6	1	-	5	-	0 + 30	-	-	-	-	-
Mutovu	*21*		*1*	*3*	*2*	*3*	-	*30*	-	*1*	*1*	*1*	*1*
Rwishywa	*n/k*							*30*	-	*1*	-	-	*1*
Total (S1)	115	85	14	6	6	16	9	310	3	4	1	1	6
Total (S2)	*11*	*10*	*1*	*3*	*3*	*3*	-	*220*	-	*3*	*1*	*1*	*2*
Total (T*)	46	43	6	2	5	4	5	310	1	3	1	-	4

The locations in italic depend to Stratum 2 (cf. Table 5), the mill in Muganza is damaged.

** The seven members of the AMECOBI carpenter association planned to move their activities to the new building in Tangabo.*
*** The new Nyabimata Sector office is built on a hill which is probably too far away from the future grid.*

On the other hand, the big tea factory (90 staff) on the way to Gambiriro would constitute a reliable electricity consumer, especially during hours in which the population consumes less. By itself it consumes the threefold of the electricity the planned micro-hydro plant will generate, currently provided by their own fuel engines. Both potential customers entail the problem that serving them would be both costly and would not bring about a considerable amount of household connections due to a lack of residential areas in their surroundings. For the tea factory, the line from the plant to Nyabimata Primary School would need to be extended by more than four kilometres only passing one very small household cluster in Ruhinga. Yet, the latest plans (cf. GTZ-IS 2009) indicate that the line from the MHP to the tea factory passing Nyabimata and Ruhinga is the most likely option. Beneficiary projection in this report will therefore be based on this part of the target area designated T* in Table 9.

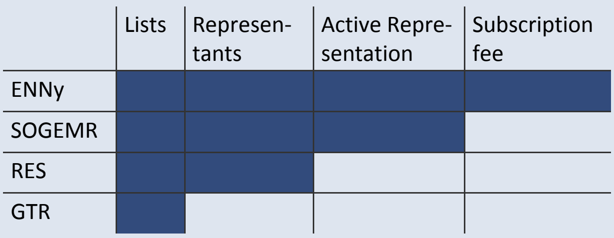
Box 7: Consumer Associations

One of the sustainability criteria defined by EnDev for PSP Hydro is that consumer associations are active and representative of community interests. In order to enable the expression and representation of community interests already in the preparatory phase, project developers were requested to initiate the founding of consumer associations. The registration of a consumer association was actually made a precondition for the grant contract signature.

Correspondingly to their advancement in the project realisation, the associations of the different project sites have developed different tasks and purposes. A basic feature of each association is the expression of interest by means of signing in a list. The next step is the election of a representative of each beneficiary agglomeration. At the time of the baseline survey, ENNy was most advanced in its effort to build up a consumer association. Nine different regional associations have been established, each of which aready collected subscription fees in the order of 1,000 FRw (1.35 EUR) for households and 10,000 FRw (13.50 EUR) for institutions. As an incentive to join, people were told to possibly receive electrical installation material for a reduced price. The purpose of the assembled money is yet unclear and will be defined later with the association members. For example, the purchase of a mill is being considered.

An advantage of this subscription fee is that the association membership is a better indicator of the actual interest and ability to conncet than simply subscribing in a list. At Musarara [MU], for example, already around 1,000 people subscribed, although many of them live in areas that probably won't be covered by the grid in the years to come.

The status quo of the different associations is described in the following table.



3.5 REPRO – Murunda [MD]

Leaving the Kigali-Kibuye communication road at Rubengera, it takes another hour on an earth road along Lake Kivu to reach at Murunda. Murunda is the project region of Rural Energy Provider (REPRO), a recently created Kigali-based private energy company. The Murunda Parish that has been established in 1909 lies in the center of the project region. It has also been the Parish that brought forward different development interventions in the areas of health, education, and artisanry in this agriculturally dominated region.

The micro-hydro plant (MHP) is going to be built down the hill of Murunda Parish at the same location as the former MHP. The latter was put in place in 1980 with the support of Belgian funds. It was thenceforward managed by the Parish. After the Electrogaz grid arrived at the village in 1990, for two years both systems coexisted feeding into the existing low-voltage grid. After years of malfunctioning, the MPH ceased to provide electricity in 1992. For the years around 2004 myriads of blackouts have been reported. Nowadays, the system functions reliably, which can be also ascribed to fact that the district hospital is located next to the Parish.

Against this background a peculiar electricity provision system has evolved. Two meters being directly connected to the Electrogaz grid currently provide some 240 clients – households and small enterprises – in the region. The totality of enterprises, households and social infrastructure institutions located in the regions covered by the existing grid, represented by the shaded areas in Figure 6, are given in Table 10. The two meters and the whole grid are managed by a consumer association. With their limited capacities, they are doing their best to maintain the grid functional. The longest lines to Gashaki and Shyembe sum up to some estimated three kilometers each. In combination with poor-quality low-voltage line material, the line stretching across inadequately long distances leads to enormous transmission losses and power drops at the outskirts of the grid (cf. Box 8). Nevertheless, considering the reliable service provision for the vast majority of the population, the village currently has to be qualified as electrified. In addition, it has to be noted that power cuts observed these days are very rare and seem to mainly stem from the fact that the consumer association only buys new electricity credit as soon as the old one is used up and power is down. Hence, the electricity provision problem does primarily originate from poor grid conditions and management and not from a lack of electricity.

Although there is no time schedule yet, Repro plans to improve and extend the local grid.

Figure 6: Map of Murunda Site

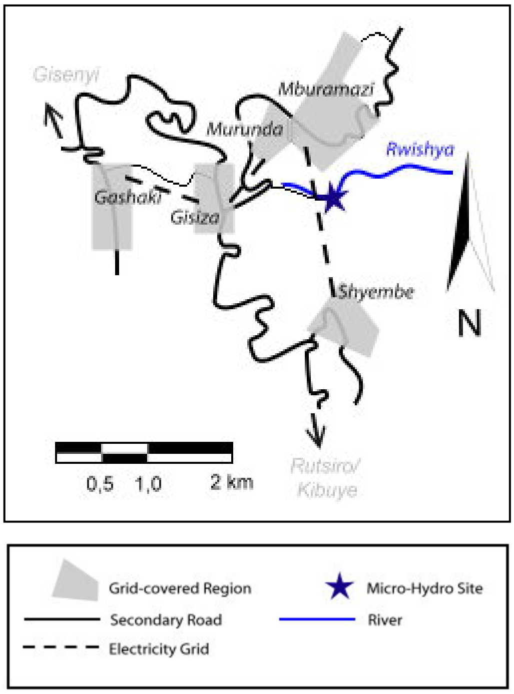


Table 10: Current Figures of Potential Customers for Murunda Site

Village	Shops	Bars	Restaurants	Barber Shops	Carpenter Workshops	Mills	Tailor Shops	Households	Health Center	Primary Schools	Secondary Schools	Sector Offices	Churches
Gisiza	21	25	2	3	1	3	3	60	-	-	-	-	-
Gashaki	4	7	1	-	-	-	-	35	-	-	-	-	-
Murunda	1	-	-	-	1	1	-	40	*	1	1	-	1
Mburamazi	50							170	-	-	**	1	-
Shyembe	25							70	-	1	-	***	1
Total (S1)	150							375	0	2	1	1	2

* Hospital; ** Centre de Formation de la Jeunesse; *** Cell Office

Box 8: Grid Problems in Murunda

Since Electrogaz did not want to assume responsibility for the substandard electricity grid of the former MHP, a shed has been constructed next to the parish sheltering five electricity meters that connect the entire region to the 30 kV Electrogaz grid line: one each for the hospital, the parish and the Banque Populaire, and the other two for the lines providing the population. One line goes via Murunda to Gisiza up to Gashaki. The other one covers Mburamazi and has a branch connection to Shyembe with another meter only for that part of the grid (cf. Figure 6).

The connection to Shyembe has even been added only very recently. The local population used funds of "Ubudehe", a government-sponsored programme that follows a participative approach to finance this local infrastructure projects completed in mid 2008.

Not different from the already existing lines, cheap, poor-quality material was used for this new connection in order to reach as many households as possible.

As a consequence of this and the long distances of up to three kilometers, massive transmission losses can be observed. Since these losses occur beyond the meters, they have to be covered by the respective population. In our case, the costs are split between the consumers in form of a lump-sum surcharge to the monthly electricity bill. For the six months preceding the survey, these costs have been equivalent to those for six to twelve kWh per months in Mburamazi, for people in Shyembe, the surcharge of 3,230 FRw (4.30 EUR) even corresponded to 24 kwh. In addition, the consumer association set a minimum consumption of 5 kwh per months and fixed fees for an electrician and the consumer association. These extra costs jointly make a household consuming 2 kwh per month, for example, paying 2,100 FRw (2.8 EUR) per kwh, five times higher than it would have been for direct Electrogaz clients. A household consuming the average of 12 kwh still incurs 2.5 times higher electricity costs.

3.6 Control Villages

In order to test for the development hypotheses as done in chapter 4 already before project implementation sufficiently comparable control villages have been chosen and surveyed additionally (cf. also chapter 2.3 - With-without Comparison). The comparability is at the same time crucial for analyzing how many and which type of people actually connect to the grid and which appliances they use. Due to the very low electricity coverage in rural Rwanda it proved difficult to trace adequate villages. Nonetheless, some villages with reasonably comparable characteristics have been found. In Table 11, these villages are categorized according to the following criteria:

- The **Province**, i.e. the region, is a defining basic characteristic to capture climatic, geographic and agricultural differences. Since three of the project sites are in the North and one in the South, control sites have been chosen accordingly. Although Kibangu belongs to the Western Province, it is located in the middle longitudinal corridor of Rwanda, too (cf. Figure 1).
- The **year of electrification** is decisive for the question whether sustained effects of access to electricity can already be observed. Since Nyamyotsi is electrified for only one year, certain development hypotheses cannot be tested by means of data from this village.
- The criteria "**rural agricultural structure**" and "**tarmac road access**" are locational factors that determine fundamentally the economic potential of a region. The project sites constitute the standard of comparison being characterised by dispersed settlements, agricultural imprint and – except Kavumu – remoteness to infrastructures and supra-regional markets.

Table 11: Comparability Criteria for Control Villages

	Macro				Micro	
	Province	**Year of electrifi-cation**	**Rural agricultural structure**	**Tarmac road access**	**Unrestricted access to/ use of electricity**	**Efficient utilisation of electricity**
Kibangu	W	1987	++	++	-	-
Gasarenda	S	~ 1990	+	o	+	++
Nyamyotsi	N	2006	++	++	o	-
Nyanga, Cy.	N	1987-1992	+	+	+	++
Rutsiro	W	~ 1990	+	++	++	++
Base	N	1990	++	+	++	++
Mpenge	N	~ 1990	++	++	+	++

The assessment of the comparability of the control to the project villages varies from "very comparable (++)" to "not comparable (-)".

Beyond these *macro* village factors, the sites differ in *micro*, i.e. household level, aspects as well:

- Whether households enjoy **unrestricted access to and use of electricity** implies how far they can use electricity without impediments and restrictions. An impediment would be for example the reluctance of the electricity provider to connect new households. An example of restricted electricity usage is the order given by the electricity provider not to use certain electric applications that require a lot of power.
- **Efficient utilisation of electricity** prevails if customers have incentives to use electricity efficiently. In general, this is the case if a metering system is put to practice, while a flat rate system (see Kibangu and Nyamyotsi) entices customers to waste energy.

For the latter two household level criteria it is assumed that the micro-hydro plants will function without problems such that households are able to use electricity without hindrance and that a metering system will be introduced encouraging people to use electricity sensibly. Although the project sites are not a homogenous group of settlements, each control village in principle constitutes a control to the whole treatment group. The only exception is the Mpenge control region (as originally intended) which has been assessed only in terms of its comparability to the originally proposed Mpenge project sites.

3.6.1 Kibangu [KI_C]

In its basic characteristics, the Kibangu site (Kibangu Sector, Muhanga District; photographs KI-01 to KI-03 in the Electronic Annex 0) is very much alike those of Musarara [MU] and Nyaruguru [NY]. It takes one and a half hours by car to do 25 km to the next tarmac road. The village is a center of dispersed agglomerations in a radius of maybe five to ten kilometres. The rural development association COFORWA is the biggest employer and manages the MHP. Besides that, it is also the biggest electricity consumer. Only the COFORWA guest house, offices and the chairman's housing consume 50 to 60 percent of the electricity. The MHP was installed in 1987 at the Nyakabanda River with the help of a Belgian priest. As this clergyman died in the meantime, funding got difficult. Due to these circumstances, necessary repairs could not be executed since 2004. It is assumed that the alternator excitation system is defective leading to the 65 kw plant currently running at only 30 kw providing electricity to 175 clients. Consequences of this limited performance are frequent black- and brownouts, since more than a year applications for new connections are rejected and connections of defaulting debtors are cut earlier. People are instructed not to use appliances with high power demand such as irons. Moreover, employees of COFORWA, currently more than fifty, have been traditionally given priority in terms of electricity access. Therefore, the Kibangu site neither provides free access nor does it allow for unrestricted use of electricity.

Although electricity meters are successively introduced, a flat tariff system (250 FRw (0.35 EUR) per light bulb and 500 FRw (0.70 EUR) per socket and month) is still prevailing whereby customers are not induced to economically use electricity. Hence, Kibangu proved to not represent an adequate control site and was therefore abandoned by the survey team.

3.6.2 Gasarenda [GA$_C$]

Gasarenda is located on one of the main east-west traffic axes between Butare and Cyangugu, 40 km from Butare, halfway between the District capital Gikongoro and the Nyungwe Forest. It marks the end of the Électrogaz electricity line from Butare, the only line supplying the Southern part of the country. As this line follows exclusively the tarmac road, it was not possible to find a village that was less favourably located in terms of access to infrastructures. Due to this relatively privileged location, Gasarenda became one of the first commercial centers in Rwanda. However, the underlying structure is still sufficiently rural and allows the comparison with the project sites. Electricity reached the region around 1990. Gasarenda comprises an area of around 700 households, while only half of them live close to the electricity line. In total, 221 clients are connected, including several MSEs and institutions. Like everywhere in Rwanda,

Photo 2: Village Center at Nyamyotsi

Électrogaz is at present also in Gasarenda reluctant to connect new households, whereby the unrestricted access to electricity is partly impeded. For a detailed description of the covered region see Appendix A4.5.

3.6.3 Nyamyotsi [NI$_C$]

As one of the first international donor organizations active in the recovery of the Rwandan micro-hydro sector, UNIDO is currently realizing three projects. The first one already in use, named after the river Nyamyotsi, is located only few kilometres from the Musarara site [MU] south of Ruhengeri. The tarmac road from Ruhengeri ends after 8 km at the village Kampala, and after further 5 km one arrives at the mini-grid covering the sector office with a health center and a primary school, the commercial center of Gashyushya and households all around (cf. photographs NI-01 to NI-04, Electronic Annex 0).

After half a year of test operation, the plant was officially inaugurated in February 2007. Technical and financial management was handed over to the district with representatives of the local population. Similar to Kibangu, a flat tariff system was put in place (at least for the time being) that ranges from 1,500 FRw (2 EUR) for private households to 10,000 FRw (13.30 EUR) for the mill and carpenter. Due to a customer-friendly connection policy – households only had to pay the installation in their homes and 1,000 FRw (1.35 EUR) for the connection to the grid – the site already counts 195 customers. Even more households are installed but did not pay the 1,500 FRw bill and were therefore cut from electricity.

As for the time of the first baseline in 2007, the connected households were not satisfied with this uniform pricing since electricity consumption varies enormously among them. Furthermore, voltage fluctuation (according to the population representative the source of error is a missing transformer at the power house) destroyed several electric appliances such as radios and computers in the sector office. The local miller even declared to have lost two times the dynamo of his mill, which cost him both times 350,000 FRw (470 EUR). A third major problem arises from the sand carried by the river that brings the MHP to a standstill during and after heavy rain. An investment dossier prepared by SHER in December 2005 with additional information is available, since Nyamyotsi was RES' first proposal for PSP Hydro. They had to withdraw because UNIDO made a claim for the site.

In the meantime, at least the first two problems seem to be tackled through the provision of old conventional meters by Electrogaz and technical upgrades. In how far the situation actually improved, could, however, not be found out.

Photo 3: Main Road at Gitare (Cyanika)

3.6.4 Nyanga and Cyanika [CY_C]

One of the few "off-the-main-road" electrified regions comprises a group of villages located at slip roads along the 23 km road from Ruhengeri to the Ugandan border between Nyanga and Cyanika, each 3 to 5 km far in the sectors of Kinoni and Kagogo. These villages near Lake Burera are namely Nyanga (photos CY-01, 02; Electronic Annex 0), Kabaguma (CY-03), Kinoni (CY-04) and Gitare (CY-05, 06). The electricity access of these remote areas dates back to the period of 1987 to 1992. It is the result of the location along the transmission lines of the nearby Ntaruka 11.25 mw hydropower plant. They also benefit from this location in the form of a very reliable electricity provision.

3.6.5 Base [BAc]

The control villages in Base and adjacent Nemba sector are located in Rulindo District in the Northern Province. Near Nyirangarama, famous for its juice production and roughly halfway between Kigali and Ruhengeri, one has to take the slip road to Byumba to reach the cells of Kiruri (BA-01, 02), Gatete (BA-03), Nyamugali (BA-04, 05), and Rwiri (BA-06, 07). The region was inhabited by Arabs and Indians in the 1960's, who settled here to do business and trade. The region is crossed by a number of rivers and characterized by fertile land, favouring the strong agricultural orientation of the population and the creation of tea plantations in the region.

3.6.6 Rutsiro [RUc]

The Rutsiro control villages can be reached via the road from Rubengera to Murunda along the shore of Lake Kivu. They therefore share common characteristics with the Murunda site. Households have been interviewed in Rutsiro (RU-01), Bumba (RU-02, 03), and Mushubati (RU-04 to RU-06).

3.7 Redefinition of Village Types for Survey Analysis

The survey setup was originally intended to only include non-electrified project villages and comparable electrified control villages. Considering the information provided on the individual villages in this chapter, this initial classification of villages has to be adapted. Data analysis in the following chapter shall be conducted long the classification depicted in Table 12. Since Murunda is already electrified, it will be included both in the groups of Project Villages and that of electrified villages depending on the research question.

Within the scope of this report, Mpenge finds itself in the group of electrified urban Control Villages. This is due to the facts that firstly the areas targeted by the original project developer GTR – as found during the survey – as well qualify as already electrified and secondly this project was cancelled by GTZ afterwards. In the meantime, an investor was found willing to exploit the same micro hydro plant site at Mpenge River. Yet, so far it is not decided upon the locations in peri-urban Ruhengeri that will be electrified. Accordingly, it is unclear whether the collected data can serve the new project. Since most of the area surrounding the MHP site is already electrified, it remains as well to be seen, whether the new project can be classified as a non-electrified or electrified Project Village.

A second village in this group is Gasarenda, which turned out to be not sufficiently comparable to the project villages. Due to this lack of comparability, the following analysis will draw on electrified urban Control Villages only in restricted cases.

Furthermore, Kibangu [KIc] finally was not surveyed, since it failed to comply with the comparability criteria on the level of electricity access and use. Taking into consideration that the Nyamyotsi [NIc] site was operated only for half a year at the time of the survey, it could serve the project's interest in first outcomes of the intervention. Yet, due to this recent electrification date, it also violates a main comparability criterion and is neither included in the control village dataset.

Table 12: Adapted Village Classification for Survey Analysis

	Project Village	Rural Control Village	Urban Control Village
non-electrified	Kavumu [KA] Musarara [MU] Nyaruguru [NY] [n=269]		
electrified	Murunda [MD] [n=93]	Base [BAc] Nyanga/ Cyanika [CYc] Rutsiro [RUc] [n=180]	Gasarenda [GAc] Mpenge [MPc] [n=127]

4 Analysis of Survey Results

In this fourth chapter the processed survey data is presented and discussed. The household data is divided according to the questionnaire components outlined in chapter 2.4. The structure thereby reflects the impact to be expected in each of these fields: While the household structure is unlikely to change substantially due to the project intervention, the expected impact on household energy is the highest. Of course, the analysis focuses on the results of the project sites. Data on control villages enriches and qualifies this analysis as well as the examination of specific subgroups like individual project sites, different socio-economic classes or electrified households.

4.1 Household Structure

This paragraph presents a basic profile of the surveyed households including household sizes, composition and main occupation of household members. Since this information is straightforward and least affected by the way questions are formulated in different surveys, it allows for scrutinizing the comparability of the surveys that were designed to be representative for rural Rwanda, i.e. the national Household Living Conditions Surveys EICV1 of 2001, EICV2 of 2006 and the Demographic and Health Survey of 2005 (DHS). Table 13 summarises the data from the different surveys. In the subsequent paragraphs, it will be referred to data for Rwanda or rural Rwanda only at selected passages and comparative figures will be provided mainly by the control villages.

The average number of household members in the 362 households of the four project sites is 5.46, ranging from 5.14 in Murunda [MD] to 5.74 in Nyaruguru [NY]. While the wealth indicator (for more details on the indicator, see chapter 2.5 or appendix A2) was constructed in a way not to be biased in favour of either bigger or smaller households, wealthier households in

Table 13: Summary of Data on Household Composition

	Average Household (HH) Size				Children per HH (per Adult)	Adults per HH	Share of Female Population	Share of Male Heads of HH
	Total	poor	middle	Rich				
non-electrified Project Villages	5.57	5.38	5.71	5.75	2.63 (0.90)	2.93	51.3	81.0
electrified Project Village	5.14	4.96	5.12	5.42	1.98 (0.63)	3.14	51.8	75.3
rural Control Villages	5.21	5.22	5.32	5.13	2.40 (0.86)	2.81	48.5	79.9
urban Control Villages	5.86	5.89	5.73	5.08	2.69 (0.85)	3.17	52.2	80.2
DHS *values for rural pop.*	4.5	-	-	-	2.11 (0.88)	2.39	53.1	66.0
EICV2 *values for total pop.*	5.0	5.4	5.0	4.7	2.20 (0.79)	2.80	52.5	76.0

The DHS is designed specifically to measure demographic issues and is therefore considered to be a more reliable source of demographic information. The EICV on the other side is in its purpose to "measure household expenditures, consumption and income, as well as demographic and socioeconomic characteristics of the population of Rwanda" (EICV 2006) closer to this baseline study.

the project villages tend to be slightly bigger – a relationship that does neither hold for the control villages nor the data from EICV2. For EICV2, it cannot be ruled out that this is due to the differences in the poverty/ wealth definitions. However, the subindicators by which the biggest 15 percent of project village households outperform the rest – housing conditions, education of head of household and telecommunication expenditures – seem not to be sensitive to the household size. Apparently, households in the project villages manage well to tackle the normally poverty-reinforcing effect of a larger amount of descendants.

According to the classification by the International Labour Organization (ILO), household members of 15 years or older were considered adults, while members younger than 15 years were considered children. Apart from Murunda, where far less children are present, the children per adult ratio is around 0.85 in project and control villages and is thereby identical to the value for the rural population in whole Rwanda. This means that the high proportion of 46 percent of the population is younger than 15 years. Across all villages, four out of five heads of households are male. Households headed by a female normally (in 95 percent of the cases) lack the father. In Murunda, most often lack father and or mother.

Photo 4: Subsistence Farmer in one of the Project Villages

In total, 22 percent of the households lack one parent. Households that lack both parents and whose head of household is under 21 are almost non-existent. These vulnerable groups seem however to cope relatively well, since their wealth indicators introduced later on are only slightly worse than those of the two-parent households.

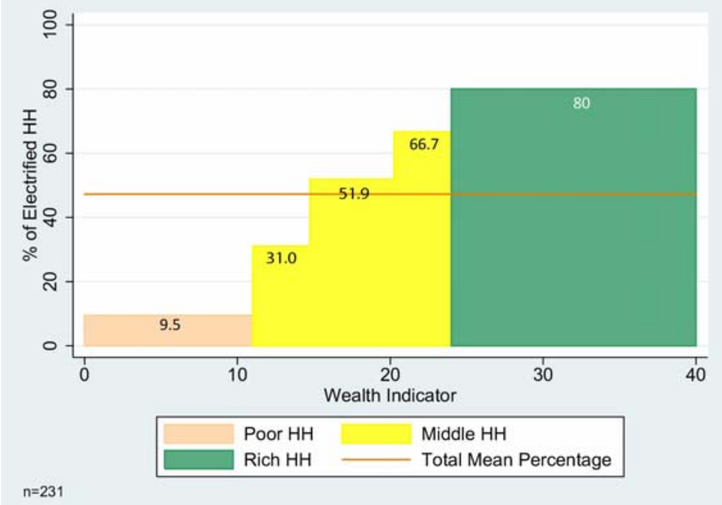
Table 14: People Whose Main Occupation is Agriculture
(as % of working population)

	%
non-electrified Project Villages	78.7
electrified Project Village	53.7
rural Control Villages	57.6
Urban Control Villages	34.6
Rwanda – rural	87.3 [1] 84.9 [2]
Rwanda – urban *excluding Kigali*	56 [1]

Sources: [1] = EICV2; [2] = DHS

Comparing the baseline figures with those provided by the Rwandan National Institute of Statistics, one observes well differences, which even exist between the data from the DHS and the EICV, too. More importantly, Table 14 reveals that the percentage of people working as subsistence farmers in the control villages is substantially smaller than generally observed in rural areas in Rwanda (including the project villages) and even lower than in urban areas. While it will be dealt with the economic consequences of this observation in the next chapter, it has to be clarified here that this circumstance does not reflect a violation of the comparability of the project and control villages. It rather testifies the assumption made in paragraph 2.6 that due to the closeness to the village and

Chart 1: Percentage of Connected Households in the Control Villages According to Their Wealth Indicator



commercial centers, service sector workers are more abundant among the people living under the electricity grid.

Another basic question to be discussed at this point is how far the elaborated wealth indicator relates to the probability of a household to get connected, i.e. whether wealthier households connect substantially more often to the grid than poorer ones. Chart 1 depicts this relationship graphically. On average 47 percent of the households in the rural electrified villages (both Murunda and the control villages) are connected to the electricity grid. This figure actually varies considerably: While only 9.5 percent of the poor households are connected, among the rich ones, more than three out of four households have grid electricity. Hence, wealth and electricity connections do correlate to a significant extent. Results from the following paragraphs shall help to investigate, in how far the electricity access is not only consequence, but also origin of the wealth.

Summary Box 1: Household Structure

- **Household size and composition** are obviously least affected by the provision of electricity. Households in the non-electrified project villages count on average 5.6 members, which is slightly more than in Murunda (5.1) and the rural control villages (5.2). While the child/ adult ratio is relatively constant across villages and with 0.9 only slightly below one, significantly less young people inhabit Murunda that exhibits a mere ratio of 0.6.
- The data presented in this paragraph addressed **representativity** concerns, too. Though differences across village types are observed in data that is supposed to be invariant, they are within the bounds of typically observed survey variance. Obviously, due to the representative sampling of households living close to the electricity grid, a higher proportion of people occupied in non-agricultural activities make up the surveyed population in electrified villages. In urban control villages this proportion is even less than half. They will henceforth not be further analyzed.
- **Poor households** connect eight times less than wealthier households. Along this baseline report, the question of poverty/ wealth will therefore be taken into special account.
- 47 percent of the surveyed households in rural electrified villages are grid connected. An extensive enquiry among 150 households along the electricity grid in Nyanga/ Cyanika, where the connection propensity is assumed to be similar to that for the project villages, corroborated this figure. Since the connection rate can be further raised through accompanying measures (among the surveyed population in Murunda, it amounts to 54 percent), the **expected medium-term connection rate** is one half.

4.2 Household Economy

The economical situation of the surveyed households is important for estimating the ability of households to invest in grid connection and the actual capacity to pay for electricity. The comparison with control villages especially casts light on the productive use of electricity.

4.2.1 Main Occupation

Agriculture is the predominant activity practised (cf. Chart 2). In the electrified project village Murunda same as in the rural control villages the number of adults working in services in the public and private sector is twice as high as in the non-electrified project villages. Especially women's access to non-agricultural occupations remains very poor (cf. Chart 3). Since the large majority of households in the analysed rural villages (85 percent in comparison to 49 percent in urban control villages) cultivate their own fields, only few village people state to be unemployed or to take on household chores in both electrified and non-electrified villages. That agricultural activity is not necessarily substituted by other employments can be taken from the urban control villages where there are twice as many people unemployed or doing temporary work (16 percent) than in the rural villages.

Looking at the working population only, the differences in numbers of people active in the

Chart 2: Main Occupation of Adult Household Members by Village Type

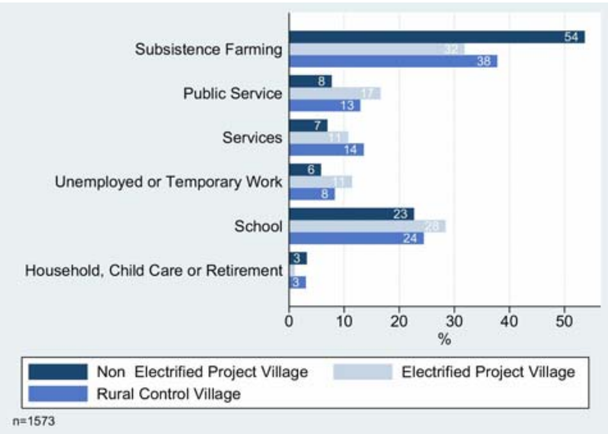


Chart 3: Main Occupation of Adult Household Members in the Project Villages by Sex

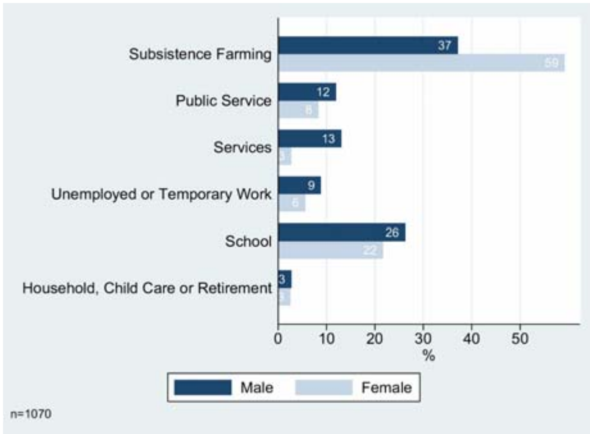
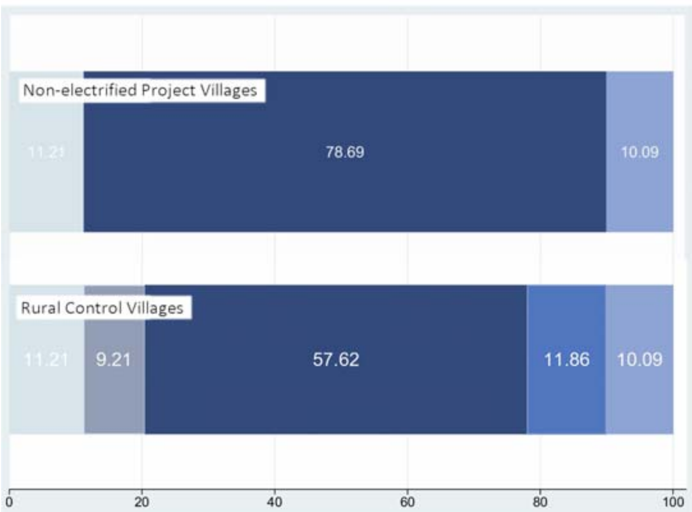
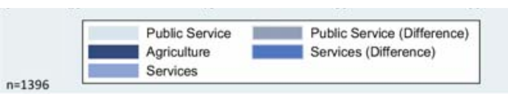


Chart 4: Comparison of the Working Population in the Project and Control Villages





various economic sectors can be analysed. Chart 4 depicts this comparison. It gives an idea of which jobs are occupied by the difference in people active in non-agricultural sectors, which amounts to about 21 percent. Nine percent are public servants. This indicates better access to infrastructure services in these areas such as schools, health centers and police stations. On the other side, 12 percent more people in the rural control villages exert income-generating activities in the private service sector. Among these, home businesses are very uncommon (only 1 to 2 percent of the households indicate a productive use at home) and do not occur with a higher probability in electrified regions. Neither is there any specific type of service which dominates home businesses such as sewing. Even welding and carpentry home businesses can be observed. Income-generating activities are mainly concentrated in the commercial areas ("centres de négoce"). They are dealt with in more depth in chapter 4.5.

4.2.2 Cultivation

Coming back to agriculture, cultivators in the non-electrified project villages plant a relatively wider range of crops than the other analysed groups (cf. Chart 5). At the same time, among them the share of agricultural households selling part of their products beside autoconsumption is higher (Chart 6). Table 15 lists the main cultivated crops and transformed products for the project villages. As in whole Rwanda, the two predominant food crops are beans and sweet potatoes. In terms of production and revenues from agricultural products (including transformed products), Kavumu [KA] and Musarara [MU] are most active, while at Nyaruguru [NY] plots on average are significantly smaller and the soil quality is worse. At Murunda, a narrower set of crops is planted yielding average outputs while inputs (including workload and cultivated land) are highest.

A similar comparison regarding agricultural in- and outputs is executed between project and control villages and leads to a somehow surprising outcome. Table 16 and Chart 7 present the results. The monetary values are probably questionable in absolute terms. Yet, since the evaluation team found no indication for a higher precision of the statements of one of the two compared groups, there is no reason for doubting the meaningfulness of *relative* comparisons. On the same plot sizes (with a –

Chart 5: Cultivated Crops by Village Type

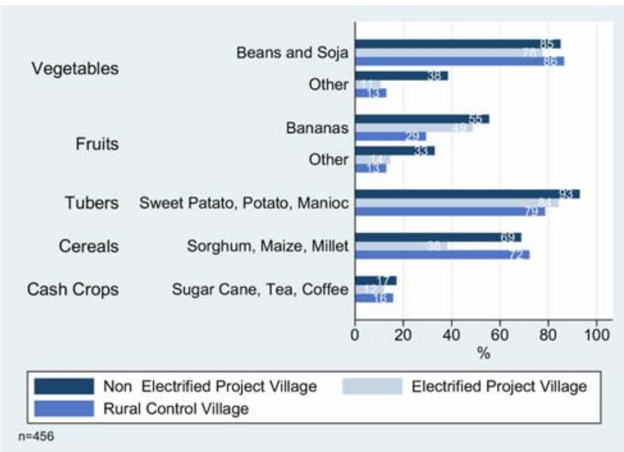


Chart 6: Percentage of Farmers Selling Their Products by Village Type

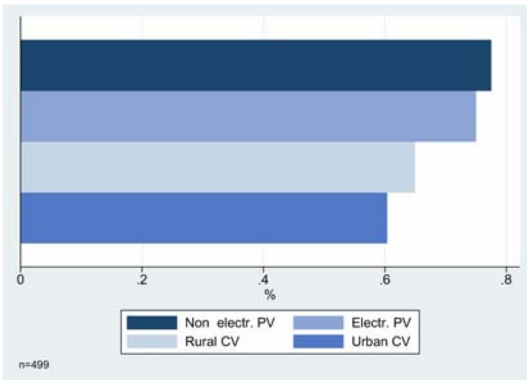


Table 15: Main Crop Products in the Project Villages

Cultivated Crops		Processed Products
Beans	1.	Banana Beer / Juice
Sweet Potatoes	2.	Millet Flour
Bananas	3.	Sorghum Flour
Manioc	4.	Manioc Flour

Table 16: Averages for Agricultural In- and Outputs

	Annual Revenue from Crop Products in FRw	Value of Annual Home Consumption in FRw	Agricultural House-holds' Weekly Farming Workload in hours	Annual Expenditures on Agricultural Inputs in FRw
non-electrified Project Villages	107,050	123,850	63.5	33,100
Difference	+63%	+20%	-20%	-32%
rural Control Villages	65,750	103,600	79.5	49,000

on average – probably similar soil quality) cultivators in the project regions manage to both produce and consume more agricultural products, while they even work less and spend fewer money on agricultural inputs such as pesticides and non-family field workers.

The information gathered during the baseline survey does not suggest any reasoning for these circumstances or any structural linkage to the question of electricity access. It might nevertheless be kept under observation how these values develop in the years to come. More importantly, two things have to be considered. Firstly, while across all villages more than 89 percent of cultivating households own the plots they cultivate on, there is a huge amount of households whose agricultural surface falls below the minimum farm size to feed a Rwandan family, which UNDP estimated at 0.7 hectares (ha). According to Chart 7, half the population do not surpass this threshold. Yet, this is still lower than the nationwide value of 62 percent (EICV2). The consequences are nonetheless very palpable. While these households suffer 4.4 month from food shortages, the families with more than two ha declared to have insufficient food only during 2.5 months – for data on the prevalence of food shortages in the course of the year, see Chart 8, where peaks are present during the rainy seasons in April and October. This relationship does on the other hand not hold for the control villages. Another difference between the two groups lies in the correlation between plot size and wealth, which is more pronounced – at least among middle and high income households – in

Chart 7: Household Cultivated Area

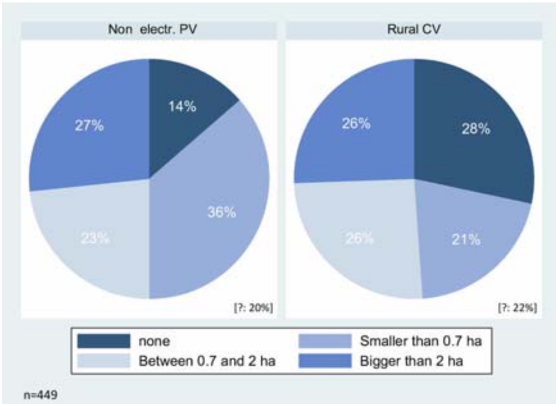
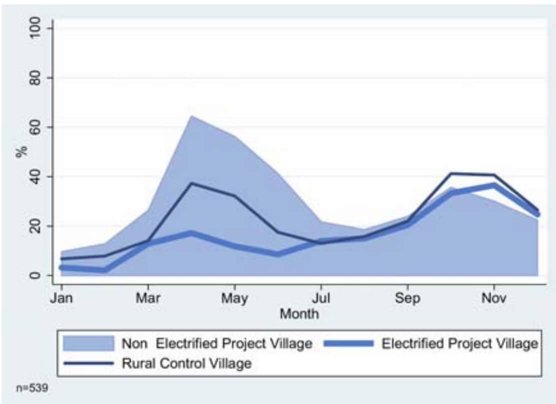


Chart 8: Percentage of Households Stating to Suffer from Food Shortages



the project villages. The data thereby seems to support the finding that the plot size is less decisive for the economic wellbeing of a family in the control villages, probably because the dependence on agriculture is lower there. Secondly, the relative high values for the project villages in Table 16 should not disguise that several decisive factors are still inadequate. Apart from uninfluenceable cultivation conditions (climatic changes can be observed in Rwanda leading also to less predictable harvest), these factors encompass agricultural techniques and tools, inputs (seeds, fertilizers), marketing and the rate of unionisation. The average agricultural equipment of a Rwandan cultivator, for example, is very basic. It comprises two hatchets and a machete. On top, half of these households possess a spade, every tenth a barrow. All other tools are present in less than two percent of the cultivator's households.

4.2.3 Crop Transformation and Animal Husbandry

In the project villages, the percentage of cultivators transforming part of their crops is 52 percent. Their main products are those already mentioned in Table 15. The degree of households who sell part of their transformed products differs considerably between Murunda (98 percent) and the non-electrified project villages (56 percent), whereas the average yearly revenue is almost identical and averages 64,000 FRw (85 EUR).

Concerning the nexus between electricity and crop transformation, data analysis after the first data gathering in 2007 indicated that more households engage in flour processing after electrification. It was reasoned that the majority of non-connected households either go to the usually more expensive fuel-run mills in the village or to the most nearby electrified village. These higher financial and time expenses seemed to deter some of the households from producing flour at all. Looking at the data of the extended data set does not allow for this conclusion anymore. The two predominant transformation outputs, flour and beverages (banana and sorghum beer and banana juice) are analysed in Table 17. Flour production among the relevant households, i.e. those which plant any flour input at all, is even largely higher in the non-electrified villages. One reason for this different outcome is that the analysis does not include the urban control villages of Mpenge and Gasarenda anymore, where milling is more common.

Animal husbandry contributes only little to household income. While three-fourths of the households in the project regions raise animals at their place, only one fourth of these did earn any money from sales of animals or animal products in the preceding year. This observation can often be explained by the fact that many households just started to raise animals. Correspondingly, they are relatively inexperienced and benefit from their animals mainly by means of the dung they produce. Expressing agricultural activity in terms of both crop cultivation and animal husbandry, one observes again that Murunda as the only already electrified project village bears a structural resemblance rather to the rural control villages than to the other project villages. Only four percent of the households in the project villages neither engage in crop cultivation nor in animal husbandry. In Murunda, this value is 13 and in the rural control villages 16 percent (cf. Table 18).

Table 17: Crop Transformation Outputs

	non-electrified Project Villages	electrified Rural Villages
Flour	62 [18]	34 [0]
Beverages	75 [85]	83 [85]

The table states the percentages of those crop transforming households which produce the respective crop transformation output while planting the necessary input (e.g. millet, sorghum, manioc, etc. for flour). The figures in brackets name the percentage of households among each group which transform by hand.

Table 18: Agricultural Activity

non-electrified Project Villages (n=269)			
		Animal Husbandry No	Animal Husbandry Yes
Crop Cultivation	No	12 (4 %)	17 (6 %)
	Yes	38 (14 %)	202 (75 %)

electrified Project Village (n=93)			
		Animal Husbandry No	Animal Husbandry Yes
Crop Cultivation	No	12 (13 %)	5 (5 %)
	Yes	23 (25 %)	53 (57 %)

rural Control Villages (n=180)			
		Animal Husbandry No	Animal Husbandry Yes
Crop Cultivation	No	29 (16 %)	11 (6 %)
	Yes	43 (24 %)	97 (54 %)

4.2.4 Remittances

The category of "Other income" is made up mostly of remittances and other transfers, which mainly originate from former household members. 22 percent of the project village households stated that at least one former household member migrated. This value differs from 14 percent in remote Nyaruguru to 31 in Musarara situated close to Ruhengeri. The average number of migrants these households recorded is 1.8. In 70 percent of the households at least one household member emigrated within the last five years. The migrant's reasons for migrating and the respective destinations are compiled in Table 19. Surprisingly, only 15, i.e. one fifth, of those households, which stated that members of their family migrated, benefit from remittances. 7 of them rejected to reveal the actual amount of money transferred by the migrant. Since especially the information on migrants and their remittances is sensitive, these figures should be assumed to be higher. Although the enumerator's impression was that no information has been hidden, this was probably the case at some households. A sound statement on whether remittances form an appreciable and reliable super-subsistence income source that might help households pay their electricity bills therefore is not possible. Nevertheless, remittances have been included in the calculation of the income variable.

Table 19: Migration Characteristics in Project Villages

	%
Reason for Migration	
Marriage	48
Seasonal or Every-day Work	33
Lack of Work and/ or Land	8
Destination	
Kigali	31
Ruhengeri	13
Same Sector	11
Same District	11
Abroad	5

4.2.5 Savings and Credits

Even more than remittances, data on savings and credits may suffer from the withholding of information and shall accordingly be treated with reserve. Considerable 48 percent of the project village population declared to possess a bank account. Due to the good accessibility of its Banque Populaire (UBPR), the value is even 63 percent in Murunda. Across all villages, at least 70 percent of these households possess an account at this bank, followed by Coopec, another Rwandan non-bank financial company. The figure for actual savings is slightly lower, as can be retrieved from Table 20. The table gives an account of credits taken in the last five years, too. Due to extreme outliers, median values are more meaningful here. While median savings are 45,000 FRw (60 EUR), median credits amount to 200,000 FRw (270 EUR) (in both cases, the averages and medians are taken from those households that actually dispose of savings and/ or credits).

For both savings and credits, four observations were made: (i.) although the rural financial markets are rather poorly developed, total numbers of cases are relatively high; (ii.) both numbers of cases and the average amount of savings and credits differ extremely between the different wealth groups even if taking outliers into account; (iii.) if not for security reasons, they are set up mainly for investment reasons (the importance of school fees is especially remarkable); (iv.) another aspect – which cannot be taken from the table – is that these main purposes are quite similar for the different wealth groups, i. e. poor households save money and take out loans for investments as well (and even more for school fees), though with significantly lower amounts.

Table 20: Savings and Credits

	Percentage of Households Disposing of …				Average [and Median] Amount of … in FRw				Main Purposes (% of Households)
	PV	PV_p	PV_m	PV_r	PV*	PV_p*	PV_m*	PV_r*	PV*
Savings [last year]	45	14	59	84	328,500 [45,000]	25,000 [10,000}	86,500 [20,000]	1,107,000 [100,000]	-
Credits [last 5 years]	30	10	33	45	482,000 [200,000]	67,000 [40,000]	338,000 [150,000]	669,500 [375,000]	Construction (28), Commerce (22), School Fees (21)

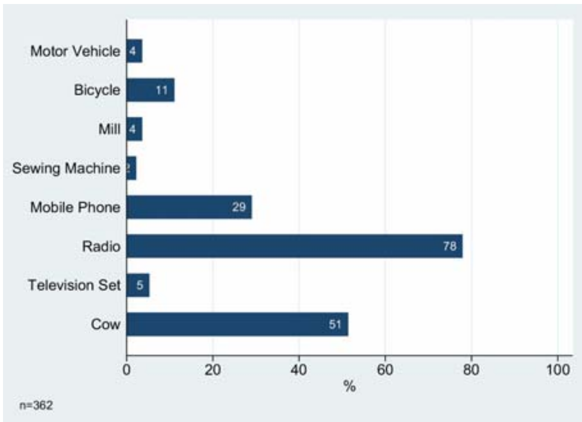
PV = Project Villages; PV_p = poor Households in PVs; PV_m = middle households in PVs; PV_r = rich households in PVS (for the classification into poor, middle and rich, see 0 and appendix A2)

** Among those households which dispose of Savings and/ or Credits.*

4.2.6 Assets, Expenses, Income

Chart 9 and Chart 10 give a first idea of the economic situation in terms of ownership of assets and (main) expenditure classes. The different specific assets and expenditure classes will be scrutinized in more detail in the following two chapters if not already dealt with above. Income is a too biased indicator of economic welfare to give any useful information in absolute terms. Instead, jointly with assets and expenses, income has been included in the Wealth Indicator (cf. chapter 2.5), whose distribution is illustrated in Chart 11 for the project and control villages. Most notably, the percentage of poor households in the control villages is 40 percent lower than in the project

Chart 9: Ownership of Assets



villages. This becomes evident when comparing the individual villages of both groups (Chart 12). Nyaruguru [NY] is considered the poorest village with the majority of the people (60 percent) classified as poor. In the other two non-electrified project villages Kavumu [KA] and Musarara [MU], poverty/ wealth structures are similar to each other. The situation at Murunda [MD] comes again very close to the structure observed in the rural control villages. In terms of the box and whisker sizes, i.e. the gap between the poor and the rich, only Murunda stands out. Differences are, however,

Chart 10: Expenditures

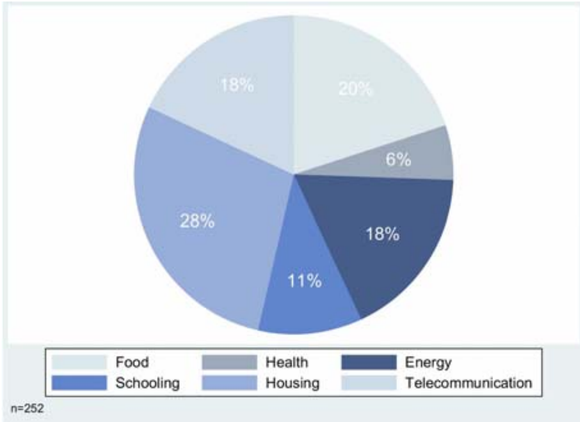


Chart 11: Wealth Indicator

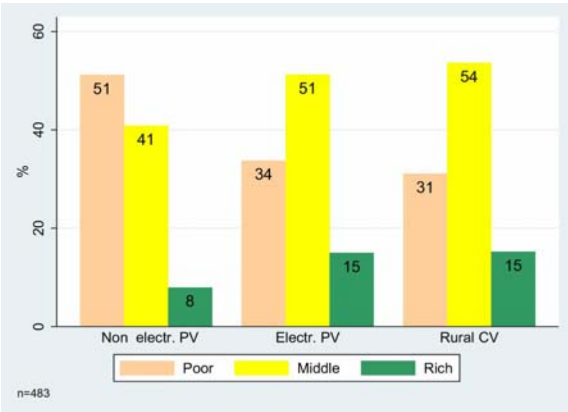
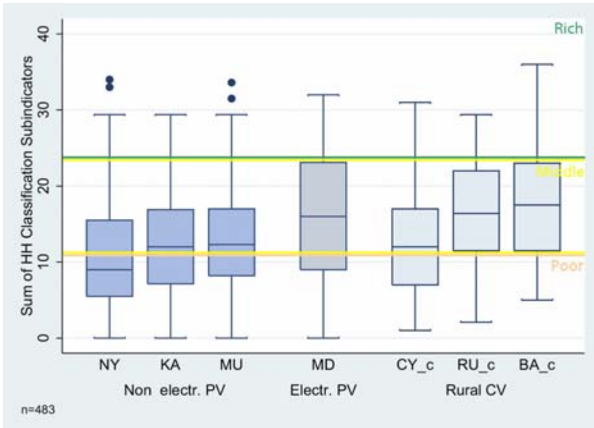


Chart 12: Wealth Indicator by Village

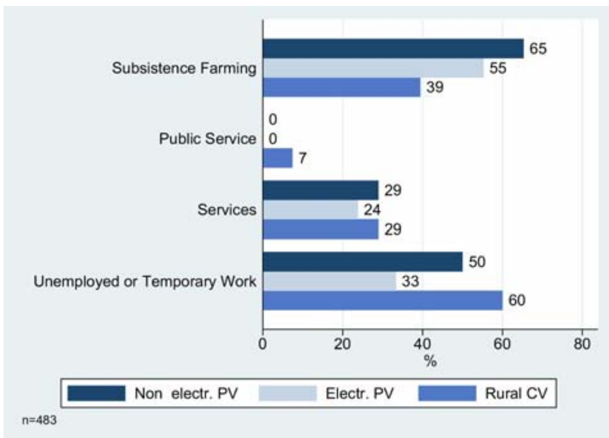


While the wealth indicator values are presented in the left chart at the aggregate level, the right chart gives the sum of the subindicators. The horizontal line in the box represents the median, the lower bands of the boxes are the 25% percentiles, the upper bands are the 75% percentiles. Including the whiskers, which show the range of the observations, an illustrative picture of the conditions in the individual villages is being drawn.

to small to allow drawing conclusions about inequality among the population.

Focussing more on poor households, one may distinguish between the household's head main occupation and examine the proportion of poor households among each of these occupation categories. Thereby, the vulnerability to poverty of households according to their main wage-earners work can be assessed. Chart 13 clearly shows the differences between these groups. While there are no poor among those 40 heads of household whose primary occupation is public service in the project villages, almost two-thirds among farmer heads of household are classified as poor there.

Chart 13: Proportion of Poor Households According to Head of Household's Main Occupation



Summary Box 2: Household Economy

- The population in the project villages is **predominantly occupied in the agricultural sector**. Farming output figures are higher than in the control villages, while direct improvements in crop planting through electricity access cannot be expected. Nevertheless, cultivators often lack improved farming inputs, techniques and sufficient land, factors that will be further stressed in the future due to climatic changes and demographic pressure.
- **Home businesses** are very uncommon in Rwanda. Less than two percent of the households indicate that they productively use electricity at home – both in control and project villages.
- Other agricultural activities but crop planting are yet underdeveloped. Investments in **animal husbandry** are quite new for most of the households. Empirical evidence concerning the feasibility of low-scale electricity-needing accompanying activities (like cooling) does not yet exist. Theoretically, **crop transformation** becomes more attractive after electrification. Mainly with regard to flour production, cost savings can be expected, which are assessed in chapter 4.5. Surprisingly, however, people in electrified villages do not have more of their crops being transformed before selling the agricultural output.
- While household expenditure will be scrutinized at corresponding passages in the following paragraphs, the extent of **remittances** seems to be rather negligible. Considering the possibility of hidden information and that – according to national data – the young and non-poor are more likely to move than the poor, remittances might nevertheless play a role as a financing source for electrification investments.
- In order to give a profound picture of the economic situation of the households and to account for some inaccuracies typical for data recorded in developing countries, a comprehensible **wealth indicator** has been developed, which combines 14 subindicators representing assets, expenditure and income. Half the inhabitants in Kavumu, Musarara and Nyaruguru are classified as poor, while this holds for only a third of the population in Murunda and the rural control villages.
- The anti-poor pattern in electrification normally goes through two channels: More developed communities are more likely connected and poor people can less afford the connection. Since the target villages are in less favoured areas of Rwanda, the inter-regional **inequality** may be reduced due to the development measure. In relation to the second aspect, it was already found in the last chapter that poor households connect far less. The analysis of this chapter provides only little evidence concerning a higher intra-regional wealth disparity in electrified villages.

4.3 Social Life of Households

Expected impacts on the social life of the household members can be (i) better learning conditions through lighting and (ii) the exemption from household chores or (iii) better health due to improved indoor air through less indoor smoke. In combination with a variety of other everyday life determinants of the population, these aspects shall be investigated in the following.

4.3.1 Education

Compulsory primary school attendance was introduced in Rwanda in 1979 when the state took over the sovereignty of the formerly catholic and Belgian influenced school system. Primary school fees have been abolished in 2003. Secondary and tertiary education is still poorly developed, especially in the surveyed regions (for more information on the current situation of primary and secondary schools, see chapter 4.7).

Since 53 percent of the surveyed population was under 18 years old, 39 percent of the population is still in school, vocational training or university. Among the adult population, this share is still around 25 percent (Chart 14). In the non-electrified project villages, 21 percent are without basic education, i.e. six years of primary school. This is significantly more than in the control villages, where this value is only 11 and more than in Murunda. People not having visited or finished primary school also bring about the most pronounced differences among the project villages: While in Murunda [MD] and Kavumu [KA] only 12 and 16 percent did not conclude their first six years of schooling respectively, this percentage amounts to 26 at Musarara [MU] and 28 in Nyaruguru [NY]. Twelve percent of the population did not visit any school at all. This percentage will decrease for sure in the future, since it already corresponds to only 6 percent among adults aged under 35 years. As in whole Rwanda, figures for people having concluded secondary school or university are very low. With 20 percent, a significant share in this regard can only be observed in the villages Murunda [MD]

Chart 14: Adult's Highest Educational Degree Completed by Village Type

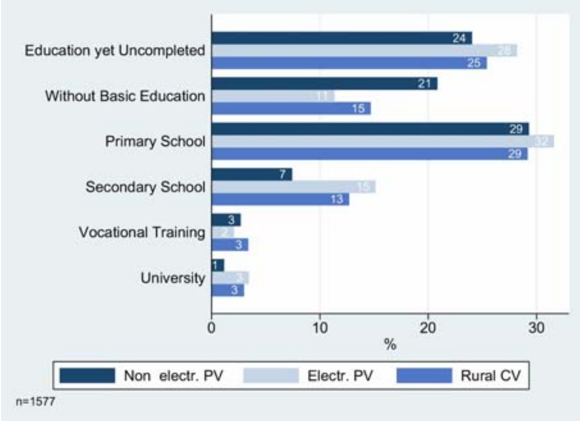


Chart 15: Average Years of Schooling at the Village Level

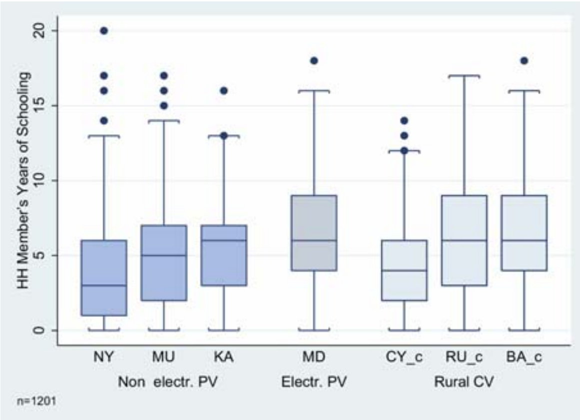
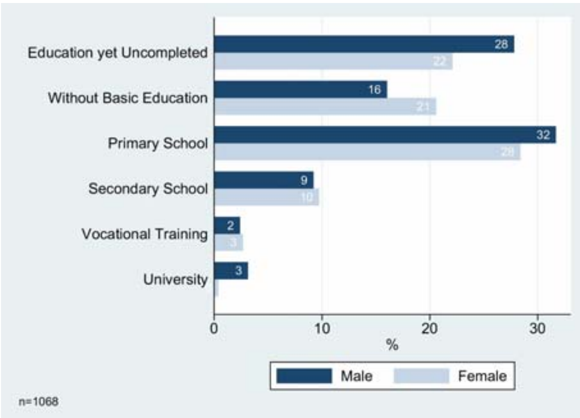


Chart 16: Adult's Highest Educational Degree Completed of Project Village Population by Sex



Rutsiro [RU_C] and Base [BA_C]. The average years of schooling of people having finished school there range from 7.1 to 7.5, while they only reach between 4.8 [NY] and 5.9 [MU] on average in the other villages (Chart 15).

Gender-related data on education suggests a rather positive picture (Chart 16). In the "middle layer" (primary school, secondary school, vocational training) differences are marginal. Pronounced differences to the disadvantage of females are pertinent above (university) and below (no education). At least concerning the latter, improvements are to be expected looking at school children information: 98 percent of children of both sexes between seven and 14 regularly visit school.

The specific attendance rate of schoolboys and -girls is difficult to measure at the household level. It would reach 99 percent according to the answers given on the total number of days absent in the month preceding the interview. Though according to random inspections at schools attendance rates actually exceed 90 percent in general (cf. chapter 4.7 on schools, which also provides detailed information on indirect education impacts through the electrification of schools), this figure is probably too high. Main reasons for not attending school were illnesses and a lack of schooling material. The majority of the cases occurred in Nyaruguru [NY]. Since free of charge school lunch supported by the World Food Programme (WFP) in Nyaruguru District create incentives for the parents to send their children to school, even the amount of days absent is tolerable.

4.3.2 Health

Main issues of the Rwandan health system are the provision of safe drinking water for the population, the reduction of infant mortality and illnesses related to malnutrition. More general information on health in Rwanda can be found in chapter 4.6 on health centers. Same as with schools, that chapter gives insights into the indirect health impacts through the electrification of health centers, while here direct impacts on household level are presented and analysed.

80 percent of the surveyed population possesses a health insurance, predominantly the "mutuelle de santé", a governmental sponsored health insurance. In this regard, the baseline data partly dating back from 2007 might already be outdated. This has to do with the consistent and efficient decentralized government agenda in the health sector intended to achieve universal health insurance coverage. Though measures are taken to promote the inclusion of poorer parts of the population into the system, baseline data indicates that rather the poor are those without insurance (be it because of the lack of financial resources or of information). Health expenditures correlate considerably with wealth with rich households spending twice as much on health as poor ones. 50 percent of poor households uttered that they are never or at least only seldom able to pay for necessary medicine, more than double as much as in the rest of the project village population. Monthly health expenditures (without contributions to insurance schemes) average 1,450 FRw (1.90 EUR) in the project villages.

Table 21: Prevalence of Chronic Diseases among Households (in %)

	non-electrified PV	electrified PV	rural Control Villages
Malaria	42.2	42.0	49.2
Intestinal Parasites	37.7	22.6	27.1
Diarrhoea	7.2	4.3	1.1
Respiratory System Disease	30.0	18.5	18.8
Eye Problems	19.3	18.5	14.1

PV = Project Village/s

Taking a look in Table 21 at the recurrent diseases in the sample population, one observes that – apart from Malaria, which can be assumed least responsive to socio-economic

Table 22: Prevalence of Relevant Diseases among Household Members by Sex (in %)

Respiratory System Disease (n=2284)				Eye Problems (n=2266)			
	non-electrified PV	electrified PV	rural Control Villages		non-electrified PV	electrified PV	rural Control Villages
male	10.3	2.7	5.4	male	4.2	4.6	3.4
female	9.5	5.5	6.8	female	6.1	5.5	3.9
total	9.9	4.0	6.1	total	5.1	5.0	3.7

PV = Project Village/s

conditions – the prevalence of all main diseases is highest in the non-electrified project villages. Diseases affecting the respiratory system and those concerning eyesight are of highest interest for electrification programmes as they should be tackled by means of electric lighting and stoves replacing smoke-producing kerosene lamps and firewood. A second, relatively unrecognized health benefit on household level might result from displacing candles with leaded wicks (cf. WB 2008: 43). However, candles are not used for lighting that much (see chapter 4.4.1).

Concerning cooking habits in the control villages, while only about 5 percent of households cook outside, only 2 percent of connected households have purchased an electric stove. An impact of electricity in this regard is therefore not to be expected in the short term perspective. On the other hand, all but three connected rural households possess electric lighting. Among them, only 25 percent keep on using kerosene lamps. Hence, three out of four connected households switched totally from traditional to modern lighting sources. A significantly better health status could, however, not be identified among this group in comparison to the rest of the population. In general, no significant relationship between indoor air quality and health status could be verified by means of the baseline data. It should, though, be remarked that poor households are more exposed to indoor smoke, since their kitchens are six times more often (29 percent) in the main house than in non-poor households. Gender-related data on respiratory system diseases and eye problems is depicted in Table 22. This raw comparison gives indicative support to the hypothesis that women – as the persons primarily responsible for cooking and therefore more exposed to indoor cooking smoke – would suffer more from these diseases than men.

As mentioned in the introducing phrase, water is a key health concern. 83 percent of the interviewed project village households fetch it both for drinking and other purposes such as washing and cooking from improved, safe water sources. Improved water sources are protected sources and wells, public taps, cisterns and the water company Électrogaz in contrast to unprotected sources and wells, rivers and lakes. The rest splits up into 15 percent, who do not have access to improved water, and a tiny rest with both improved and non-improved water sources. 47 percent stated to always boil their drinking water, 12 percent to sometimes do so.

4.3.3 Housing

Rural agglomerations as social and cultural entities like in Europe did not exist till 1994. In the visited project villages, they still do not exist, though agglomeration processes are under way (cf. Box 6). The dispersed habitations on the different hills are connected by a network of footpaths and tracks. Thanks to this dispersion, the population primarily being engaged in

Table 23: Physical Housing Information

		non-electrified PV	electrified PV	rural Control Villages
Dwelling	Modern	60	97	93
	Traditional	40	3	7
Outside Walls	Stone/ Brick	12	46	28
	Soil	88	54	72
Roofing Material	Corrugated Iron	40	8	42
	Tile	58	92	58
Flooring Material	Cement	33	54	46
	Soil	62	20	37
Windows Fitted w/ Glass	Yes	23	52	52
	No	77	48	48

		non-electrified PV	electrified PV	rural Control Villages
Property Status of Estate		92	87	83
Dimension of Estate in m^2	Average	420	235	380
	Median	260	120	220
Housing Investments Last Year in FRw *	Average	133,000	362,000	203,000
	Median	30,000	35,000	70,000

PV = Project Village/s

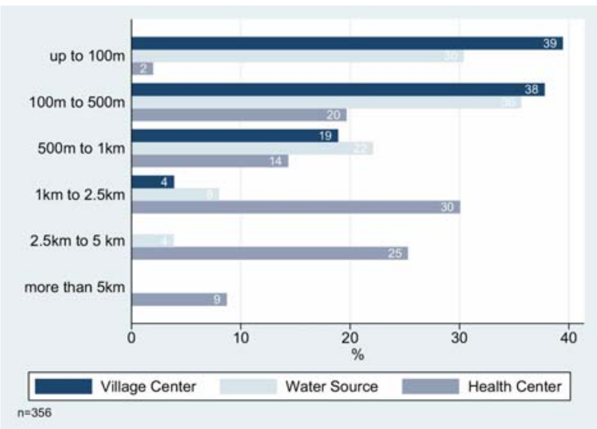
** Of those 40 to 50 percent of households, which had any home maintenance, extension or repair expenditures last year.*

agriculture and cattle breeding has to do only short ways to their fields. "Modern" dwellings prevail, normally featuring a rectangular construction style, air-dried bricks, several rooms, glass windows and a corrugated iron roof. While in the control villages already 77 percent of the houses are considered as "modern", this figure reaches 59 percent in the project villages (Table 23). Even among the traditional houses, straw roofs for example are very uncommon – only five interviewed households have this type of roofing material.

4.3.4 Access to Infrastructure and Information

The mountainous relief and landlockedness of Rwanda hampers the provision with infrastructure and information facilities in Rwanda. 90 percent of transport takes place via roads (UNCTAD/WTO 2006), of which some eight percent are paved (UNCTAD 2006). The introduction of mobile telephone services in 1998 has been hugely successful as fixed telephone services failed to meet the market demand. Mobile network reached in 2007 90 percent of the population and 80 percent of the surface area; the two operators had more than 300,000 customers.

Chart 17: Distances to Local Infrastructure



The distances to local infrastructure facilities are depicted in Chart 17. Half the population lives closer than 200 meters from the village center; the way to the water source is not far for them either: maximum 300 meter. On average, households in the project villages take 600 meter to get to this source. Health centers are of course less accessible. According to the definition of the Rwandan Health Ministry that a population has access to health care if the service can be reached by foot in one and a half

Table 24: Telephony

	non-electrified PV	electrified PV	rural Control Villages
Type of Telephone Used			
mobile phone [1]	46	91	74
public phone [2]	48	9	24
[1] + [2]	19	-	2
Main Purpose			
only work	10	38	43
work and private	43	21	22
only private	47	39	35

	non-electrified PV	electrified PV	rural Control Villages
Telecommunication Expenditures per Week in FRw	1,600	3,300	2,300
Frequency of Telephone Use for…			
Work	1 p. day	multiple times p. day	multiple times p. day
Calling Relatives Abroad	1 p. month	1 p. week	1 p. week
Calling Relatives in Rwanda	1 p. week	1 p. day	1 p. week

PV = Project Village/s

hours, 95 percent of the project village population actually has access to health care. This is even higher than the Rwandan average of 85 percent (MINISANTE 2003). Health expenditures, which evidence whether health care is made use of, do not correlate with the distance to the most nearby health center. Only for households living in greater distances than the one and a half hours foot walk, health expenditures are significantly lower indicating the appropriateness of the official definition.

Means of transportation are very rare. 14 percent of the project village households do possess any. They sum up to 51, including 40 bicycles. Every forth was bought the last year.

Radios are present in 78 percent of non-connected project village households same as in rural control households. In electrified Murunda, even 85 percent have at least one radio. For this village, information is as well available on the type of energy source needed. Astonishingly, only six percent only possessed a battery radio implying that the vast majority switched to plug-in (30 percent) or dual-source radios (64 percent). Connected households in general have their radio switched on for longer time (7 hours 30 minutes per day) than non-connected households, where the radios play on average for 5 hours and 15 min a day. A television set is owned by only five households

Photo 5: Radio as an Information and Entertainment Source

at the non-electrified project sites, corresponding to two percent. In the rural electrified villages, still only 12 percent possess a TV set and even among connected households only every fourth.

Finally, studying telecommunication it was found that a proportion of 44 percent uses telephones in the non-electrified project villages, contrasting to around 75 percent in the electrified villages. The use of telephones strongly depends on the economic situation of the household. Telephone expenditures among poor households amount to minuscule 75 FRw (0.10 EUR), while middle tend to spend 900 FRw (1.20 EUR) and rich households 3,500 FRw (4.70 EUR) per week on telephony. The use patterns of those households that use any telephone regularly are represented in Table 24. People in the project villages (still) use public phones more often, use the telephone less for work and call less in general. Over 90 percent of households using public phones do not possess a landline or mobile phone indicating the importance of this private phone alternative. The amount of landline telephones is negligible.

Less than half as many households in non-electrified project villages own a mobile phone as in the electrified villages (20 compared to 55 percent). For one, this difference is due to the uneven network coverage – according to the interview responses, only 33 percent of the surveyed non-connected project village households are covered by a mobile telecommunication network compared to 62 and 81 percent in electrified Murunda and the rural control villages respectively. In addition, there are three further factors relevant for this difference that are as well seen as related to the provision of electricity: (i) The wealth levels already depicted in Chart 11 on page 35; (ii) the proportion of people active in agriculture compared to services, which is far lower in the non-electrified project villages (cf. Chart 4 on page 29), while at the same time the penetration of mobile phones among households with subsistence farming household heads reaches only 0.24, 1.43 among civil servants and 0.79 among people active in (private) services; (iii) the opportunities to charge batteries – the majority of project village households has to walk more than one kilometre and 50 percent have to pay 100 to 400 FRw per charging, while far less people have to leave their home or working place in order to charge their mobile phone battery in the electrified rural villages and – even including non-connected ones – only 11 percent pay for this service.

4.3.5 Time Usage

Comparable data on how the sample population divides up its time is available in the latest Rwandan Household Living Conditions Survey EICV2 from 2006. It comes to the following main conclusions concerning time use and gender-related differences: (i.) Women work shorter hours than men: 28 compared to 35 per week, ranging from 25 (30) hours in agriculture to 57 (59) in the skilled service sector. The reason for this is seen in the shorter hours worked in agricultural and labouring occupations; (ii.) The shorter hours for women are seen as "a reflection of the heavy nature of the work and the domestic duties of women […]" (NISR 2006). While men only spent 6.9 hours on household chores, women work for more than 21 hours per week in the household; (iii.) Men in rural areas are far more likely to have a second job than women, which partly explains the shorter hours worked by women.

The related baseline data is found in Table 25. It supports finding (iii.) with men having four times more often a second occupation and finding (i.) regarding women's fewer number of hours worked at a job. This is, however, not due

Table 25: Gender-related Data on Time Use

		Male	Female
Mean Hours Worked per Week in…			
	Agriculture	32 n=190	32 n=291
	Civil Service	42 n=54	39 n=39
	Services	55 n=61	48 n=13
	Total	38.4 n=314	33.6 n=351
Percentage of Adults with a Second Job		13	4

to shorter hours worked in agricultural and labouring occupations (which are quite similar for men and women in the project villages), but instead due to less women in the civil service and private service businesses (cf. Chart 3 on page 29) where average hours worked are generally higher. Data on hours spent on household duties – related to the second finding – has been gathered in the baseline only for the case of energy source procurement. It was enquired how much time it takes per week to buy the different energy sources such as batteries, kerosene and firewood – without differentiating between males and females. Concerning other household duties, it was asked instead whose responsibility the specific duties are. The results are given in Table 26. The strongest electricity-induced time saving would stem from electric cooking, which would reduce both the time for cooking and for collecting firewood. As already mentioned in chapter 4.3.2, widespread use of electric stoves is, however, not to be expected. Therefore, significant time savings will not materialize. Time savings from obsolete purchases of other energy sources (kerosene, candles, and batteries) due to electric lighting are relatively small and only reach about 15 minutes on average per week.

Table 26: Responsibility for Household Duties in %

	Firewood	Water	Lighting	Cooking
All	25	15	38	10
	2h*[1]		0.25h*[1]	
Male Adult only	25	6	8	6
	1.4h*[2]	3.0h*[2]		1.3h*[2]
Female Adult only	28	29	43	59
	2.2h*[2]	2.4h*[2]		9.2h*[2]
Children only	10	35	6	12

** These figures give an account of the hours spent per week by the respective population group on the relevant household duty. *[1] is taken from the baseline, *[2] and *[3] from the EICV2.*

It was unfortunately only belatedly found out that information on the average working day duration has been inconsistently asked by the enumerators. The same holds for activities during evening time after sunset, which might be influenced by electric lighting.

Another potential impact on time use concerns studying for school children. These

Box 9: Connected Households and Their Counterfactual

So far project and control villages have been compared only on an aggregate level. In order to study specific direct impacts of electrification, it suggests itself to additionally focus the analysis on connected households in electrifed villages. Since these households, abbreviated in the following to V_c, tend to be better off, they probably show different characteristics, e. g. a higher educational background. As this would bias the analysis of the impact of electrification and household connection (people in connected households might read more because of electric light *or* because they are better educated, while we want to isolate the first cause here), they cannot be compared to households in the project villages in general. Instead, a credible counterfactual, i. e. a properly comparable subgroup of households in the non-electrified project villages with similar or even equal socio-economic characteristics, has to be found. In our case, this group is constructed by means of a set of household and house variables such as parental education. This information serves as covariates for a so-called probit model estimating the connection probability. Essentially, these covariates are those sub-indicators of the developed wealth indicator (cf. appendix A2) that are assumed non-responsive to the connection. For more details on this approach, refer to BENSCH ET AL. (2009). The generated group named PV_m thereby portays the most plausible equivalent of project village households to connected ones in the electrified villages.

are, however, difficult to assess at the household level in the present case. Secondary schools are normally organised as boarding schools, which is why secondary school pupils are rarely at home. Primary schools usually last from 8 a.m. till 16.30 p.m. with a 90 minutes pause. Lower primary (classes 1-3) is often organised in "double vacation", i.e. one class is held in the morning and the other in the afternoon (for more information on schools, see chapter 4.7). Primary school pupils therefore already spend relatively much time with studying at school. Moreover, they contribute significant amounts of domestic labour to the household. Nevertheless, they are occupied with learning at night and differences between connected and non-connected households are also noticeable here. In this case, responses from connected households in the electrified control and project villages (CV_c) are inspected in comparison to only those households PV_m in the non-electrified project villages that are actually comparable to that subpopulation CV_c (for a reasoning of this approach, cf. Box 9). The third and most appropriate matching-based comparison comes up to a value of 14 minutes, corresponding to a 26 percent difference. The respective values of connected households and households from non-electrified project villages, each belonging to a matched pair of households with children attending primary school, are 67 and 53 minutes.

Summary Box 3: Social Life of Households

- Since the population is very young, almost 40 percent of it is still in **formal education**, i.e. school, vocational training or university. Among the adult population in the non-electrified project villages, a relatively high proportion of 21 percent is without basic education, i. e. six years of primary school. The situation is better in the electrified villages, for example in Murunda this proportion is 15 percent. Average years of schooling accordingly differ across village types. While they only amount to 5.3 in Kavumu, Musarara and Nyaruguru, people in the electrified villages including Murunda went to school two years more on average.
- Basic **health** care is accessible for the large majority of the population. Three forth of the population has a health insurance; only five percent live more than a 90 minutes foot walk away from the next health center. Though electric lighting substituted traditional lighting sources entirely in three out of four connected households, the – concerning indoor air quality – more relevant electric cooking will neither find significant demand nor would it be desirable. Widespread use of electric stoves would overstrain the capacity of both the local grids and the MHPs.
- **Access to infrastructure** (other but health) **and information** is still very scarce or unequally distributed. 14 percent of the project village households own any means of transportation, of which only 13 households, i. e. 3.5 percent, have a motor vehicle at their disposal. Radios are ubiquitous in both project and control villages. Connected households possess slightly more and listen more to the radio. Television on the other hand is not that common. Even among connected households, only every fourth is the owner of a television set. The use of telephones strongly depends on the household's economic situation. Telephone expenditures among poor households amount to minuscule 75 FRw (0.10 EUR), while middle already spend 900 FRw (1.20 EUR) and rich households 3,500 FRw (4.70 EUR) per week on telephony. Despite the lack of electricity and lower network coverage, already 20 percent (compared to 55 percent in electrified rural villages), own a mobile phone. Far less people have to leave their place in order to charge the mobile phone battery or to pay for this in the control villages. An improved access to mobile telephony and to media through radios and TVs impacts other socio-economic dimensions positively as well, e. g. health through an increased awareness of health issues (WB 2008: 43) or higher agricultural revenues through higher price transparency (PRAHALAD 2006).

- **Housing** conditions are deficient in the project villages with only 60 percent of the households having a houses considered as “modern”. This figure reaches more than 90 percent for Murunda and the rural control villages. On the other hand, 92 percent in the project villages own the plot they live on in comparison to 87 and 83 percent in Murunda and the rural control villages respectively. Accordingly, only two percent of households in the non-electrified project villages are burdened with paying rent in contrast to 12 percent in electrified ones.
- Impacts on **workload** – especially that of women – could unfortunately not be analysed by means of the present dataset. The relevant transmission channels at least provide little indication on significant impacts to be expected. The relief from household duties is negligible. On the other hand new job opportunities for women in the service sector emerge where hours worked tend to be higher.
- **Time use** is another relevant observation field, for which sufficiently consistent data lack to do a robust impact assessment at this point. Especially night activities facilitated by electric lighting are expected to show effects.
- Positive impacts of electrification on **studying** will primarily materialize at the school level, since pupils spend a lot of time, on secondary schools often the whole time at school. Nevertheless, longer hours of learning in the evening are noticeable at the household level, too: Primary school pupils spend on average 26 percent more time on studying after sunset in connected households than in comparable project village ones.

4.4 Household Energy

4.4.1 Energy Sources and Uses

Energy is subdivided into modern and traditional energy. Traditional energy comprises primarily candles, kerosene, petrol, diesel, batteries, wood, charcoal and dung. Modern energy forms on their part are (reliable) grid electricity, solar panels, generators and – to a limited extent – car batteries. These have advantages in terms of versatility, power and rather lower prices. Due to lacking grid electricity, only 5 percent of the surveyed population in the project villages have a modern energy source: Half of them possess individual generators, there are a handful of car batteries, and one solar panel. Instead of usage of modern sources, energy is provided almost entirely by traditional energy sources listed in Table 27.

This table compares the data of project village households with those of connected households in the control villages. Values for the total average energy expenditures are given in Table 35 on page 50. Same as with the analysis of primary school pupils in the preceding chapter 0, the analysis incorporates also the group of "matched non-electrified project village households". In this case,

Table 27: Data on the Use of Specific Energy Sources

		Candles	Kerosene*	Batteries for Torches	Batteries for Radios	Wood**	Charcoal	Grid Electricity
% among all PVs / CV_{el} Households	PV_n	12	91	18	76	90	4	-
	PV_{el}	45	66	14	49	92	9	54
	V_c	45	35	9	22	89	14	100
	PV_m	19	93	28	88	92	5	-
Average Monthly Consumption	PV_n	9.7 pieces	1.5 l	2.8 pieces	4.3 pieces	260 kg	1.2 bags	-
	PV_{el}	4.9 pieces	2.5 l	3.1 pieces	4.4 pieces	360 kg	1.1 bags	11.3 kwh/ month
	V_c	4.1 pieces	2.9 l	3.4 pieces	4.1 pieces	390 kg	2.0 bags	12 kwh/ month
	PV_m	9.4 pieces	2.2l	2.9	4.6	275 kg	1.3 bags	-
Average Monthly Expenditures in FRw	PV_n	480	1040	350	540	1975	3500	-
	PV_{el}	290	2270	390	550	2500	4200	2,560
	V_c	250	2590	410	500	3500	8100	2,410
	PV_m	470	1500	360	570	2450	3900	-

PV_n = non-electrified Project Villages (n=268); PV_{el} = electrified Project Village/ Murunda (n=93); V_c = connected households in rural control Villages and Murunda (n=129); PV_m = households in the Project Villages, which have been matched to V_c (cf. Box 9 on page 43) (n=129)

** Kerosene is meant here as lighting fuel and therefore includes some cases of petrol and diesel as well. On the other hand, this variable does not contain any fuel for powering generators.*
*** Conversion factors for firewood are: 1 fagot = 20kg; 1 ster = 350 kg; in case of trees, the conversion into sters was carried out according to the size of the tree*

however, the only notable differences between project village households in general (PV) and the subgroup of matched households (PV_m) are that more households among PV_m use the different energy sources than among PV. Moreover, PV_m consume considerably more kerosene for lighting. Therefore, the following conclusions hold for PV as well as for PV_m: Firstly, it becomes evident that grid electricity does not entirely substitute traditional energy sources – even in villages that are electrified for years. Significant reductions in the use of traditional energy sources can be expected for kerosene for lighting devices and batteries for radio use. Candle consumption will probably decline since candles seem to act rather as a backup lighting source in connected households. Batteries for torches are not affected by electrification. While control village households in the 2007 baseline exhibited a monthly per connected household consumption of 20 kwh, the broader and exclusively rural database now reveals an average of only 12 kwh. Even as this value was not available for some households (mainly due to pre-paid metering), it is rather improbable that these households have a structurally different consumption pattern and would thereby bias this outcome.

The impact on cooking and therefore on the use of energy sources which go along with it (wood and charcoal) will probably be negligible, too. Only two percent of connected households possess an electric stove. Even though prices for the traditional cooking fuels soared in the last years – according to MININFRA 2006, charcoal prices rose by 220 percent between 2002 and 2005 – the high purchase price of an electric stove will probably continue to deter people from buying one. Electric cooking is not a realistic option from the electricity supply side either, since they increase peak load substantially, thereby overstraining the MHPs if widely operated. In any case, cooking energy efficiency can be ameliorated by means of improved stoves, which can already be found in three forth of the project village cooking places. This value is similar to the one found in a baseline survey among cattle raising households for the National Domestic Biogas Programme Rwanda

Table 28: Electrical Appliances

	non-electrified PV (n = 268)	electrified PV (n = 93)	rural Control Villages (n = 180)
Iron	0.4	25	16
Electric Stove	0	2	2
Refrigerator	0	0	0.6
Cassette Recorder	0.7	10	3
Fan	0	0	0
Radio	78	85	78
Television Set	2	15	11
Telephone*	20	55	58

** More information on telecommunication can be found in 4.3.4.*

(HUBA & PAUL 2007), which was conducted at the same time as the first part of present baseline study. A reason for the more extensive use of charcoal in connected households can probably be found in their better economic situation. Annual electricity consumption even in the connected households only reaches 125 kwh (for comparison: the EU average in 2003 was 4,040 kwh (VDEW 2006)).

Electrical appliances in the surveyed households are enumerated in Table 28, whereas the household members primarily using the respective appliances are listed in Table 31. Apart from radios and mobile phones, only irons and television sets can be found in significant quantities in the control villages. Yet, more than every second surveyed connected household (53 percent) uses electrical appliances beyond lighting, radios and mobile phones. In the non-electrified project villages, most of the appliances are non-existent and, hence, only very few households get in contact with them at all. For example, only five of them mentioned that they use any appliance, which they do not possess themselves, out of home (like at a friend's or a neighbour's house). Households were also asked, which electrical appliances they would be most tempted to purchase in case of grid connection. With no surprise, the favourites have been lighting

Table 31: Utilisation of Electrical Appliances (in %)

	Radio			Lighting*			Telephone			Television		
	PV_n	PV_{el}	CV	PV_n	PV_{el}	CV	PV_n	PV_{el}	CV	PV_n	PV_{el}	CV
All	75	70	73	66	83	79	43	20	22	- **	59	69
Male Adult only	11	12	10	4	-	5	26	18	25	- **	12	14
Female Adult only	7	14	7	21	9	9	9	13	8	- **	6	7
Adults only	3	4	7	1	4	3	14	24	38	- **	12	7
Children only	2	-	3	3	1	-	9	7	3	- **	6	3

PV_n = non-electrified Project Villages; PV_{el} = electrified Project Village (Murunda); CV = rural Control Villages

** including traditional lighting* *** too few observations*

devices (69 percent), radios (63), and television sets (29). Yet, remarkable 22 percent stated to be interested in purchasing electric appliances that could be possibly used for productive uses (sewing, carpentry or haircutting machines, welding torches or an electric mill).

4.4.2 Lighting

Lighting as the most relevant service delivered by electricity shall be further illuminated in this paragraph. In combination with the use data of traditional energy sources in Table 27, the data on lighting devices used in the project village households shown in Table 29 gives a larger picture of lighting patterns in the households. Kerosene lamps are the dominant lighting sources, while the kerosene

Photo 6: Agatadowa, a Traditional Kerosene Tin Lamp

Table 29: Traditional Lighting Devices

		PV_n	PV_{el}	V_{el}	PV_m
Agatadowas (Traditional Tin Lamps)	#	0.90	0.36	0.08	0.82
	h	2.4	2.3	2.4	2.5
Hurricane Lamps	#	0.40	0.43	0.25	0.73
	h	2.7	2.2	1.4	2.7
Torch	#	0.11	0.04	0.03	0.16
	h	-	-	-	-

Table 30: Modern Lighting Devices in Connected Households

		Exterior	Interior
Incandescent Light Bulbs	#	0.5	2.0
	h	3.8	3.3
Fluorescent Tubes	#	0.4	0.5
	h	4.4	3.8
Energy Saving Bulbs	#	0.6	2.5
	h	4.8	3.7

 # = quantity per connected household; h = hours lit per day

PV_n = non-electrified Project Villages; PV_{el} = electrified Project Village/ Murunda; V_c = connected households in rural control Villages and Murunda; PV_m = households in the Project Villages, which have been matched to V_c

Table 32: Daily Lighting Output in Households

		PV_n	PV_{el}	V_c	PV_m
lighting hours	h	4.1	14	24.5	5.7
luminous flux	lmh	565	8,700	18,600	1,130

PV_n = non-electrified Project Villages; PV_{el} = electrified Project Village/ Murunda; V_c = connected households in rural control Villages and Murunda; PV_m = households in the Project Villages, which have been matched to V_c

h = hours lit per day; lmh = lumenhours/ day

consumption per household is relatively low, since they are used only for two to three hours after night falls at around 6 to 7 pm. The elevated kerosene consumption of matched project village households PV_m found in Table 27 seems to stem from the disproportionate presence of hurricane lamps in these households. Main problems experienced with kerosene-lit lamps are too much smoke (expressed by 53 percent of project village households; multiple answers were possible), the elevated price (36 percent) and the inefficiency of this lighting source (19 percent). Since, after sunset, social life outside the household is very limited, only few torches are in use. The data of connected households in Table 29 and Table 30 mirrors what has already been mentioned in chapter 4.3.2: three out of four connected households switched totally from traditional to modern lighting sources. On average, three light bulbs and a tube light are used by connected households for some three and a half hours. Energy saving bulbs are increasingly utilized as well. Whereas these compact fluorescent light bulbs summed up to 0.4 per connected household in the 2007 baseline, the average is 3.1 including the 2008 data.

Abridging all lighting usages, one arrives at an average of 4.1 hours for the non-electrified project villages and of 24.5 hours for connected households. Murunda with both connected and non-connected households achieves an average of 14 hours (cf. Table 32). Even more important than the quantity of lighting is the quality. Hurricane lanterns and traditional tin lamps have a lighting radius of less than two meters. Consequently, the quality of these lighting sources is appraised rather negatively (Table 33). The luminosity can, furthermore, be technically assessed in terms of “Lumen”, which is the unit of measurement of lighting output. Lumen values (lm) of the different lighting sources relevant for the survey are listed in Table 34. The resulting differences between non-connected and connected households are enormous: The average luminous flux – referred to as well in Table 32 – of all lighting sources in those 97 percent of project village households that rely on traditional lighting sources only, sums up to 63 Lumen hours (lmh) a day; in comparison to 18,600 lmh in connected households, i.e. a factor of 300. Matched project village households PV_m, with some households possessing a generator or solar panel, reach 1,130 lmh/ day.

Table 33: Assessment of Lighting Quality by Households

	Lighting Quality			Good for reading	
	good	medium	bad	yes	no
Incandescent Light Bulbs	90	9	-	93	7
Fluorescent Tubes	93	5	2	98	2
Energy Saving Lamps	91	8	-	93	5
Agatadowas (Traditional Tin Lamps)	10	43	45	10	89
Hurricane Lamps	17	64	17	24	75

Table 34: Lumen Values

	Lm
Paraffin Candle	11.8
Kerosene Wick/ Agatadowas	11.4
Hurricane Lamps	32
Incandescent Light Bulbs (60 W)	730
Fluorescent Tubes (40 W)	1,600
Energy Saving Bulbs (11 W)	600

lm = lumen

4.4.3 Energy Expenditures

The total average energy expenditures for all households in the project villages are given in Table 35, including the different energy types listed in Table 27 on page 46 plus generator fuel. The share of these expenditures in total expenditures allows checking for a relationship generally cited in the development literature (ALBOUY AND NADIFI 1999). This relationship implies that energy spending rises less than proportionately with income: The poor spend 10 to 20 percent of their income on energy, the rich only about 2 percent. The baseline data somehow qualifies this hypothesis for the surveyed population. Firstly, differences between the different wealth categories are less pronounced. This may, however, be due to the fact that only major expenditure categories have been considered while minor ones predominantly comprise luxury goods such as furniture, which are consumed more by wealthier households.

While the cited relationship holds for the non-electrified project villages, the portion of energy expenditures among rich people's total expenditures is even higher than among middle and poor households' expenditures. A second unexpected outcome is that the increased use of energy makes connected households in the end pay more on energy than comparable non-connected households. In combination, the data suggests that additional consumption opportunities delivered by electricity causes the reversal of the cited relationship, such that that energy spending among connected households rise more than proportionately with income.

Financial saving potentials primarily exist with regard to kerosene for lighting devices and batteries for radio use (cf. 4.4.1). Total cost calculations reveal that kerosene hurricane lanterns cause annual costs of 20,300 FRw (27.05 EUR), while incandescent light bulbs induce costs of 12,650 FRw (16.90 EUR) and energy saving (compact fluorescent) bulbs of only 2,550 FRw (3.40 EUR) (this total cost

Table 35: Energy Expenditures

		Total	poor	middle	rich
Households in non-electrified Project Villages	Monthly Energy Expenditures in FRw	3,850	2,050	3,800	13,250
	Share of Energy Expenditures in Total Expenditures*	19.1	25.6	19.0	16.8
Households in electrified Project Village	Monthly Energy Expenditures in FRw	5,750	1,950	6,750	9,450
	Share of Energy Expenditures in Total Expenditures*	14.1	15.9	13.2	14.0
Connected Households in electrified Villages	Monthly Energy Expenditures in FRw	8,000	1,950	6,900	11,250
	Share of Energy Expenditures in Total Expenditures*	15.8	10.8	14.5	19.1
Matched Households in Project Villages	Monthly Energy Expenditures in FRw	5,450	2,200	4,050	13,250
	Share of Energy Expenditures in Total Expenditures*	17.0	24.2	17.8	16.8

** Total Expenditures are the sum of the main expenditure classes referred to in the chapter on Assets, Expenses, Income (4.2.6).*

calculation is demonstrated in Annex A6). This cost decrease is even more pronounced when quality of lighting (chapter 4.4.2) is accounted for. The costs of radio use can be best assessed in terms of costs per listening hour. With 2.4 FRw (0.3 ct) for an 18 Watt radio, these are 58 percent cheaper for plug-in radios than battery-run ones.

4.4.4 Attitude towards Electricity

The general perception of the planned project grids is very positive so far. 96 percent of the population in the non-electrified villages and 57 percent of non-connected households in Murunda would – at least theoretically – like to connect. The others mentioned financial restrictions as the reason for not showing interest. Only one interviewee stated that she regards electricity as unnecessary. The main advantages expected from electricity are compared in Table 36 with the advantages perceived by connected households. Questions were posed openly, which means enumerators did not suggest any answer alternatives. This indicates that the non-connected population in the project villages has relatively rational expectations in terms of the possible applications and benefits of electricity. Their responses are remarkably similar to those of connected households. The only notable difference, which lies in the appreciation of the impact on village level, may be interpreted in two ways if one assumes that electricity plays a role. Either the impact of electricity on security matters is higher than expected by the non-connected project village population or the actual development impact of electricity is judged to be smaller by connected households.

Table 36: Perception of Main Advantages of Electricity

	Non-connected Project Village Households		Connected Households	
	(n=311)	%	(n=129)	%
at the Household Level	1. Lighting	72	1. Lighting	91
	2. Appliances	8	2. Appliances	5
	3. Studies	5	3. Work	2
	4. Development	5	4. Studies	2
	5. Work	5	5. Development	1
at the Village Level	1. Lighting	32	1. Lighting	50
	2. Development	27	2. Security	25
	3. Security	20	3. Development	12

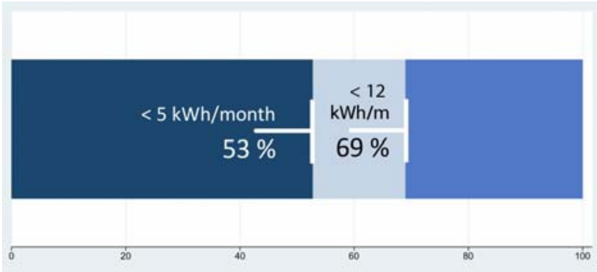
Households in non-electrified project villages mentioned a wide range of applications and benefits that might render their every-day life and work more efficiently and faster: e. g. work preparation at night, welding or fuel cost reduction. The same diversity holds both for new activities to be developed when having electricity and courses that teach how to use electricity productively and which the interviewed households would like to participate in. 82 percent stated to be willing to create new projects; 95 percent are interested in participating in electricity use teaching courses. Experiences from the connected households can, though, not nourish this enthusiasm. Eight percent actually developed any novel activity potentially in need of energy, such as commerce, milling, hairdressing or welding.

On the other hand, people were asked, what they consider as inconveniences of electricity. 60 percent either did not know or not see any disadvantages of electricity. Among connected households, still quite a lot – four in ten – do not see any inconvenience. The rest mainly uttered the threat of an electric shock as such. Only once, reparation delays and twice high prices were mentioned. It was not elicited the importance attached to electricity by the population in comparison to other needs and problems in their home or community. Such questions are subjected to the so-called auspices bias, referred to in social psychology with reference to responses of subjects being influenced by the organization that conducts the study. In our case, such answers would be biased in favour of electricity, since the questions are posed within the context of an electrification project survey. Yet, a relevant independent study can be cited. For the Development Plan of Gicumbi District, where the Kavumu site [KA] is located, the population was asked to organize problems occurring in their community into a hierarchy (GICUMBI 2007: 44). People in Mutete sector, where the beneficiary centers of this site are located, ranked insufficient electricity sources only ninth of ten real issues behind bad housing conditions and insufficient road and communication infrastructure. Most pressing problems in the population's opinion are difficult schooling and weak agricultural and animal production.

The vast majority of the surveyed population regards the electrification of social infrastructure as prioritary (more than 81 percent in non-electrified project villages and even more in electrified villages). In order of priority, these comprise health centers, schools, administrative offices and street lighting. Although the connection of the proper dwellings will probably already be a heavy financial burden for the households, roughly the same amount of people is willing to contribute financially to these electrification efforts.

Since electricity would be a totally new asset for the population, people had some difficulties in expressing the willingness to pay for it; 15 percent did not know what to answer. The values for the other project village households are depicted in Chart 18. This graph translates the willingness to pay into the corresponding amount of electricity, which can be consumed with such a sum of money applying Electrogaz prices. Two thresholds are added – on the one hand 5 kwh per month, corresponding to 1,160 FRw (1.50 EUR). This electricity quantity would not allow for anything more than lighting. The second threshold is at 12 kwh per month, which equals the average consumption of the surveyed connected households (cf. Table 27). One fourth of the households indicated an even higher willingness to pay with values ranging up to 50,000 FRw (67 EUR). Concerning the ability to pay, 40 percent of the interviewees in connected households stated to work more than before electrification in order to be able to benefit from the access to electricity and to afford the electricity bill.

Chart 18: Willingness to Pay



4.4.5 Grid Connection

The high up-front costs of grid connection are the major barrier for grid connection. The additional mini-survey conducted at Mpenge [MP] (see Box 5) found that for 80 percent of households without electricity the sole reason for why they do not connect to the electricity grid was the connection fee (although they probably underestimate the burden of the monthly bill).

The actual costs arise from (i) the cable connecting between the house and the grid and (ii) the installations inside the dwelling. The average of the costs mentioned by connected households is 98,000 FRw (130

Photo 7: Electricity Grid at Nyamyotsi [NI_C]

EUR) for the connection and 40,000 FRw (53 EUR) for the internal installation. Considering the input costs, these values may probably be cut by half for a household living close, i.e. less than 20 meters, to the grid. The PD of Musarara [MU] for example announced a fee of 50,000 FRw to cover the connection (i).

70 percent intend to finance a connection by savings, further 20 percent by a credit. The rest proposed selling assets such as harvest or a cow. Among connected households, who actually made the connection, credits were of less import. While the overwhelming part paid with savings or cash, only 8 percent actually took a credit in order to pay for the connection. Credits are, nevertheless, an option for most of the households. Though this amount will probably not be enough, two thirds are at least not reluctant to take a credit of 20,000 FRw (26.70 EUR) for grid connection, half of them to take a credit of at least 50,000 FRw (67 EUR). Knowledge of micro-credits, called “Ikimina”, is almost universal, as 90 percent know it. Independent of the payment scheme, three forth see themselves able to spent 20,000 FRw on electricity connection, 43 percent 50,000 FRw or more. This sum might be, though, in some cases misinterpreted as a single payment by households not taking consumption costs into account.

Though this will not be at the customer’s choice, the population has been enquired about their preferred metering systems. Prepaid metering, which is the PD’s preferred system so far, was introduce by Electrogaz under the name of Cash Power outside of Kigali in the end of 2006. Since the system is, nevertheless, widely known due to its application in mobile telephony, 36 percent mentioned it as their preferred system. 46 percent would choose monthly bills and 14 percent prefer a flat rate system. These values have been almost identical for already connected households in the 2007 baseline. Meanwhile, the pre-paid “Cash Power” system has been successively put in place in various regions of the country, obviously demonstrating its advantageousness. At least, among connected rural control households visited in 2008, 87 percent preferred the pre-paid system. The first impression of the survey team that richer households favour pre-paid, since they are more familiar with the system and possibly recognize more the inherent cost control, is not supported by the data.

Since the PDs expect a considerable movement towards the future grid, another question posed was whether households would be willing to move house in order to get in reach of the grid. Only 23 percent answered with yes. For 64 percent of the rest, moving house would be too costly. 18 percent referred to the distance to their fields as the primary reason for not being inclined to move. 7 percent mentioned both. On the other side, three forth of connected households consider it worthwhile moving house in order to get close to the grid.

Concerning grid electricity alternatives for the case that the grid would be too far away and moving house would not be feasible, 23 percent would be satisfied with car batteries and 38 percent with rechargeable lights. Taking into consideration that these acceptance levels were elicited within the bounds of a rural electrification project, they can be considered as quite high. In such a setup, people tend to feel reluctant to accept less convenient alternatives. E. g. in a similar baseline study in Benin, only two percent of the surveyed population expressed interest in alternatively being fed by car batteries or photovoltaics (see HARSDORFF 2007: 25). A further cost-reducing alternative would be meter sharing by several households. This option is worthy of consideration for 53 percent of the households.

Summary Box 4: Household Energy

- In the non-electrified project villages, energy is delivered predominantly by traditional **energy sources**. Only five percent of the surveyed population dispose of a modern energy source. They spend on average 3,850 FRw (5.10 EUR) per month on energy, which corresponds to a roughly fifth of total expenditures. The increased use of energy by connected households results in higher expenditures, which, though, on average comprise a smaller share in their total expenditures.
- The most relevant electricity impact for households is **lighting.** Outstanding 72 percent of the households in non-electrified project villages and even 91 percent in connected households see lighting as the main advantage of electricity. This is due to (i) more convenience because of the presence of a light switch; (ii) better quality – connected households consume 7 times more lighting and 300 times more Lumen hours than non-connected ones relying only on traditional lighting sources; (iii) less indoor smoke and (iv) lower costs – e. g. savings amount to 38 percent if kerosene is replaced by incandescent light bulbs, 88 percent if substituted by compact fluorescent bulbs.
- Three out of four connected households switched totally from traditional to modern, electric lighting sources. Apart from kerosene for lighting, significant **resource savings** in terms of traditional energy sources can be expected for batteries for radio use. They are used in 22 percent of connected households, three and a half times less than in non-electrified project village households. Plug-in radio use is 58 percent cheaper than in the case of using batteries.
- Apart from radios, only mobile phones can be found in the majority of households in electrified villages. Irons and television sets are present in 10 to 25 percent of households there. Yet, more than every second connected household uses electrical appliances beyond lighting, radios and mobile phones. In the project villages, most **electrical appliances** are non-existent. Since only a minimal proportion of the population uses these appliances outside their home, little experience with electricity and electrical appliances exists. However, they seem to have relatively rational **expectations** in terms of the possible applications and benefits of electricity. Their responses are remarkably similar to those of connected households in this regard. The general perception of the planned electricity grids is very positive so far.
- Without explicit efforts from external sources, **productive uses** of electricity do emerge to a reasonable but not substantial extent. Among connected households in the control villages, 8 percent actually developed any novel activity potentially in need of energy, such as commerce, milling or welding.
- The high up-front **grid connection** costs are the main barrier for households in electrified regions to get connected. These would further rise substantially, if the household would need to move house in order to get into the reach of the electricity grid. Only 23 percent see themselves capable or willing to do so. In order to finance the connection, micro credits might be an option. While only one fourth of them have taken a credit in the last five years, households in the non-electrified project villages seem to be open for taking credits.
- After the **prepaid system** ”Cash Power” is successively penetrating also rural areas, the vast majority of connected households interviewed in 200 8 declared to prefer this billing system indicating its advantageousness.

4.5 MSEs

With close to 90 percent of the population living by subsistence agriculture (many of them below the food poverty line), the diversification of employment opportunities plays a prominent role for sustained rural development in Rwanda. Off-farm businesses in non-urban areas are, however, rare and covering only a very limited range of business types. Transport costs are high, market access is weak and energy costs and interruptions are prohibitive for most of small scale producers.

As outlined in chapter 2.4 and 2.6, micro and small enterprises (MSE) have been surveyed in a way similar to the one applied for households. In total 61 MSEs in project and 46 MSEs in control villages have been visited in the 2007 baseline. In 2008, no further MSE have been added to the database. The figures for all MSEs located in the areas covered by the planned electricity grids are quantified in the chapters 3.1 to 3.5 on the different project villages. These chapters also give an account of the already developed business ideas conditional on electricity provision. The existing MSEs predominantly depend to one of the following six groups: Bars/ Restaurants, Shops, Barber Shops, Mills, Tailor Shops and Carpenter Workshops. In the control villages and Murunda [MD], further businesses in need of electricity were found, such as welding, battery charging, a bicycle repair workshop, one shop with photocopying, film exhibition spaces, but also more specialised retailers like shoe shops in Gasarenda [GA_c].

Due to the structural distinctness of the different business types from one another, summary statistics for all MSEs would be meaningless. Summary statistics by business type would, on the other hand, not be exploitable either, since they would lack a sufficient amount of observations. Therefore, only some specific, project-related questions will be taken up here.

25 percent of the interviewed MSEs in project villages already possess an electricity source. The existing mills own a generator; barbers often have a generator or a car battery. Some bars/ restaurants also have a car battery or generator at their disposal. Among control village MSEs, more than half are connected. In only one case, a connected MSE possesses a generator at the same time. On the other side, there is a single case of a mill, which uses a generator in an electrified region. All of the connected MSEs stated that electricity enabled them to work faster and more efficient. They praised in specific the continuity of electricity supply, the improved quality and the availability of electric lighting.

One third of them explicitly created new activities such as welding and battery charging, but also a bar and a barber shop. Craftsmen in the project villages commonly do not have the knowledge to create new activities. Even the mastery of electrical machines for their proper business (such as electrical saws for carpenters) is lacking in most cases. The same holds for basic management skills. Anyway, nine in ten of these small scale businesspeople are interested in taking further training courses, even if these courses took place at night.

MSEs in the project villages feel challenged by a variety of problems and bottlenecks. Main issues are in order of importance

- Lack of clients
  Since purchasing power is low, insufficient demand leads to a low turnover for most of the MSEs.
- Financial matters
  Especially financial capital is lacking, but also taxes and non-payments by clients pose problems for the small businesspeople. Poor availability of credits was uttered only by MSEs in control villages.
- Inputs
  Machines are either missing or are very old. For some MSEs, there is also a shortage of (primary) material like wood and cloth.
- Electricity
  Fuel and electricity are either missing or too costly from the interviewee's point of view.

Concerning the overall financial capacity of the MSEs, some additional figures may be given: Three forth of the project village MSEs dispose of a bank account. The same amount of businesses have savings; the savings of one third of them exceed 100,000 FRw (133 EUR). Businesspeople are also relatively willing to invest in grid connection: 60 percent agree on paying at least 50,000 FRw (67 EUR) for electricity access. Half the MSEs have taken a credit during the last years. Credits are also the favourite payment type of every fifth of the project village MSEs. However, both MSEs from control villages and discussions with bank employees revealed that credits for machinery are totally uncommon at rural banks.

The findings from the baseline survey concerning MSEs can be summarized along two core characteristics: (i) The commercial usability of electricity and (ii) the corresponding attainable socio-economic impact. These two aspects shall give an idea of how many MSEs will be prone to connect to the future project grids and in how far the local community actually benefits from its electrification. They are dealt with in the following paragraphs and put in a nutshell in the form of Chart 19, which follows these explanations on page 59.

- **Bars/ Restaurants**

  Bars and Restaurants show the lowest attainable impact, because it is most probable that only lighting and possibly an entertainment device (radio, TV) will be used if connected to the grid.

  Although the electricity investment costs will be relatively low, bars and restaurants won't be that inclined to use electricity. This is due to the fact that bars rather generate low turnovers and restaurants are often open only once a week at market days.

- **Shops**

Especially shops and their clients benefit in theory from longer opening hours and lighting owing to electricity. Lighting allows for better exhibiting the offered goods. Shops might purchase a refrigerator for cooling drinks and keeping perishable food cool, for nearby bars and restaurants as well. Another application of electricity they might offer is a public telephone.

The high competition among shops only leaves low revenues and little money to invest in grid connection.

- **Barber Shops**

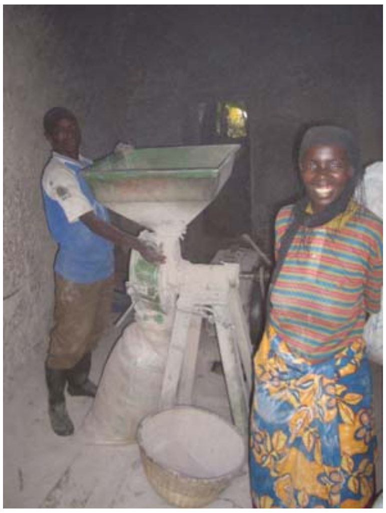
  Though electrical haircutting machines are cutting much more neatly and fast, they won't be an innovation even for the project villages. Grid electricity will mostly just substitute a generator or car battery, which usually provide electricity for the haircutting machine, tubes for lighting and a radio system. Possibly, some more haircutters will establish themselves, which will also lower the customer prices (among project village households, hairdressing was – behind lighting and television/ radio – the third most frequent answer to the question what purpose they want to use electricity for). Having the hairs cut mechanically, which costs 50 FRw (0.07

EUR) and commonly takes place outside or at a market, will nevertheless stay for sure the cheaper option. At present, connected barbers are two to three times more expensive.

Because of the low switching costs and the cheaper grid electricity, barbers usually have an incentive to electrify their shop.

- **Mills**

Mills play a very important role for rural communities, since big part of the population needs their service for processing their agricultural production like millet, sorghum, and manioc. So far, in almost all project villages, fuel-run mills can be accessed. Whether they will be substituted by electricity-run mills and whether additional new ones will be purchased depends, among other things, on the grid reliability. Since mills need much power, reliable power supply is especially critical for these devices. Table 37 gives an idea of how responsive millers are to grid electricity reliability. Though electricity supply is now quite reliable, five of six mills at Gasarenda [GAC] are fuel-run because of frequent power outages in the last years. On the other hand, all mills are powered by grid electricity at Nyanga, because grid electricity is constantly reliable there. Of course, the purchase price is relevant for mills, too. Probably even more than for other MSEs, since they face higher



Control Village	Unrestricted use of electricity	Electricity Provision	Mills
Kibangu [KI$_C$]	-	weak power	electrical mills can not be operated
Gasarenda [GA$_C$]	+	frequent power outages last year; now quite reliable electricity supply	1 electrical and 5 fuel-run mills
Nyamyotsi [NI$_C$]	o	voltage fluctuations	dynamo of the electric mill is broken; a generator had to be purchased
Nyanga, Cyanika [CY$_C$]	+	mw hydro power plant nearby being a reliable electricity source	all mills are electrical

Table 37: Mills in the Control Villages

This table exemplifies the categorization of "unrestricted use of electricity" made in chapter 3.6. The electricity provision in each control village is briefly described in the third column. By means of information on the existence of either electrical or fuel-run mills in the right-hand column, the influence of grid electricity reliability on the type of energy source used by mills becomes evident.

switching costs. Apart from grid connection, they also have to buy a dynamo in order to be able to operate the mill electrically provoking costs of over 300,000 FRw (400 EUR). In case of switching to electricity, the relevant economic impact is primarily the milling price reduction to be expected, which results from cheaper input costs for the miller. In case of additional mills, an important social impact will be time saving. Table 38 lists the prices, millers set in selected villages. It becomes clear that prices tend to be lower with electricity-run mills, but that also other factors than the energy input influence the price such that fuel-run mills might even offer lower prices than electricity-run ones. The impression gleaned from the field visits is that two major other factors are capacity utilisation, i. e. how many clients go to a mill, and the level of competition between different mills.

- **Tailor Shops**
  Electrical sewing machines positively impact on the corresponding region, since they imply a new service. Clothes and decorations that are not realizable with mechanical sewing machines can be sewed. The purchase price of an electrical machine is, however, around twice the price of a mechanical one (70,000 FRw, 95 EUR). Moreover, higher-value clothing is for most of the rural population an unaffordable luxury. Because of that electrical sewing machines usually can be found in small town and cities only.

Table 38: Price per kg Ground in FRw for Different Mills and Agricultural Products

	Agricultural Product		
	Sorghum	Maize	Wheat
Fuel-run Mills			
Gasarenda [GA_C]	15-20	40-50	-
Nyamyotsi [NI_C]	15	25	25
Nyaruguru [NY]	15-20	35-40	30
Rusumo [KA]	10-15	30	20
Electricity-run Mills			
Gasarenda [GA_C]	15-20	40-50	-
Kampala*	10	20	20
Nyanga/ Cy. [CY_C]	10-15	20	20

** Kampala is the closest electrified village in the surroundings of Nyamyotsi [NI_C].*

- **Carpenter Workshops**
  Connected carpenter workshops, equipped with carpenter machinery are considered to have the highest impact among the examined MSEs. Furniture of considerably higher quality can be produced in less time. Due to bigger market sizes of carpenters (already today, carpenters in Nyaruguru [NY] sell part of their products to Kigali), effects on revenue and employment can also be sizeable.
  The up-front costs of machinery purchase in this case can reach millions of FRw, which is even for carpenter associations difficult to afford.

Photos 8 and 9: Furniture by a Non-Connected Carpenter from Kavumu [KA]

Photos 10 and 11: Furniture by a Connected Carpenter from Gasarenda [GA_C]

Chart 19: Commercial Usability and Attainable Socio-Economic Impact of Electricity

4.6 Health Centers

Rwanda's health system is traditionally managed in a decentralized manner at the district level. The health sector is heavily dependent on external funds that are channelled by the districts to the individual health centers. In the surveyed region, Global Fund, FHI and Save the Children not only finance investments such as new buildings, solar panels or television sets, but also current expenditures such as kerosene for refrigerators or personnel costs. Apart from budget restrictions one observes that Rwanda chronically lacks human resources in the health sector, which suffered enormously from the war in 1994. Since 97 percent of the doctors are concentrated in hospitals, especially rural health centers are affected. A2 nurses make up the bulk of the health workforce. They have two years of secondary education and nursing training each. While typically six to eight of them work in one center, in Musenyi [KA] there are only three. The further personnel is composed of a lab technician, auxiliary staff and nurse aides.

The country is evenly divided up in official catchment areas ("zones de rayonnement") comprising 20,000 people on average. Between 750 and 1500 patients one serves per month. At present, a population is defined as having access to health care if the service can be reached by foot in one and a half hours. Considering the current distribution of facilities, this applies to about 85 percent of the Rwandan population – in the surveyed regions even to 95 percent. The mandatory governmental sponsored health insurance scheme, *mutuelle de santé*, in which more than two thirds of the population in the surveyed region are enrolled, covers the most common health issues. It is expected that the population covered by this scheme will further increase.

Since the hospital at Murunda [MD] is already reliably connected by Electrogaz, the following will only deal with rural health centers. These can be grouped into three categories according to their electricity supply:

Photo 12: The Health Center at Mutete [KA]

Category 1:

Those centers which have a reliable electricity supply: Mbuga [GA_C], Gitare, Kinoni and Ntaruka (all CY_C). These represent the proper control group.

Category 2:

Centers that possess solar panels, which do not generate electricity anymore: Gatonde [MU], Musenyi [KA] and Ruheru [NY] belong under this category. Since these clinics are also without electric lighting, necessary operations and rounds at night have to be lit unhygienically by means of kerosene hurricane lamps. Patients arriving at night must wait until morning to receive care. Microscopes can only be used at sunlight.

Category 3:

These health centers possess solar panels and/ or grid electricity that only function erratically. This concerns both the project sites in Muganza and Nyabimata (both NY) and on the other side Nyakigezi [NI_C] and Gitega [KI_C]. The electricity source is still able to feed light bulbs and tubes and television sets with video for sensitization purposes. Power is, though, not reliable enough to maintain the cold chain. In order to ensure drug storage and blood safety, they have to operate kerosene-run refrigerator/ freezer combinations same as the second group. The disadvantage of these appliances

Box 10: Cost Considerations for Health Centers

A standard-efficiency electricity-run refrigerator/ freezer combination consumes on average 2000 Wh per day resulting in costs of 8,000 FRw (10.90 EUR) per month. A comparable kerosene-run model, consuming some 25 litres of kerosene a month, provokes exactly the double cost. Yearly expenditures can thereby be reduced by 100,000 FRw (136 EUR). However, the technology switch may in the end lead to a cost increase instead of cost savings: Total lighting hours in newly electrified health centers increase to such an extent that the fuel savings are more than compensated (see HARSDORFF 2007). Imputing the electric lighting costs for the health centers of our project sites, one arrives at an amount of 7500 FRw (10.20 EUR)* while they currently consume on average roughly six litres of kerosene per month costing 3,900 FRw (5.30 EUR). Hence, according to these figures, one would actually observe a rebound effect, however to a lower extent than suspected.

** It is assumed that 20 (mainly energy-saving) bulbs are used for interior lighting, according to three different use profiles. Moreover three tubes are used for exterior lighting. The daily electricity consumption is derived as follows: 10 x 0,5h x 11 W + 5 x 2h x 40 W + 5 x 4h x 11W]^{interior} + [3 x 10h x 40w]^{exterior} = 1875 Wh/ day.*

is that, apart from the inconvenience of obtaining fuel, current costs are higher (cf. Box 10). Power among these third-group health centers is neither sufficient to allow for the usage of computers and printers.

Further appliances that can sometimes be found in connected health stations are centrifuges and VHF Radio Communication Sets. Of course, even in connected health centers fuel-run appliances can be found. This is especially the case for hygiene-related appliances. Water heating and sterilization is sometimes even done with charcoal. Which type, the electric or the traditional one, is cheaper including investment and consumption costs, is not always clear. Unreliable energy sources are problematic, since backup appliances have to be kept: For example three of the four health centers in the third group possess *both* kerosene-run and electric refrigerators (while the latter are all broken at the moment). An example for an indirect impact of electrification on service provision is the greater willingness of health personnel (same as education workers) to stay in communities that have electricity (WB 2008: 34).

Table 39 gives an overview of the individual electricity situation in each of the health centers in the project regions. In addition, there is a hospital in Murunda [MD], which is, however, already reliably connected by Electrogaz; another hospital is planned by the District administration in the center of Gatonde [MU] but its realisation is not foreseeable. Finally, the opportunity came up recently to connect Shyira Hospital in the Mukungwa River Valley via a newly planned Electrogaz MT line. This would constitute a further important health institution to be considered for EnDev counting. Yet, no reliable information on the electrification status and the potential beneficiaries are available.

Looking at the current electricity provision given in the table, one observes already now critical cases for EnDev counting. On one hand, those health centers of category 2 may possibly violate the "additionality" criterion because other donors already take into consideration electrifying the institution (or they may even be already supplied with a new solar panel when the project grid is erected). On the other hand, it has to be decided whether those health centers of category 3 violate the "new access"-criterion. Due to the big catchment areas, these considerations gain substantial implications for the beneficiary counting: A single health center serving some 20,000 people weighs more than the totality of households that can be expected to be countable in all PSP Hydro sites.

Since all health centers have at least some electric installations, the costs of connecting to a project grid are lowered. However, some might wait for free of charge solar panels given by other donor organisations. Taking into consideration the experience from the control sites and data given in an USAID document on electrification options for rural health centers (USAID 2006), one can expect the daily electricity consumption to amount 8 kwh, i.e. 250 kwh per month.

Table 39: EnDev-related Aspects Concerning Health Centers in the Project Regions

	Existent Electricity Source	Existent Electric Installation	Current Pop. in Catchment Area
Category 2 - Currently possessing no functioning electricity source			
Gatonde [MU]	Existing solar panels are not operational. Belgian cooperation is asked for substitution.	Around 20 rooms are already equipped.	22702
Musenyi [KA]	Solar panels since more than five years out of order. According to its Development Plan, the Gicumbi district plans to equip the Health Center with new panels.	Partly installed. Since it is assumed that the solar panels still function, an estimate for a completion of the installation was obtained amounting to 2,500 EUR. Several donor organisations were asked for grants.	18992
Ruheru [NY]	Solar panel since more than a year out of order. Few days before site visit, three generators and a solar panel have been delivered.	One of the two buildings is professionally installed thanks to grants by Global Fund.	20700
Category 3 - Currently possessing a limited electricity source			
Muganza [NY]	6 Solar panels since 2005 in use.	Complete installation.	21934
Nyabimata [NY]	Solar panels provide electricity for the medical check-up building sponsored by Global Fund.	Medical check-up building sponsored by the Global Fund is installed.	26610

4.7 Schools

In order to attain its goal of a knowledge-based society written down in the Vision 2020, Rwanda tries hard to improve its education sector. After primary school fees have been abolished in 2oo3, the sector has been fundamentally reformed, for example by means of granting parents a say in the management of schools. Meanwhile, the education budget has risen immensely. However, the capitation grants introduced in 2004 remain very low. Schools have only since little time the resources that allow for small and basic investments in the school infrastructure. Education planners currently implement the extension of basic education to nine years as it is the case of Mugina Primary School [KA]. While the reduction in over-aged enrolment will cause the gross enrolment rate for primary schools to go down in the years to come, gross enrolment for secondary education has to and will rise substantially. It currently stands at 16 percent, compared to an average in Sub-Saharan Africa of 28 percent (MINEDUC 2006).

Among 2,200 primary schools in Rwanda, 90-95 percent are without electricity and only half of the 600 secondary schools are connected. In order to improve and extend its programme of solar panel distribution to primary schools, the education ministry MINEDUC currently collects data on the different electricity provision activities for schools. Electricity is particularly of political interest, as Information and Communication Technology (ICT) is a special focus of Vision 2020. Although the plan to provide every school with computers till 2015 is not reachable, the high development potential of the education sector creates an interesting intervention area for PSP Hydro. Concerning the current electricity provision, the picture is quite different for schools than for health centers. Health centers need constant electricity supply for several reasons, and therefore all have been equipped with solar panels, which are the preferred off-grid electricity option when electricity is needed for longer hours. Secondary schools, on the other hand, are currently equipped mainly with generators. They are only used in the evening, mostly for lighting. Primary schools do not yet use significant amounts of energy.

4.7.1 Primary Schools

Whether primary schools in the project villages will electrify depends on the trend of school budgets and the extent to which they will overcome problems that are still more pressing. Table 40 lists these problems according to the priority of headmasters. Half the schools name the state of repair of the school buildings as their main problem (cf. also Table 41). Nine out of 13 primary schools in the project regions have outdated school buildings partly dating back to the 1940's. Three schools got a one-off grant by the African Development Bank (AfDB). The only school of which the state of repair is satisfactory, the one in Sekera [NY], profits from a direct partnership to a German primary school. To illustrate the extent of the second problem, overcrowded classes, one may also consult Table 41. The average of the pupils/ teacher ratio of 87 is significantly above the Rwandan average of 69 (headmasters who do not teach have not been counted). Class sizes within one school range on average from 41 to 66, with single classes of up to 80 pupils. Since schools are allowed to employ new teachers autonomously from part of their budget, this budget item also competes for funds with electricity. The third problem of poverty in

Table 40: Problems among Primary Schools as stated by Headmasters

1.	Buildings
2.	Overcrowded Classes
3.	Poverty in General
4.	Water
5.	Electricity
6.	Lack of Didactic Material
7.	Furniture

general was primarily pronounced in Nyaruguru [NY], which also results in the lowest attendance rates. While they are mostly above 90 percent, spot checks in Nyaruguru revealed classes with rates of only 60 percent.

Table 41: Primary Schools in the Project Areas

	Pupils	Pupils/ Teacher Ratio	State of Repair Index*	Studies at School Index**	Electric Appliance Index***
Kavumu [KA]	811	81	0	0	0
Mugina [KA]	1165	73	(3)	2	1
Mutete [KA]	1131	81	0	1	1
Kiryi [MP]	833	76	1	(2)	0
Gatonde [MU]	1126	66	1	2	1
Rusasa [MU]	958	74	1	1	1
Bigugu [NY]	1208	81	1	(2)	0
Muganza [NY]	1164	97	(2)	0	2; *PC in headmaster's office*
Nyabimata [NY]	1836	102	0	(1)	2; *panel out of order*
Ruheru [NY]	1693	94	3	1	2; *two teachers are currently trained in ICT*
Ruhinga [NY]	411	137	0	0	-
Rwishywa [NY]	1100	85	0	1	0
Sekera/ Mutovu [NY]	1824	83	4	1	0
Shyembe [MD]	1053	66	3		*3; PC out of order, two classes with lighting*
Murunda [MD]	*no information available due to holidays*				*school is located next to Electrogaz grid*

** The State of Repair Index describes in which conditions school building currently are: 0 = bad and insufficient; 1 = bad and sufficient; 2 = bad and new buildings coexist; 3 = reasonable old and new buildings coexist; 4 = good. Figures in brackets imply that new building are planned or already under construction.*

*** The Studies at School Index reflects the time pupils spend at school. It is observed that schools progressively extend this time until they finally fall back on studying at night, which necessitates lighting classes. "0" means that pupils only go to school during usual schooling hours, Monday till Friday, 8 o'clock till16.30."1" indicates that pupils of the higher classes study at school in the holidays three to five times a week or on Saturday mornings. With "2", these studies are both in holidays and on Saturdays. The next step "3" would be studying at night. Figures in brackets imply that the school is currently undertaking the step towards this workload.*

**** The Electric Appliance Index shows which electric appliances and electricity sources already exist: While "1" is the standard equipment of torches and one or two radios, "0" means that even these are broken and non-existing. "2" stands for a school that possesses the standard equipment and a solar panel to feed a computer. "3" implies grid connection with part of the rooms installed with electric equipment.*

Photos 13 and 14: Two Different Primary Schools at Nyaruguru

Electricity was ranked as the fifth biggest problem. Even this might exaggerate the current importance of electricity for primary schools, since the poll was made within the bounds of an electrification project survey. Namely, it is more than questionable why schools should invest in computers if they lack didactic material such that 50 pupils have to share one to ten textbooks. Rusasa primary school [MU] with 950 pupils, for which the figure of didactic material expenses was available, spends 65,500 FRw (90 EUR) for school books this year. According to key informants parental contributions are not viable as an alternative funding source for electricity. For example, the Kiryi Primary School [MP] made an enquiry about the paying capabilities of the pupils' parents regarding the financing of the installation of a solar panel. Only 100 were considered as being able to pay the one-off contribution of 500 FRw (0.70 EUR). Among the project sites only those in Nyaruguru [NY] currently contribute financially for special school expenditures. In their case, parental school feeding contributions amount to 100 FRw (0.13 EUR) per month, while the ingredients are provided by the World Food Programme (WFP). But even this tiny sum through which parents spare themselves to buy and prepare the food for their children is paid throughout the surveyed schools by only 60 percent of the parents.

Among the **control sites**, only Bwuzuli primary school [MP] has parental contributions for electricity, 1000 FRw (1.30 EUR) per year. Concerning electricity, other observations made in the twelve visited control schools are the following: Six schools are currently not connected. Among them, one even possesses appliances such as a TV, video and overhead projector. Another one is connected only for some days during vacation through the neighbouring church when special events are organized for pupils supported by Compassion, an evangelical Christian child sponsorship organisation. A third school has two computers sponsored by World Link, which broke down more than a year ago. The connection was finally cut half a year ago after the electricity bills have not been paid anymore. On the other side, five of six connected schools use electricity only to power the headmaster's office, while in one case pupils directly profit from this circumstance since a television set, two computers and a keyboard in this room are used for lessons. Another school wanted to connect one classroom, too. The installation costs were estimated at 164,000 FRw (220 EUR), but after outdoor cabling worth 58,000 FRw (80 EUR) was stolen during vacation, the project was cancelled. The only primary school that actually started to provide classes with electric lighting is Kinoni [CY_c]. Here, lighting is important, since the school is located in a very dark and cloudy region due to the nearby volcanoes. Nevertheless, darkness is also an issue for the PSP Hydro sites. During the rainy seasons (mid-March to end of May and October to November) it happens that up to four times a week classes have to be stopped for an hour or even the whole afternoon. This situation will not necessarily improve with lighting, since some teachers stated that it is rather the noise of the rain (especially on corrugated iron roofs, with which primary schools are more and more equipped) than the obscurity that disturbs classes.

Altogether, a very low electricity consumption pattern of monthly 10-50 kwh is to be expected. Due to holidays, this will be further limited to only nine months a year. For primary schools, the decisive question for EnDev monitoring will not be whether the existing electricity sources can be seen as modern and satisfactory. As Table 41 depicts, of the three solar panels that currently exist, one is broken, one not yet used and only one in use for the headmaster's office. The question should rather be whether such a low-volume consumption can be counted, especially if it is mostly not for teaching purposes.

4.7.2 Secondary Schools

Secondary schools on the other side do have significant electricity needs. That is why all but one schools listed in Table 42 do have a functioning, though not necessarily sufficient

Table 42: Secondary Schools in the Project Areas

	Electricity Source (/ monthly fuel consumption)		**School Development**	**Pupils**
Mutete [KA], *lower secondary*	Generator, bought in 2006		For 2008, an enlargement of the school is planned including six new classes and a dormitory for around 500 students. The school shall then count 600 to 700 students.	300
	120 l	78.000 FRw (105 EUR)		
Gatonde [MU], *lower secondary*	Solar panel provides electricity for two tubes		An extension to upper secondary might take place.	590
Nkunduburezi [MU]	Generator, bought in 2005		Since 2005, the number of pupils increased by more than 50 %. A further increase in the number of pupils is expected.	780
	90 l	67.500 FRw (90 EUR)		
Bigugu [NY]	Generator dates back to 1991. It had to be repaired five times in the first half of 2007, provoking costs of 150.000 FRw (200 EUR).		-	540
	200 l	140.000 FRw (190 EUR)		
Mutovu [NY], *lower secondary*	-		The school started provisionally in the sector office building and an adjoining place in 2005. A new building complex is still in the planning stage.	112
Murunda [MD]	Direct electricity access to the Electrogaz grid		An expansion plan for the coming five years envisages to additionally offer computer science classes. The school shall then count 800 students.	600
Gatare [MD]	Will probably be connected to the existing electricity grid.		Youth formation center ("Centre de Formation de la Jeunesse") scheduled to be inaugurated in the beginning of 2009.	(200) *planned*

electricity source. It is primarily used for lighting at night. Every day, often also during the weekend, students typically study from 18 to 21.30h with a one-hour break for supper. Places lit are classes, the dining room and the dormitories of the boarders who normally make up around two thirds of the pupils (in Bigugu [NY], boarders make up 96 percent, and in Gatonde [MU] where overnight accommodations are very limited, only 26 percent). For entertainment and didactic purposes, the schools possess consumer electronics like a television set, radios, video or DVD player. Moreover, all staff members charge their personal mobile phone batteries and a photocopier is sometimes in use.

However, the electricity sources can be used so far only at night time since it would be too costly to run the generator the whole day and the solar panel at Gatonde [MU] is not powerful enough to provide electricity for more than two tubes during two hours. Not only the appliances listed above could be used at any time during the day, also computers and their accessories could be included in the lessons. Up to now, only at Nkunduburezi [MU] PCs are used sporadically. Apart from the school development plans mentioned in Table 42, completely new secondary schools are not planned for the project regions so far. Instead, a new secondary school level will be probably added in the near future to Mugina Primary School at the Kavumu site [KA].

Among the seven secondary schools at the **control sites**, all but one use computers permanently, although with limits, since skilled teachers are lacking. These schools with between 380 and 620 pupils are equipped with 10 to 16 operative computers while up to half of them are used for administrative purposes. Substituting generators by grid electricity will bring about substantial cost savings. According to energy experts[1], generators usually need one litre of fuel to produce 3 kwh of electricity. Considering the average price of 700 FRw per litre paid by the schools, 50 percent could be saved through electricity. The substitution of firewood by electric stoves is improbable. All visited secondary schools only use firewood with all its negative side effects (deforestation, high costs and bad indoor air quality (cf. KA-SS1c - KA-SS1f)). High acquisition cost for electric stoves, lower reliability of the energy source, habituation and incertitude about potential cost savings seem to be reasons for this reservation. Actually, due to the sheer non-existence of electric stoves at schools it is difficult to estimate the cost savings. Currently 10 to 15 sters (stacked cubic metres) per month per 500 pupils are consumed provoking cost of 40,000 FRw (55 EUR) on average.

Concerning EnDev counting and the impact assessment of the electrification of secondary schools, the question in dispute is whether schools will be able to extend its electricity use thanks to grid electricity access. A mere substitution of generators by grid electricity cannot be seen as a sufficient programme impact.

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[1] cf. for example http://www.alaskasun.org/pdf/SolarPhotovoltaics.pdf and http://eprints.ucl.ac.uk/archive/00002640/01/2640.pdf.

4.8 Communal Services

After the administrative reorganisation in 2006, new sectors had been formed which changed remarkably the regional political structure. Often new **sector office** buildings have been constructed, which mainly are not connected yet. The sector offices located in the project regions are listed in Table 43. A typical sector office consists of a staff of six members: the executive secretary, an accounting secretary, persons in charge of social and civil affairs, an agronomist and recently also a veterinary. Opening hours are normally from 7 o'clock till 15.30h. Hence, lighting is rather seldom needed. Experience in connected sector offices shows that this is the case when it is raining and when reports have to be written, which happens about five times a month. Probably all sector offices will also be equipped with at least two to three computers in the near future. Up to now, the sector offices equipped with computers received them mainly from former regional institutions that closed recently. The Rusasa sector office [MU] is an exception in this regard. Last year it received a generator plus computer from the district. Since the office does not have the necessary budget so far to pay for the fuel, both the generator and the computer are yet unpacked. The Ruheru sector office is the other office that already possesses electricity access. Though it has been equipped with twelve solar panels last year, the administration is not able to benefit properly from the electricity as well. Due to a lack of power, not even the one PC with printer in their possession can be used. Instead, these devices were given to the court house and electricity is used to charge mobile phone batteries and for electric lighting, which is needed to write reports.

Table 43: Sector Offices in the Project Areas

	Sector Population	Electricity Source
Mutete [KA]	19,954	-
Rusasa [MU]	~ 20,000	generator
Muganza [NY]	17,515	-
Ruheru [NY]	~ 21,000	12 solar panels
Murunda [MD]	17,806	grid electricity

Table 44: Churches in the Project Areas

	Wor-shippers	Electricity Source		Wor-shippers	Electricity Source
Adventist Church [KA]	100	generator	Adv. Church Mpuza [NY]	*150*	-
EER Rusumo [KA]	50	-	EER Cyezi [NY]	*200*	-
EER Kavumu [KA]	2000	-	EER Rwishywa [NY]	600	-
Jehovah's Witnesses [KA]	100	-	Mutovu Catholic Church [NY]	*300*	-
Mugina Catholic Church [KA]	2000	generator	Muganza Cath. Church [NY]	1200	0,9 kw generator
Mutete Catholic Church [KA]	300	-	Ruhero Catholic Church [NY]	200	(generator of Muganza Ch.)
ADEPR Rusasa [MU]	150	car battery	Nyabimata Cath. Church [NY]	*300*	?
ADEPR Cyinama [MU]	300	1,5 kw generator	UEBR Bigugu [NY]	*200*	?
			Murunda Parish [MD]	3500	grid electricity
Rusasa Catholic Church [MU]	*300*	?	ADEPR Shyembe [MD]	*150*	grid electricity

Churches and Mosques do as well play an important role in the local communities. Apart from messes, in some cases they have an associative character and also offer chorals and alphabetisation courses. If connected, they are equipped with lighting, a microphone, music instruments, an amplifier and loudspeakers. However, these are normally only used on Sunday and at church festivals. In case the priest of the church lives next-door, considerably higher electricity consumption can be expected since they often enjoy a relatively high standard of living. The churches that exist in the project regions are presented in Table 44.

Other communal services that might additionally be taken into consideration are the Court Houses of Muzo [MU] and Gambiriro [NY] – it should be noted that both have high-performance generators at their disposal.

5 Conclusions and Recommendations

The present study brings about the following compilation of conclusions and recommendations, which are presented according to the study objectives described in chapter 2.1.

Objective 1. Portray the socio-economic conditions in the project regions.

- A detailed picture of the socio-economic status quo in the project region households is provided in chapter 4.1 to 4.4. Main characteristics are abridged in summary boxes that conclude each of the chapters. It is complemented by village descriptions in chapter 3 and information on enterprises and social infrastructure institutions in 4.5 to 4.8.

Objective 2. Serve as a data basis for monitoring activities.

- The processed data collected through questionnaires in 393 project village and 348 control village households constitutes a profound and reliable basis for future monitoring activities.
- The calculation formula for counting the people the energy facilitation programme Energising Development can be held accountable for ("EnDev beneficiaries") has been developed further and adapted to the concrete case of Rwanda. **Estimations of the probable number of EnDev beneficiaries** in 2010 are given in Table 45. They sum up to 41,200.
- These figures yet hold a **high degree of uncertainty**, since none of the projects has started its operations in electricity provision so far. At this stage of project progress, the rich collection of individual information and data assembled in this report and summarized in Annex A7 are therefore at least as important as these aggregate figures. In addition, a proper account of the different **elements of uncertainty** is crucial to properly appreciate the numbers. This is provided in Box 11.

Table 45: Estimates of EnDev Beneficiaries

	Kavumu	Musarara	Nyaruguru*	Total
Number of people provided with **lighting/household energy**	366	604	546	1,516
Number of people provided with **energy in social infrastructure**	12,259	10,865	5,571	28,695
Number of people provided with **energy for productive use**	2,543	5,684	2,781	11,008

* = *according to the latest grid planning from early 2009 (cf. GTZ-IS 2009), part of the areas originally targeted by ENNy will not be served for the time being; the estimates originally provided in 2007 have therefore been adjusted.*

Box 11: Elements of Uncertainty related to the EnDev Beneficiary Estimates

The figures provided on the probable number of EnDev beneficiaries have been derived by seeking to make most appropriate use of all available information on the project and the project sites. For the case that the projects are actually implemented, the figures give an indication of what might result in terms of beneficiaries. Yet, a variety of uncertainty factors remain that may seriously affect these numbers.

First of all, the areas covered by the **project grids**, which are fundamental to the determination of project beneficiaries, are not yet definite. This holds for all sites, even though ENNy's project grid outline originally proposed in their business plan has been revised in this baseline report. Neither is it possible today to substantiate the feasibility of future network expansions planned by the different project developers.

Information and **data collection** for all three sites listed in the table dates back to the year 2007. Structural rural development in areas as the ones targeted generally tends to be negligible in the absence of external interventions. Whether rural development policies promoted by the government or, for example, changing weather patterns made a difference remains speculative. The information and data presented may therefore partly not reflect the current status quo in 2009 or that before start of operation of the different projects.

The **calculation formulae** are mainly those proposed by EnDev. Adaptations have only been made when they seemed to more appropriately reflect EnDev counting guidelines for the concrete case of Rwanda. However, EnDev considers substantially overhauling its counting rules for all projects that are set into opration from 2010 onwards. Since this is the case for at least part of the PSP Hydro sites, that overhaul will also influence the counting result. In any case, this report most likely delivers all data necessary to feed these new formulae as well.

At least according to the current counting formulae, health stations and sector offices have a very high **share in EnDev counting**: the 5 facilities at the three sites make up 65 pecent of the total beneficiary figure, whereas 5 households, for example, only arrive at a percentage of 0.02. Connecting one health station or sector office more or less therefore substantially changes the outcome.

As these institutions are at the same time most prone to be **pre-electrified** by means of generators or solar panels, it will be highly relevant how EnDev handles the counting of these cases. Additional bigger pre-electrified consumers that came up only after the baseline survey are a tea factory in Nyaruguru [NY] and a hospital at Musarara [MU]. While EnDev has not yet finally decided upon the handling, this report, again, delivers clues for the decision process. The way they have been treated in the counting of this report is shortly delineated on page 72.

It furthermore remains to be seen, whether the intervention at the **already electrified** Murunda site actually impacts the energy situation of the local population in a way that EnDev considers it to be countable (see also the comment on Murunda on page 71).

- It is not referred to the **Mpenge [MP]** intervention in the table, since the original project has been cancelled in the meantime and a business plan for the site by a new investor is still in development.
- For the rehabilitation project in **Murunda [MD]**, no estimations are provided since the village is already reliably electrified. There are, so far, no activities scheduled by the project developer that would allow a significant amount of potential beneficiaries to newly access electricity. What is more, there is only a very limited amount of potential beneficiaries in the area, since grid connection rates are already high and especially social infrastructure in the region is already connected. As is the case for the hospital, the Parish and the secondary school in Murunda, main part of them are even directly connected to the Electrogaz grid thereby not suffering from poor grid performance of the two lines managed by the consumer association (cf. Box 8 on page 21). Two potentially combinable options

remain that still allow for a valuable impact on the provision with electricity: Feeding into the Electrogaz grid and improving the grid infrastructure in the project region. It is therefore recommended to scrutinize in how far these two options might be countable in terms of “EnDev heads” thereby creating an incentive for PSP Hydro to promote such an endeavour. The first option is probably by itself attractive for the project developer REPRO. It has to be determined in how far REPRO can be required or incentivised to engage itself in the second option. It would be otherwise questionable, whether the local population would benefit from the intervention at all.

- **Already existing electricity sources** create a problem for the beneficiary count. Based on the impressions gleaned from the survey and the information received, reliable grid electricity will be a considerable improvement in comparison to the generators and solar panels that are already in use in some facilities. Using the metaphor of the “energy ladder”, which ranges from traditional energy sources like kerosene wick lamps to reliable grid electricity, these clients would also make a step upwards, though a smaller one. Accordingly, expected clients possessing a (poorly performing) solar panel or a car battery are included in the head count with a factor of 0.5, those having a generator with 0.25. These and other assumptions, on which the estimates in Table 45 are based, are explained in Annex A7.
- All projects suffered from severe delays and none of the projects has started providing electricity to the population two years after data collection. It can therefore not be warranted that the baseline survey actually reflects the status quo in the target villages before the intervention. To credibly attribute changes to electrification, it is recommendable from a methodological point of view to do a **further survey wave** in both regions immediately before the villages effectively get electrified. For example, households in other African regions have shifted from kerosene-lit lamps to battery-run LED illumination in recent times. Whether this has as well occurred in the intervention areas after the baseline surveys is of relevance, since the shift to electric lighting is considered to be the most significant impact on the household level. The supplementary data could also be used to trace development trends in the control villages thereby increasing robustness of impact findings for both the GTZ project and electrification in general.
- The customer-related **monitoring during project implementation** should serve the purpose of (i) detecting problems clients and non-clients face with electricity and grid connection. This should be the Project Developer’s responsibility, because it anyway is in their vital interest and because they probably are “closer” to the clients. PSP Hydro may, nevertheless, be supportive. Further monitoring purposes are (ii) corroborating the number of EnDev beneficiaries and (iii) monitoring the progress of individual Project Developers. These two tasks have to be done by PSP Hydro. For the planned and recommended case that pre-paid meters will be installed, monitoring instruments for the different beneficiary groups are proposed in Table 46. Thereby, the countable connections are elicited. In order to reach at the corresponding EnDev Beneficiary figures, these connections simply have to be multiplied by the matching numbers given in the tables of annex A7. Already existent electricity sources mentioned in the last bullet point have to be examined during the monitoring, too. It may well be the case that beneficiaries in the meantime already received an alternative off-grid electricity source.

Table 46: Proposed Monitoring Instruments

	Impact on EnDev Beneficiary Figures	Monitoring Object	Information Source	Costs and Reliability
Households	o	Yearly electricity consumption of connected households; proportion of clients with less than 60 kwh consumed in that period (or 5 kwh per month if connected for less time)	Billing system of the PDs	very low cost; reliable
MSEs	+	Yearly electricity consumption of connected MSEs; proportion of clients having consumed less than X (to be defined) kwh on average per month	Billing system of the PDs; Individual codes are assigned to the different MSE types listed in Table 2	very low cost; reliable
Schools	+	Information on electricity uses of connected schools, possibly double checking by means of electricity consumption	Contacting parent representatives or headmasters; Billing system of the PDs	low cost; reliable
Health Center and Sector Offices	++	Information on electricity uses of connected health centers and sector offices, possibly double checking by means of electricity consumption	Visits to the Health Centers and Sector Offices; Billing system of the PDs	medium cost, very reliable
Churches	-	None, too low beneficiary counts; could be better treated as households		

Objective 3. Investigating the development effect of the intervention through with-without comparison.

- By interviewing 735 households in the non-electrified project villages and in electrified control villages a variety of findings concerning the attainable impact of electrification projects could be gathered. This survey set-up allows for assessing energy usage and related impacts by comparing electrified to non-electrified regions. This provides orientation on what can be expected in the GTZ project villages.
- Due to the successive selection of project developers, the baseline data could not be collected at once for all project villages. Intertemporally changing factors may therefore also have influenced part of the data. Comparability can be enhanced in such a case by scheduling the two survey rounds – if possible – in the same (harvest) period of the year.
- A significant community-wide wealth impact is not predetermined. According to the developed comprehensive **wealth indicator**, electrified villages on the whole perform better than non-electrified ones. Inequality might, however, deteriorate in the short run, since poor households connect eight times less than wealthier households.

- At the household level, the most considerable benefit can be expected in terms of **lighting**. Costs per lighting hour can drop by up to 88 percent if kerosene is substituted by energy saving bulbs. Since on the other hand much more lighting is consumed in connected households, the effect of electrification on the total energy expenditures is unclear. Apart from kerosene for lighting, resource savings in the project villages can be expected due to the substitution of batteries for radio use and generator fuel, while the consumption of cooking fuels will not be affected by the intervention. The detection of positive outcomes of lighting is preliminary so far. Only concerning the studying of primary school pupils at night a positive impact could be detected.
- **Home businesses** are, generally, very uncommon in Rwanda – only 1 to 2 percent of the households indicate a productive use at home, mainly sewing and milling. It is not to be expected that electricity triggers a perceivable change in this respect, since home businesses do not occur with a higher probability in electrified regions. While there is no indication that milling is made use of more regularly in electrified Rwandan villages and other factors than the energy input such as local competition influence the milling price as well, prices tend to be lower with electricity-run than with fuel-run mills. This leads to relevant repercussions on households considering that more than half the project households engage in crop transformation.
- There is little indication that electrification has a significant impact on **women's workload**. The relief from household duties is negligible and mainly limited to lighting fuel collection becoming obsolete for electrified households. On the other hand new job opportunities for women in the service sector emerge where effective working hours tend to be higher – by 20 percent in public services and up to 50 percent in other services.

Objective 4: Provide benchmark data for a potential ex-post Impact Evaluation of PSP Hydro.

- The design of comparing electrified and non-electrified villages and connected and non-connected households in rural Rwanda already allows for predicting the main development impacts of electrification. It can, however, not replace an endline or **ex-post study** of the actual programme impact. Since important benefits of rural electrification do not materialize immediately, an ex-post impact study of the impact of the development measure should not be conducted earlier than three years after the villages are electrified.
- A future before-after comparison will probably encounter scepticism concerning the suitability of this baseline data in representing the "before" point of time taking into account the period between data collection and the yet pending start of operations. A further survey wave as already proposed would remedy this problem. An alternative option would be to **spot-check** the appropriateness of the data in serving as baseline data representing the situation before the electrification intervention. Local staff might revisit a small sample of the already interviewed households in the respective project region with a reduced form of the questionnaire covering more time-sensitive questions right before the proper electricity provision is going to start. While this is not a rigorous approach, it would at least partly back the usefulness of the baseline data in lack of resources for another survey wave.
- Based on this experience, it is advisable to make the **timing of a baseline** more dependent on concrete steps in the project cycle. For micro hydro project, the ordering of the MHP turbines, for example, still gives at least half a year and thereby enough time to implement a sound baseline survey.

Objective 5. Reducing uncertainty about demand assumptions in the target regions.

- So far, demand assumptions have been based on the business plans provided by the Project Developers. They were, in some cases, too optimistic and not detailed enough, but in general fairly well. The present baseline still suffers a variety of unpredictabilities, but it provides for the necessary information which allow to assess them, including detailed descriptions of the current status quo, maps and photographs of the project sites.
- The high up-front **grid connection costs** of some 140,000 FRw (185 EUR) including in-house installation are the main barrier for households in electrified regions to get connected, considering that many households already face enormous problems with covering their basic needs. These costs would further rise substantially, if the household would need to move house in order to get into the reach of the electricity grid. Significant movements towards the grid, as expected by the Project Developers, are therefore less expectable reducing the profitability of the electrification of the rather dispersed settlements in the project regions. Furthermore, the potential of remittances serving as a financing source for electrification investments seems to be limited. Nevertheless, households enjoy a relatively decent access to financial services.
- Consumption data from both electricity suppliers and consumers in three different control villages all show an average monthly **household electricity consumption** of 12 kwh. In the start-up, this value will probably turn out to be lower. Households will adjust themselves to the new situation and only gradually buy electrical appliances. Moreover, in case of a successful promotion of energy-efficient compact fluorescent bulbs, overall electricity consumption can be kept at low levels right from the beginning. In the course of a year, no dramatic changes are to be expected. In Rwanda, during the month of minimal consumption, only 15 percent less electricity is consumed than in the month of maximal consumption. During the day, local electricity consumption is heavily concentrated in the evening peak hours (cf. the daily load curves for Rwanda and Nyamyotsi [NY_c] in appendix A8).
- If the MHPs work reliably, **health centers** can be expected to switch to grid electricity, since they incur high fuel costs for kerosene-run refrigerators to ensure drug storage and blood safety. Moreover, they need lighting for necessary operations and rounds at night, sterilization devices for hygiene and a computer for administrative purposes.
- Primary **schools** currently seem to neither have the resources nor an elevated need for electricity. Due to the outstanding development in primary education, things may change, but probably not before 2010. On the other hand, all but one secondary school already meet their significant electricity needs with generators or solar panels. They use it especially for lighting the daily studies during night at school and the boarders' dormitories. Many schools already have computers and television sets, but due to the high fuel costs, they can use them only sporadically. It is therefore quite probable that these schools will substitute their present electricity sources for grid electricity.
- **Sector offices** would use electricity for administrative purposes, i. e. computers, printers and a telephone. Still during the project phase until 2010, most of them can be expected to have the necessary budget for grid connection and current electricity payments.
- The surveyed rural villages generally exhibit a fixed set of six types of **micro and small enterprises (MSE)**. The individual enterprises' size and markets are as well

limited: 49 percent of the surveyed enterprises are one-person operations, none has more than ten employees and, apart from carpenters, they only serve their village. The connection and equipment of carpenter workshops with electrical carpenter machinery is considered to have the highest socio-economic impact on the local community due to their bigger market size in combination with time and, in particular, quality improvements in the manufactured furniture. Further businesses that have been found in the electrified control villages and might well come up in the project villages with the arrival of electricity are welding (possibly serving as well as a bicycle repair workshop), battery charging, photocopying, and film exhibition spaces. MSE will not automatically connect. Instead, it is anticipated that they will rather connect with a business-type specific probability ranging between 10 percent for tailors and carpenters and 50 percent for barbers and millers. It has to be, further-more, taken into account that also some among the newly connected enterprises will already possess an alternative electricity source. Their percentage is expected to be 75 among mills and barbers and 10 percent among the others. The 25 percent of connected mills, for example, that will be newly provided with modern energy are likely to be mills that are purchased due to local community initiatives.

Objective 6. Surveying the anticipated requirements of complementary activities.

- In order to facilitate the achievement of the final goals that the Project Developers run their micro-hydro plants in a sustainable way and that households benefit persistently from electricity, complementary activities should focus at (i) raising the ability to pay of households (especially by means of productive uses of electricity); (ii) reducing the up-front and current costs of electricity and (iii) optimizing the customer-provider relationship and (iv) technical support.
- Craftsmen in the project villages usually do not have the necessary knowledge to create new activities. Even the mastery of electrical machines for their proper business (such as electrical saws for carpenters) is commonly not existent. The same holds for basic management skills. Hence, it is recommendable to offer **training courses** for selected craftsmen on the use of electric appliances for familiar activities and on new activities conditional on electricity such as poultry farming or juice production.
- Since **home business** activities are quite uncommon in Rwanda, their promotion should also be taken into consideration in order to foster productive uses of electricity. Beforehand, a detailed cost-benefit analysis would have to compare this option to traditional businesses exerted at a separate working place.
- In order to find a solution for the financing problem concerning the grid connection, **micro credits** might be an option. Credits for electricity or electrical appliances are very uncommon and not recommendable in any case. Instead of encouraging unsustainable consumptive uses of electricity by means of supporting connection, the project should better try to encourage productive uses through credits for productive electrical appliances including low-scale electricity-needing activities complementary to agriculture (like cooling). In this case, it is advisable to use a market analysis carried out last year by the municipal utility of Mainz (Germany) in cooperation with GTZ (KIGALI SOLAIRE 2007) as a starting point. It investigates microfinancing possibilities for photovoltaics in Rwanda. The findings should be transferable, since the most relevant credit characteristics of (i) high up-front costs, (ii) a technological asset as the purpose of the credit and (iii) few collateral to be expected of credit users are the same. An alternative, implicit and low-scale form

of micro credits would be allowing connection charges to be paid over a number of years. Activities in this field – same as for the already mentioned trainings – should be planned and realised in close cooperation with another GTZ Programme in Rwanda ("EcoEmploi") focussing on private sector development. Complementarily, grid electricity alternatives like car batteries and rechargeable lights might be considered. These alternatives, which enjoy decent acceptance levels among the surveyed population, would allow low-volume electricity use at lower investment costs.

- Poorer households connect eight times less than wealthier households. Though it cannot be the project's target to achieve a uniform connection rate among all wealth classes, such a great difference should not be satisfactory for a development measure. The elaboration of **pro-poor strategies** should therefore be considered.
- **Subsistence farmers** make up the large majority of the project village population and tend to be poorer than households occupied in non-agricultural activities. They often lack improved farming inputs, techniques and sufficient land, factors that will be deteriorated in the future due to climatic changes. In a mutual effort with local organisations like cooperatives, these conditions could possibly be influenced – often at low cost – and the resulting income might contribute to make the grid connection affordable for more farmers. This is especially important, since they commonly prefer to live close to their fields and therefore further away from the future electricity grids, which puts these households even more at a disadvantage.
- Many households lack even basic knowledge about electricity. Nevertheless, expectations are high and sometimes misled. For example, many interviewees expect to benefit from the project through employment during or after the construction phase of the micro hydro plants. Or they deem electricity to be a one-time investment without any current costs. During regularly held community meeting or meetings of the newly created consumer associations (cf. Box 7) the population should be informed ("**consumer education**") about what they can realistically expect from electricity, how they can best benefit from it and which cost they will probably incur.
- Since years, electrification has in some of the project villages been announced; in the case of Nyaruguru since the early 1990s. Even recently, some people in the project regions were told by Project Developers that the electricity would become accessible in mid 2007. In general, it is recommended to build up **trust** among the population through better communication, which especially implies reserved statements concerning the planned project start.
- The **reliability of electricity** is a very important issue. The case of the UNIDO supported site of Nyamyotsi exemplifies this well, where a range of clients have lost valuable electric appliances due to grid instability. In consequence, people are either reluctant to buy appliances at all, or they keep additional back-up electricity sources such as generators. The project shall therefore seek to guarantee a dependable and continuous electricity supply by the Project Developers at the outset.
- The project should continue to insist in the **introduction of pre-paid meters**. While prices for this meter type have dropped substantially, the benefits are significant. At Kibangu, for which billing figures have been available, uncovered bills of preceding months were quite considerable. They frequently surpassed the total billing sum of the current two-month accounting period. Furthermore, cutting the connection of non-paying clients, especially of social infrastructure institutions is an inconvenient and unpopular task. For consumers, the pre-paid system has the advantage of a higher cost control and consciousness. Data of the 2008 baseline has shown that the vast majority of

connected households actually appreciate this. Future projects do, however, have to strive for downsizing electricity provision material. Thereby, households – primarily the poorest ones – shall be targeted that will limit their electricity consumption to minimal volumes (1-2 light bulbs, perhaps a radio) for an indefinite period of time.

- Though the target population is different, it is recommended an **exchange of experiences** concerning consumer behaviour with the national biogas programme, which is jointly carried out by MININFRA, the Dutch Cooperation SNV and GTZ.

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Appendices

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Vincent	KARARA	CH	Priest of Rusumo Adventist Church	2007-05-25
Emmanuel	NZANANA	CH	Contact Jehovah's Witnesses, Rusumo	-
Aloys		CH	Priest EER Rusumo	-
César	NDAYISABA	CH	Priest Mutete Catholic Chuch	2007-05-24
Fr. Bonaventure	NGIRENTA	CH	Priest EER Kavumu	2007-07-09

MPENGE [MP]

Gilbert	MUTANGUHA		Project Developer, GTR	
Osée	NIYIBIZI		Local Companion, Mpenge	2007-05-29
Desirée	HITIMANA		Inhabitant of Bwuzuli, Economist	2007-05-29
Jean-Baptiste	NEMEYEBAHIZI		Investor PPCT	2007-05-31
Eric			Employee of J.-B. NEMEYEBAHIZI	2007-05-31
J. Bernard	HABUMUGISHA		Agronomist Muhoza Sector	2007-05-04
Jonas	CHASHOSHI		Executive Secretary Mpenge Cell	-
Bernard	GASHIRABAKE		Chef Umudugudu Bwuzuli	2007-05-31
Ésperance	MUKAMURIGO		Chef Umudugudu Giramahoro	2007-05-30
Michel	NDAYAMBAJE	PS	Headmaster Muhoza II Primary School	2007-05-28
Fidèle	NIZEYIMANA	PS	Vice Headmaster Kiryi Primary School	2007-06-01
Moses	RUMENERANGABO	PS	Headmaster Bwuzuli Primary School	2007-05-31
Clément	MUHAWENIMANA	PS	Teacher Bwuzuli Primary School	2007-05-29
Mutware	GIHEMBE	PS	Headmaster Muhoza I Primary School	2007-05-31
Gaston Joshua	MASUMBUKO	CH	Parish Priest of ADEPR Ruhengeri	2007-05-30

MUSARARA [MU]

J. M. V.	HAKUNDIMANA		Project Developer, SOGEMR	
Victor			Technician, SOGEMR	
Joseph	UWIZEYE		Construction Work Supervisor, SOGEMR	
Désiré			Constr. W. Deputy Supervisor, SOGEMR	
J. Damascène	NZABANDORA		Chairman Consumer Ass. "Intiganda", Biziba	2007-06-06
Eugène	MANIRAGARA		Executive Secretary Gahinga Cell (Cyinama)	2007-06-05
Aimable	NDIZIHIWE		Executive Secretary Rutabo Cell	2007-06-06
Pièrre Claver	NKURUNZIZA		Chairman Muzo Court House	2007-06-08
William	SERISANSIMA		Official of Gatonde Criminal Investigation Dept.	2007-06-06
			Contact "Dufatanye Kurwanya SIDA"	2007-06-06
Aphrolis	MDAWIRIMOIRA	SO	Agronomist Rusasa Sector	2007-06-07
Cyprien	MAJYAMBERE	HC	Head Nurse Gatonde Health Center	2007-06-05
Leonce	BIGIRIMANA	PS	Headmaster Gatonde Primary School	2007-06-06
Alexis	MATABARO	PS	Headmaster Rusasa Primary School	2007-06-07
Yvin	NSHIMIYIMANA	SS	Headmaster Nkunduburezi Sec. School	2007-06-06
Innocent	TWAGIRIMANA	SS	Headmaster Gatonde Secondary School	2007-06-06
Anastase	HABYARIMANA	CH	Priest Cyinama & Rusasa ADEPR Church	2007-06-05

NYARUGURU [NY]

Firmin	Mutabazi		Project Developer, ENNy	
Gabriel	NKULIYIMANA		Coordinator ADENYA	
Jean Bosco	NYANDWI		Executive Secretary Nyabimata Sector	-
Emanuel	KURAMBA		Person in Charge of Civil Affairs Nyabimata S.	2007-06-15
Celestin	NSANZINTWARI		Executive Secretary Nyabimata Cell	2007-06-11
Martin	UWINEZA		Contact AMECOBI Carpenter Association	2007-06-14

Vincent	SEBANANI	SO	Executive Secretary Muganza Sector	2007-06-14
Etienne	NIBABARIRA	SO	Person in Charge of Social Affairs Muganza S.	2007-06-13
Théofile	NGENDABANGA	SO	Executive Secretary Ruheru Sector	2007-06-15
Narcisse	TWAHIRWA	SO	Veterinary Ruheru Sector	2007-06-15
Adelinde	MUKAZANA	HC	Head Nurse Muganza Health Center	2007-06-13
Marie-Claire	NYIRAKANYANA	HC	Head Nurse Nyabimata Health Center	2007-06-14
Emmanuel	NSENGIYUNMWA	HC	Head Nurse Ruheru Health Center	-
Catherine	MUKAGASHAGAZA	HC	Nurse Ruheru Health Center	2007-06-15
Elisabeth	NREKANABO	PS	Headmistress Bigugu Primary School	2007-06-12
Jean de Dieu	IYAMULEMYE	PS	Headmaster Muganza Primary School	2007-06-13
Immacule	NYRAMINANI	PS	Headmistress Nyabimata Primary School	2007-06-14
François	MUKINISHA	PS	Headmaster Ruhero Primary School	2007-06-15
Vincent	HABIMANA	PS	Headmaster Rwishywa Primary School	2007-06-14
Isabelle	MUSABIMANA	PS	Headmaster Sekera Primary School	2007-06-13
JMV	MUHIGANA	SS	Headmaster Bigugu Secondary School	2007-06-12
Jean de Dieu	INGABIRE	SS	Headmaster Mutovu Secondary School	2007-06-13
Augustin		CH	Parish Priest of Muganza Catholic Church	2007-06-14

MURUNDA [MD]

Olivier			Project Developer, REPRO	
Félix			President of Electricity Consumer Association	2008-11-27
Emmanuel			Vice-President of El. Consumer Association	2008-11-28
Jean-Marie Muzei	SEKABARA		Priest at Murunda Parish	2008-11-27
Innocent			Manager of Banque Populaire	2008-12-02
Jean-Baptiste		SO	Executive Secretary Murunda Sector	2008-11-27

KIBANGU [KI$_C$]

Jean Damascène	NDAHIMANA		Coordinator COFORWA	
Francois-Xavier	NSEKERABANZI	SS	Headmaster Ndeza Secondary School	2007-06-26

GASARENDA [GA$_C$]

Desiré	KABERUKA		Executive Staff Électrogaz	
Concorde	MUNYANKINDI		Miller	2007-06-27
Jean	BAYICINGIRE	SO	Executive Secretary Tare Sector	2007-06-27
Sra. M. Catherine	TURAKWIZEYE	HC	Head Nurse Mbuga Health Center	2007-06-29
M.-Louise	MUKESHIMANA	PS	Headmistress Mbuga Primary School	2007-06-29
Albert	NDAYIZIGIYE	SS	Administrative Official of Sec. School TTC Mbuga	2007-06-28
Thomas	MULINDA	SS	Headmaster Sec. School Collège Mudasomwa	2007-06-28
Védaste	NSABIMANA	CH	Priest Mbuga Catholic Church	2007-06-29

NYAMYOTSI [NI$_C$]

Ladéslos	BARAJIGINWA		Consumer association Chairman	2007-07-02
John-Clauder	HABUMUGISHA		Technician at MHP Powerhouse	2007-07-02
Louis	NIYIBIZI	SO	Executive Secretary Rusera Sector	2007-07-02
Gérard	GAHIMA	SO	Person in Charge of Social Affairs Rusera Sector	2007-07-02
Gaston	HAKIZIMANA	HC	Head Nurse Nyakigezi Health Center	2007-07-05
Antoinette	MUKANDAYISENGA	PS	Headmistress Gakoro Primary School	2007-07-05
Eliezar	HAKIZUWITEKA	CH	Reverend EER Nyamutera	2007-07-05

NYANGA, CYANIKA [CY_C]

			Executive Secretary Kagogo Sector	2006-07-05
Fréderic	M.		Accounting Secretary Kagogo Sector	2006-07-03
Adrin	BIZUNUREMYI		Executive Secretary Gafuka Cell	2007-06-04
Isaie		SO	Executive Secretary Kinoni Sector	2006-07-03
Félicité	MUKARENI	HC	Nurse Gitare Health Center	2007-07-06
Anthère	MANIRAGUHA	PS	Teacher Kinoni Primary School	2007-06-04
Astérie	MUKADEREVA	PS	Headmistress Primary School Gitare II	2007-07-06
Zéphanie	RWAMAKUBA	SS	Admin. Official of Secondary School Gitare II	2007-07-06
Bonaventure	BWANAKWELI	SS	Priest/ Headmaster Nkumba Seminary	2007-07-06
Heriman	URAZIRIKANJE	SS	Admin. Official of Karuganda Technical School	2007-07-06

RUTSIRO [RU_C]

Stanislas	RUZINDANA	SO	Executive Secretary Mushubati Sector	2008-12-08
		SO	Accounting Secretary of Mushubati Sector	2008-12-08

BASE [BA_C]

Louis	BUTOYI	SO	Executive Secretary of Nemba Sector	2008-12-10
Antoine	MUHIGIRA	SO	Executive Secretary of Base	2008-12-11
Zazou		SO	Executive Secretary of Cyungo Sector	2008-12-12
Omar	BAJYIMBERE	CH	President of Mosquee of Nyamugali	2008-12-11

SO	= Sector Office
HC	= Health Center
PS	= Primary School
SS	= Secondary School
CH	= Church

A2 Wealth Indicator

Subindicators	Variable Names		Subindicator Values	
ASSETS				**19**
Dwelling Conditions				6
Construction Material of Outside Walls	hind_walls[1]	h6	0 1	
Flooring Material	hind_floor	h7	0 1 2	
Roofing Material	hind_roof	h8	0 1	
Windows Fitted with Glass	hind_wind	h9	0 2	
Cattle				4
Quantity of Cows Owned	hind_cow	h82_1	0 2 3 4	
Savings				2
Savings	hind_sav	h94	*too many missing variables*	
Ownership of a Bank Account	hind_bankacc	h92	0 2	
Means of Transportation				3
Means of Transportation	hind_mot	h110_x	0 1 3	
Education				4
Education Level of Head of Household	hind_hohedu	h20 / h13_1x	0 2 3 4	
EXPENDITURE				**15**
Nutrition				
Food Expenditure per AEQ[1]	hind_foodpe	h87 / h22t	0 1 2 3	5
Existence of Food Shortages	hind_foodsh	h89	0 1 2	
Telecommunication				4
Telecommunication Expenditure	hind_tel	h134	0 2 3 4	
Energy				3
Expenditure on Energy Sources per AEQ[1]	hind_enpe	[2]	0 1 2 3	
Electricity Source	hind_els	hdum_grid	*shall function as dependent variable*	
Education				0
Schooling Expenditure	hind_school	h40	*too many families could not estimate their schooling expenditures*	
Ability to Send Children to 2ndary School	hind_sec	h12_x / h13_1x	*too many families for whom this indicator would not apply*	
Health				3
Health Expenditure	hind_health	h118	0 1 2 3	
INCOME				**6**
Household (HH) Income				6
HH Income excl. Consumption of Home Production	hind_inc	[3]	*hind_incpw is considered a better indicator*	
HH Income per HH Member Able to Work[4] excl. Consumption of Home Production	hind_incpw	[5]	1 2 4 6	
			11 [6] 24 [7]	**40**

Annotations

1 abbreviations: hind = Household Indicator; AEQ = Adult EQuivalent

2 h164b_7/ h164c_7/ h173_x / h174_x for x=1-9

3 hind_inc is composed of a variety of variables to calculate wage and farm income (minus farm expenditures) and income from remittances

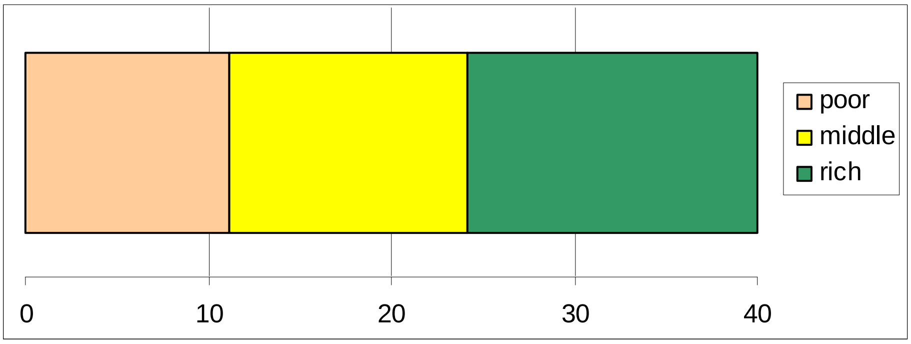
4 "Able to Work" is defined as being older than 14 and not older than 65, neither studying, working in the household or being retired. For those being older than 65, the same classification applies with an inclusion factor of 0.5.

5 like hind_inc (see 3.), but adapted to HH Member Able to Work (see 4.)

6 The values highlighted in orange represent (one possible) upper boundary of the categorization as "poor" - they sum up to 11, the maximum value for being classified as poor. They have been chosen among the different parameter value of each subindicator such that at least 75 % of the households classified as poor do not exceed this value.

7 Similar to the values highlighted in orange, the values highlighted in yellow represent (one possible) upper boundary of the categorization as "middle" - they sum up to 24, the maximum value for being classified as middle. They have been chosen among the different parameter value of each subindicator such that at least 70 % of the households classified as middle do not exceed this value.

The resulting Wealth Indicator looks as follows:



Variable Name	Unit	Codes for Subindicator Values						
		0	1	2	3	4	5	6
hind_walls	-	soil	stone or brick					
hind_floor	-	soil	stone or brick	cement				
hind_roof	-	tiles	corrugated iron					
hind_wind	-	no	---	yes				
hind_cow	cows	none	---	1	2	> 2		
hind_bankacc	-	no	---	yes				
hind_mot	-	none	bicycle	---	vehicle			
hind_hohedu	-	none	---	1^{ary} School	2^{ary} School/ Vocational Training	University		
hind_foodpe	EUR/ month	< 0.5	< 1	< 2.5	>= 2.5			
hind_foodsh	months/ year	> 2	1 or 2	no				
hind_tel	EUR/ month	none	---	< 2	< 4	>= 4		
hind_enpe	EUR/ month	< 0.5	< 1	< 2.5	>= 2.5			
hind_health		none	< 1	< 7.5	>= 7.5			
hind_incpw	EUR/ month	< 2.5	---	< 20	---	< 50	---	>= 50

A3 Adult Equivalent Scale

When comparing consumption levels between households, and using them to assess poverty and inequality, investigators face the situation that households differ in the number of members they have and in the age of these members. Larger households or those with a higher proportion of prime age adults are likely to have higher consumption needs. This is taken into account for by means of an adult equivalent scale, which allows household size to be measured in terms of "adult equivalents", recognising that the consumption needs of younger children for instance will be less than those of prime age adults. The scale used in this survey is the same that is traditionally used in Rwanda, e.g. for the EICV1 Poverty Profile Study and EICV2. The scale is reproduced in the table below.

Table A1: Rwandan Adult Equivalent Scale

Age range	Sex	
	Male	Female
Less than 1 year	0.41	
1 to 3 years	0.56	
4 to 6 years	0.76	
7 to 9 years	0.91	
10 to 12 years	0.97	1.08
13 to 15 years	0.97	1.13
16 to 19 years	1.02	1.05
20 to 39 years	1.00	
40 to 49 years	0.95	
50 to 59 years	0.90	
60 to 69 years	0.90	
More than 70 years	0.70	

Source: A. McKay & Greenwell, G. 2007. *Methods Used for Poverty Analysis in Rwanda Poverty Update Note.*

A4 Maps of Project Sites

A4.1 RES - Kavumu [KA]

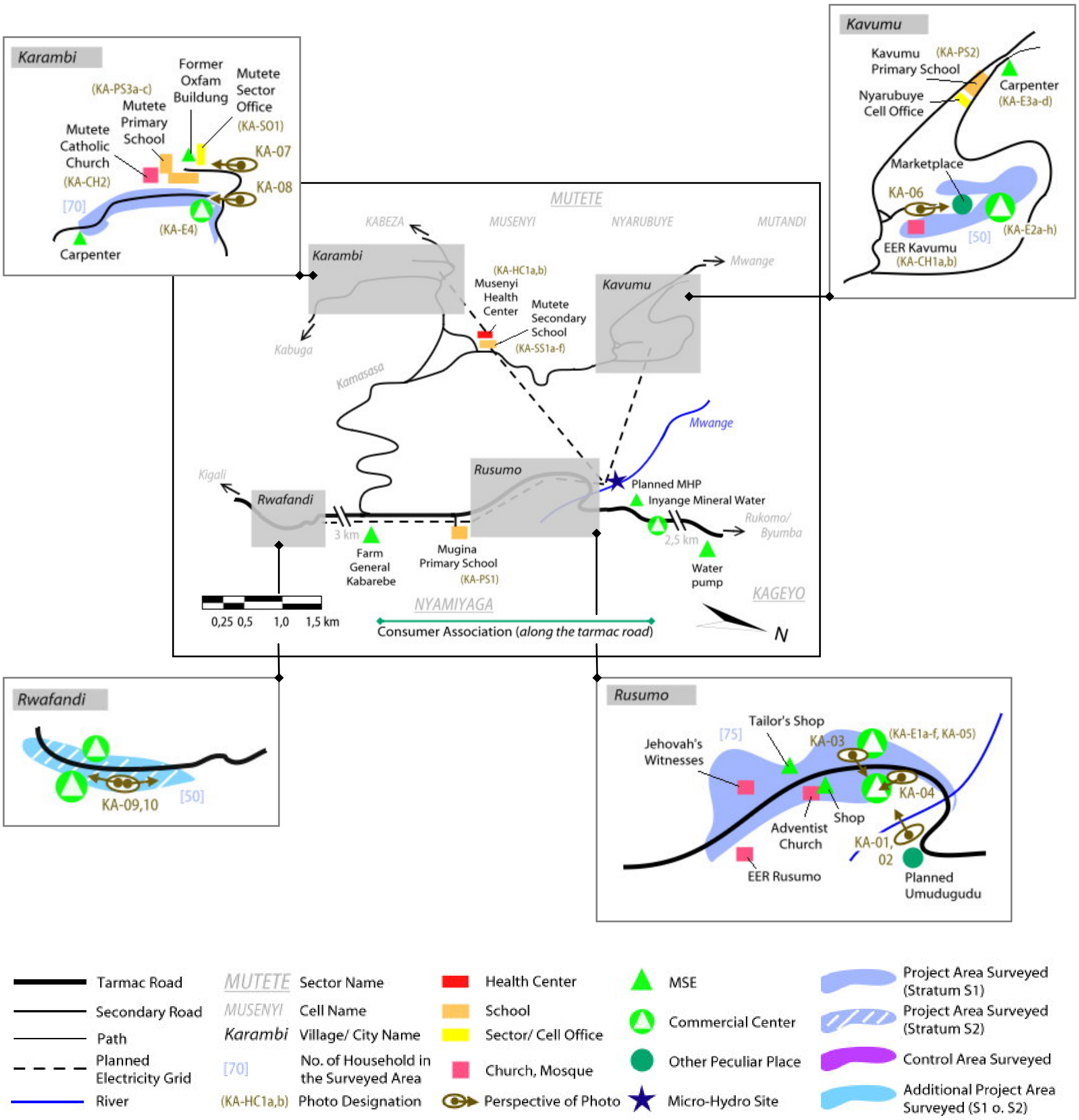


Figure A1: Maps of Kavumu Site

Photo A1: Rusumo Village Center (KA-02)

A4.2 GTR - Mpenge [MP]

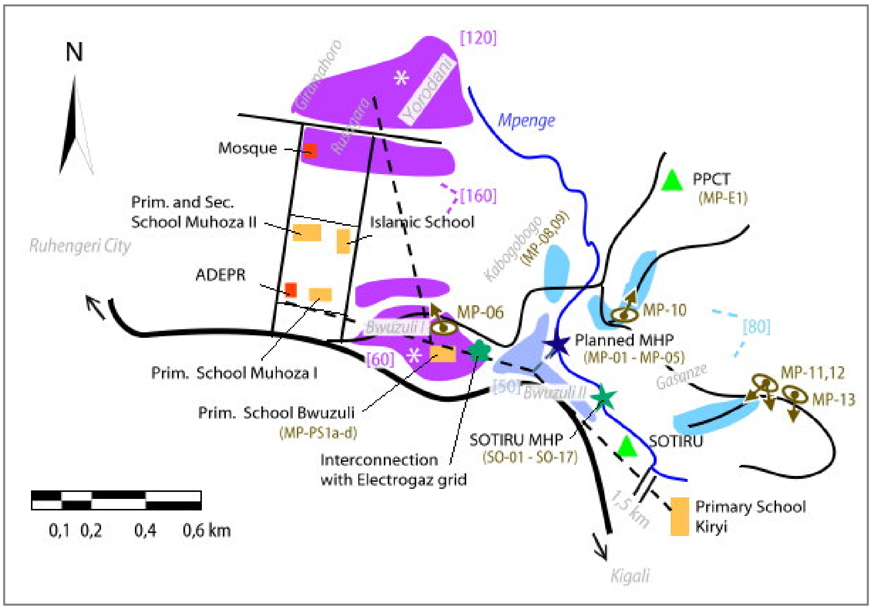


Figure A2: Map of Mpenge Site

* = These regions were formerly planned to become project regions. It was, though, found during the survey that these areas were already sufficiently electrified. Therefore, they were added to the control village region.

Photo A2: Gasanze Agglomeration (MP-12)

A4.3 SOGEMR - Musarara [MU]

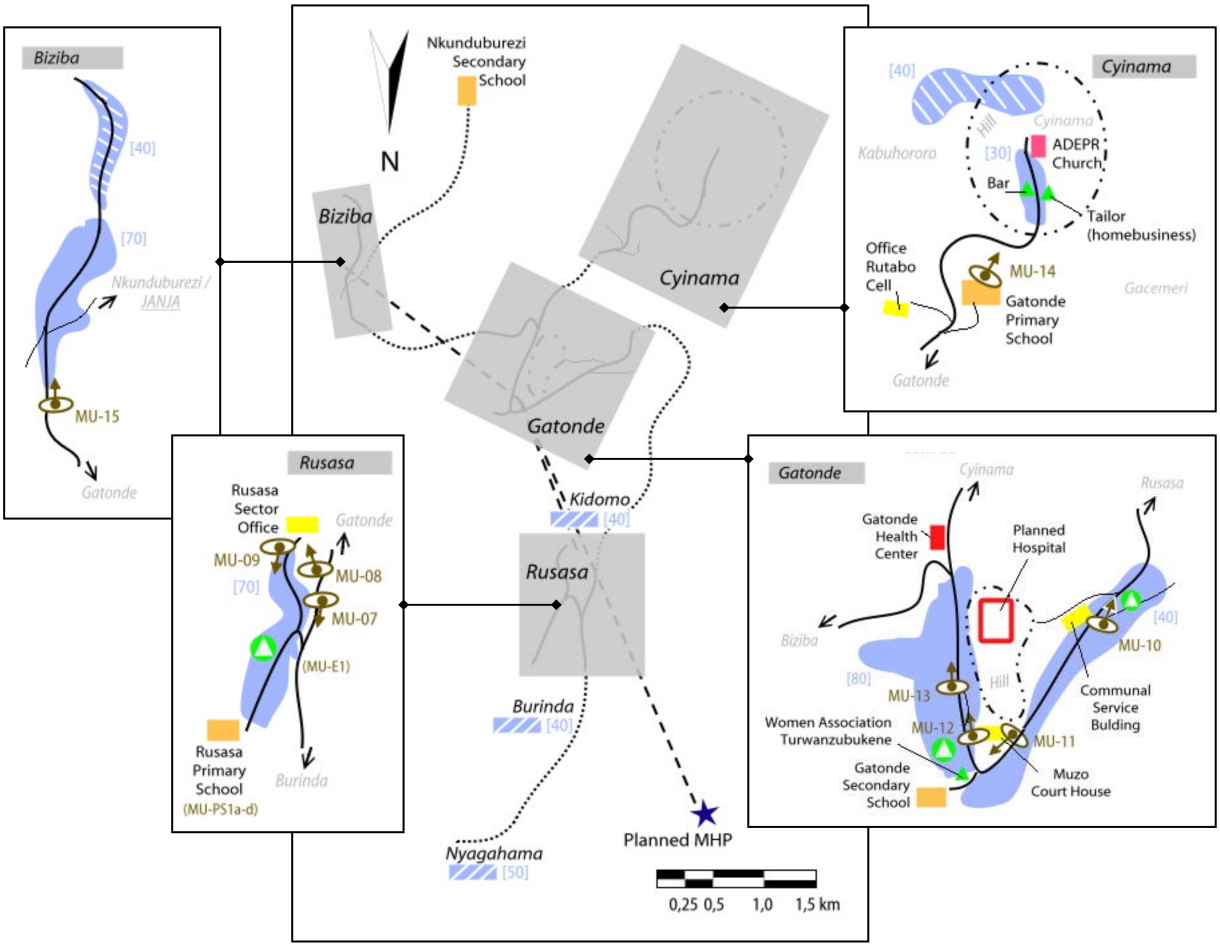


Figure A3: Maps of Musarara Site

Photo A3: Gatonde Village Center (MU-11)

Photo A4: Cyezi Village Center (NY-07)

A4.4 ENNy - Mazimeru/ Nyaruguru [NY]

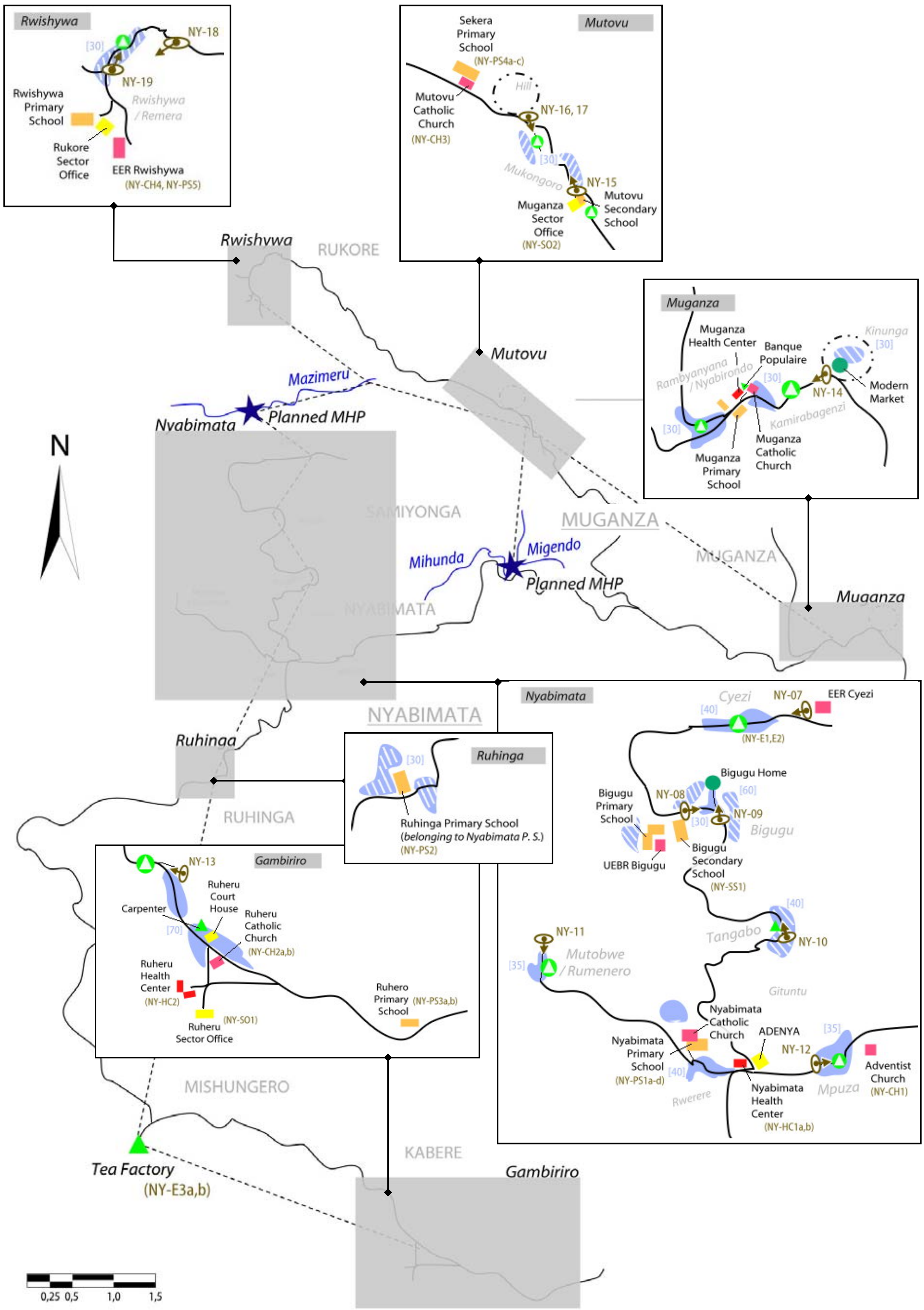


Figure A4: Maps of Nyaruguru Site

A4.5 REPRO - Murunda [MD]

Photo A5: Road at Gashaki (MD-12_gas)
Photo A6: Murunda Parish Church (MD-CH1_mda)
Photo A7: Mburamazi Village Center (MD-06_mbu)
Photo A8: Center of Shyembe (MD-15_shy)
Photo A9: Intake Weir of Micro Hydro Plant in Murunda (MD-mhp01)
Photo A10: Power House of Micro Hydro Plant in Murunda (MD-mhp03)
Photo A11: Village Center of Gisiza (MD-02_gsz)

A5 Gasarenda [GA_C]

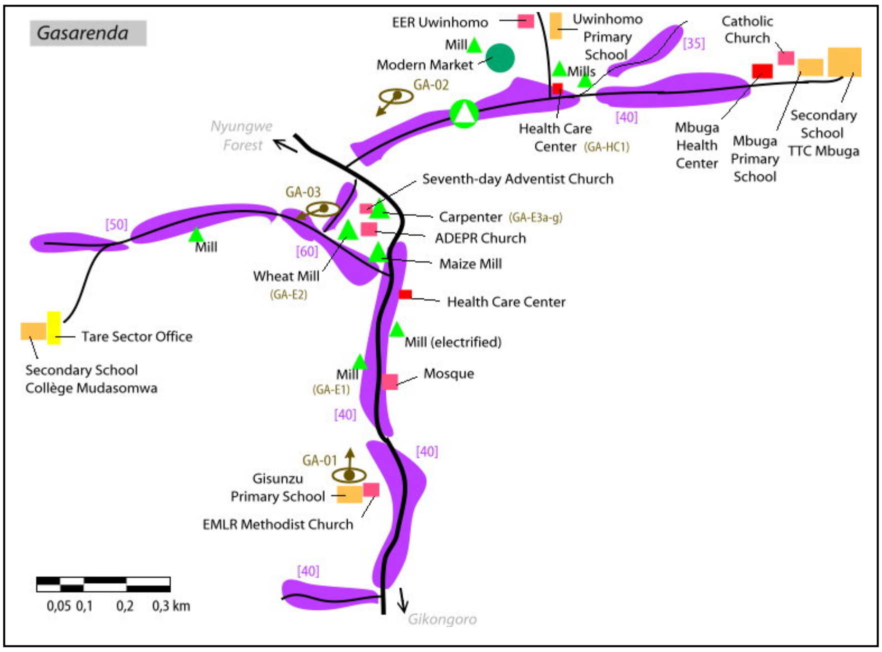


Figure A5: Map of Gasarenda

Photo A12: Gasarenda Village Center (GA-01)

The following short report on some of the main electricity clients in the control village Gasarenda shall give an impression of how electricity is used in a small Rwandan town.

CHURCHES - EER Uwinhomo is supported by the evangelical Christian child sponsorship organisation Compassion and has lighting and music instruments at its disposal. 1200 chruch-goers visit the messes of the **catholic parish church** every Sunday. The church is installed with seven tubes and four loudspeakers while it possesses a megaphone, a microphone, an amplifier and a synthesizer. Apart from Sundays only at church festivals the appliances are used, then up to 12 hours. On average once a month, external lighting is switched on, for example if pilgrims visit the parish. The electricity consumption of around 100kwh per month probably rather arises from the priest's domicile which is equipped with a refrigerator, internal and external lighting, a TV plus video, one laptop, a photocopier, an iron and a radio. The **Seventh-day Adventist Church** with 50 members pays 1,000 FRw (1.35 EUR) per month to the neighbouring carpenter for one tube that lights the room used for messes. The carpenter also provides the **ADEPR Church** with electricity. For 3,000 FRw (4 EUR) the church is enabled to use electric music instruments. Moreover, the church is already installed with tubes and one socket since five years, but not yet connected to the Électrogaz grid. The informants claimed that connection from Électrogaz was applied for two months ago. Neighbouring houses are already connected. The **Mosque** is equipped with only one bulb in the prayer room. It shares the Cash Power meter with its neighbour. The **EMLR Methodist Church** belongs to the Gisunzu PS, is therefore still quite new and also a bit far from the grid on a hill.

HEALTH CARE - The **Mbuga Health Center** has the biggest catchment area among the visited health center with 40599 people. 12 Nurses work at the center that is supported by FHI. Since electricity is quite reliable this year, the institution uses only one electric refrigerator/ freezer combination given by FHI. It would not have the money for kerosene for the non-electric electric refrigerator/ freezer combination either since it is not included in the budget. The electric equipment of the center furthermore comprises a laptop and TV plus video, two microscopes and a haemoglobinometer. Water is heated by means of a kerosene stove. The Health Care Centers, called ***Dispensaires privées,*** are both very small and suffered lately from a drop in patient numbers due to the governmental sponsored health insurance scheme "mutuelle de santé". One possesses a small cooker for sterilisation, one lamp and a tube and a microscope. The other one (cf. GA-HC01) has no appliances but four lamps and therefore a minimal monthly bill of 9 kwh 1,400 FRw (2 EUR).

MILLS - Five of the six millers in Gasarenda operate their **mills** with a diesel-run generator. Concorde Munyankindi is one of them. Beforehand, he had a dynamo and used electricity to run the mill. After experiencing frequent power outages last year, he bought the generator. He charges 40 FRw for one kilogram of Maize, 15 or 20 FRw for Sorghum, depending on the type and 15 FRw for Manioc. Per week he earns 14.000 FRw (19 EUR). Though in his opinion diesel as the predominant variable input is more expensive than electricity, he charges the same price as the miller down the street, the only in Gasarenda who uses electricity. He explains this by stating that people in the region are poor. Another disadvantage of the generator is that it provides less power. While he was able to produce 4 kg of flour in one minute with electricity, the generator only allows for milling 2 kg in one minute. The **wheat mill** "Minauterie de Nyungwe" which belongs to the same owner as SOTIRU in Ruhengeri, operates since 2004. It is in working five days a week, eight hours each day at which 4 to 5 tons of flour are produced. Decisive for constructing the factory were, in general, the growing in-country production of wheat while processing facilities were not at disposal in the whole region. Wheat is a priority crop like rice for the Rwandan import substitution policy. Between 1990 and 2005-2006 there was a remarkable increase in production of 100 percent. Moreover, especially the access to sufficiently reliable electricity and the tarred road from Butare to Cyangugu made the place an attractive location. In a small old warehouse, a **maize flour mill** operates with a 22 kw generator. Maize input costs 140 FRw/ kg and has to be bought in Kigali where it is imported mainly from Uganda, the flour is sold for 135 FRw/kg. Around 10t are produced per week, electricity costs arrive at 150.000 to 200.000 FRw per month. Electricity costs per kg can therefore be estimated at 4 to 5 FRw per kg. Four people are employed at the mill. They stated that electricity is not used due to financial reasons but because both the dynamo and the connection existed before starting the business.

Modern Market - Gasarenda has a relatively long history as a commercial hub in the region and Rwanda. The commercial center around the modern market hosts branches of World Vision, Banque Populaire and Coopec. Since June it exists the first small shop to have electronic devices repaired. The owner completed vocational training of electronics and communication.

PRIMARY SCHOOLS (PS) - None of the three Primary schools in Gasarenda currently uses electricity. While **Gisunzu PS** is still quite new and being extended, **Uwinhomo PS** with 1000 pupils is not connected though the grid passes directly by the school and feeds the church opposite the street. The **Mbuga PS** with 1400 pupils is even connected but there have been just the former storeroom (which is now used as a classroom) and the director's office installed. Lighting and two computers sponsored by World Link in 2004 were used, but the computers broke down in the beginning of 2006. After the school did not use any electricity anymore and did not pay for the monthly meter rent of 236 FRw (0.30 EUR), electricity was cut.

Secondary School TTC Mbuga - The upper secondary Teachers Training Center educates 574 students to become primary school teachers. Because the school is one of the bigger consumers in The school possesses an overhead projector, a photocopier that is broken, two television sets, four radios that all run with electricity and 25 PCs. 15 of them are sponsored by the initiative World Link and 10 have been distributed by a MINEDUC programme. Nine of them are currently broken. Since the school lacks teachers, the only teacher able to give computer classes also has to teach half his time chemistry. That's why fourth year students do not have any classes at all, fifth year student have one and sixth year students two hours per week.

Sector Office Tare - The seven offices and the corridor of the sector office are equipped with lighting. One computer and a photocopier represent the appliance equipment.

Carpenter - The carpenter is equipped with combined machines (GA-E3a-c) uses wood from Kongo to produce wooden products from simple chairs (GA-E3g) for 10,000 FRw (13.30 EUR) to luxury beds (GA-E3d-e) for 250.000 FRw (330 EUR). He employs 10 to 20 workers depending on the situation concerning orders. The monthly electricity consumption amounts to 230 kwh.

A6 Cost Calculation for Different Lighting Devices

	Lamp						fuel			indicators	
	A	B	C	D	E	F	G	H	I	J	K
	luminous flux	life	annual utilisation[4]	unit price[2]	annual unit costs	annual mainte-nance costs[3]	consum-ption	unit price	annual fuel costs	annual operating costs	unit price per kilo-lumenhour
	Lm	h	h	€	€	€	ltr/ h *or* kwh	€/ ltr *or* €/kwh	€	€	€
					C/B * D				C * G * H	E + F + I	(1000/A) * G * H
1	32[1]	5500[3]	1500	3	0,82	3,2	0,020	0,79	23,03	27,05	0,48
2	730[1]	1000[2]	1500	0,7	1,05	0	0,06	0,18	15,84	16,89	0,0145
3	600[2]	7000[2]	1500	2,2	0,47	0	0,011	0,18	2,90	3,38	0,0032

1	=	Kerosene Hurricane Lantern
2	=	Incandescent Light Bulb (60W)
3	=	Compact Florescent Bulb(11W)

Annotations

1 = Source: Nieuwenhout, F., P. Van de Rijt, and E. Wiggelinkhuizen. 1998. *Rural Lighting Services.* Paper prepared for the World Bank, Netherlands Energy Research Foundation, Petten.

2 = own research.

3 = Source: Schwarz, Dishna et al. 2005. *Lighting Technologies.* Paper prepared for gate Information Service / gtz, Eschborn.

4 = The actual values for the different lighting devices range between 1250 and 1750 hours.

A7 EnDev Beneficiary Projection

The projections of beneficiaries in 2010, for which EnDev can be held accountable, are listed on the next pages. An electronic version in MS Excel format is available in the electronic annex E6. The projections are based on the following **Assumptions**:

(i) Population Growth:

- A projection by the Ministry of Education (MINEDUC 2006) expects a population growth of 2.8 percent for the years till 2010. The resulting population growth factor 2007-2010 of 8.6 percent has been applied to the target population of health centers and the sector population.
- The proportion of primary and secondary school pupils to the total population is assumed (for simplicity) to be constant till 2010.

(ii) Development of school pupil figures:

- The Ministry of Education expects that total enrolment in primary schools in 2010 will be 3.9 percent higher than in 2007 (MINEDUC 2006). It is assumed that figures for primary school pupils will rise at the same rate.
- Secondary school student figures will probably be subject to bigger changes. Therefore, the development plans of each school individually have been taken into account. If no specific plans could be determined, a growth factor of one-third is assumed.

(iii) Probability of Grid Coverage:

- Six institutions, some households and MSEs included to the beneficiaries in the PD’s business plans are located far from the planned grid (they mostly depend to Stratum 2, cf. chapter 2.5). A probability factor of 0.25 has been applied to the headcount of these institutions.

(iv) Connection Probability:

- The overall expected connection rate among households is 0.33, i.e. every third household in the surrounding of the grid is assumed to connect to the grid. This projection is based on an extensive enquiry among 150 households along the electricity grid in Nyanga/ Cyanika. This control village is considered by the evaluation team to be most comparable in terms of connection propensity.
- Primary schools are less prone to connect to electricity. It is assumed that the probability of these schools to connect depends on the indices developed in 0. If both the “State of Repair Index” and the “Studies at School Index” are at least 1, a probability factor of 0.10 has been applied. If the sum of the two indices exceeds three, a probability factor of 0.30 is used. The other schools at included only with a probability of 5 percent. These estimated probabilities are based on the information gathered and impressions gleaned from the visits of 25 primary schools in the project and electrified control villages, complemented by information provided by the Ministry of Education.
- The calculations for MSEs are founded on the respective figures for each village given in chapter 3. The connection probabilities given in the following table are estimates based on the information gathered and impressions gleaned from the visits of the four project villages and four electrified control villages.

1.	Shops	0.2
2.	Bars/ Restaurants	0.2
3.	Barber Shops	0.5
4.	Mills	0.5
5.	Tailor Shops	0.1
6.	Carpenter Workshops	0.1

(v) Existent Electricity Source

- Some Institutions already own a modern electricity source: (old and outdated) solar panels or a generator. The change to grid electricity can be considered a significant improvement of electricity supply due to its advantages in terms versatility, power and rather lower prices. The concrete drawbacks of the present electricity sources are described in the chapters 4.6 and 4.7. The EnDev head count of institutions already owning an old and weak solar panel is reduced by multiplying it with 0.5. The head count of those beneficiaries owning a generator is multiplied with a factor of 0.25, since generators already allow for using more appliances.
- Some Households and MSEs as well already own a modern electricity source. This holds for five percent of the surveyed households and a fourth of the surveyed MSEs. Though these households will be probably more inclined to connect due to their higher purchasing power and their already revealed electricity demand, the percentage of these "pre-electrified" households will probably not add up to more than 5 percent of total customers. Among MSEs, the predominant alternative electricity sources found are generators at mills and barbers. Since the establishment of new service suppliers is likely for these businesses, too, and these will be counted like formerly non-connected enterprises, new electricity accesses will also be observed here. Taking all considerations into account, the percentage of pre-electrified MSEs among the customers of the project grids is expected to be 75 among mills and barbers and 10 percent among the others. Consequently, the percentage of newly provided electricity accesses is 95 among households, 25 among mills and barbers and 90 percent among other MSEs. For consistency reasons, the "pre-electrified" customers have to be included in the beneficiary counting as described in the previous assumption. Since the large majority possesses generators, the factors are the following:
  - Households: 95 % * 1 (newly provided) + 5 % * 0.25 ("pre-electrified" – generator) = 0.9625
  - Mills/ Barbers: 25 % * 1 (newly provided) + 75 % * 0.25 ("pre-electrified" – generator) = 0.4375
  - Other MSEs: 90 % * 1 (newly provided) + 10 % * 0.25 ("pre-electrified" – generator) = 0.925

A further relevant **Annotation** is that churches are not specifically accounted for. Since they would make up on average only 25 beneficiary head counts, a separate itemization does not seem necessary. They can be better considered as households.

The table of the projections of beneficiaries in 2010, which is listed below has the following **Legend**:

S1&2 = Stratum 1 or 2 (cf. chapter 2.6)

= Current amount of the respective beneficiary group living/ working near the prospective grid (cf. chapter 3.1 - 3.5)

GC = Probability of Grid Coverage (cf. Assumption (iii))

CO = Overall expected COnnection rate among the respective beneficiary group (cf. Assumption (iv))

ES = Existent Electricity Source (cf. Assumption (v))

CAG = Expected catchment area growth rate (cf. Assumptions (i) and (ii))

CA = Catchment Area, also implying the number of pupils of a school

CAF = Factor, by which the catchment area is being weighted according to the EnDev calculation formula developed in chapter 2.2.

AS = Accounting Shares of Institution Type (cf. chapter 2.2.2)

EEB = Expected Endev Beneficiaries in 2010, calculated by multiplying all columns

EB = EnDev Beneficiaries, if the respective institution is connected and if the EnDev criteria of a newly provided and additional access, for which EnDev can be held accountable, are fulfilled. Any of the assumptions made above (identified in the table by means of the light gray shading) are excluded from this calculation; hence, also (expected) population growth is not being considered

A7.1 Kavumu [KA]

Beneficiary	#	GC	CO	ES	CAG	CA	CAF	AS	EEB	EB
HOUSEHOLDS									**366**	
Kavumu [S1]	195		0.33	0.96		1	5.55		344	
Kavumu [S2]	50	0.25	“	“		“	“		22	
MSEs									**2543**	
Shops	20		0.2	0.93		5000	0.016		308	
Bars/ Restaurants	65		“	“		“	“		1002	
Barber Shops	8		0.5	0.44		“	0.083		729	
Mills	3		“	“		“	“		273	
Tailor Shops	1		0.1	0.93		“	0.16		77	
Carpenter Workshops	2		“	“		“	“		154	
SOCIAL INFRASTRUCTURE									**12259**	
Health Center									**7219**	
Musenyi					1.086	18992		0.35	7219	6647
Primary Schools									**278**	
Kavumu			0.05		1.039	811	3.43	0.175	25	487
Mugina			0.3		“	1165	“	“	218	699
Mutete			0.05		“	1131	“	“	35	679
Secondary Schools									**211**	
Mutete				0.25	2.33	300	16.06	0.175	211	843
Sector Offices									**4551**	
Mutete					1.086	19954		0.21	4551	4190
Churches									*irrelevant*	

A7.2 Musarara [MU]

Beneficiary	#	GC	CO	ES	CAG	CA	CAF	AS	EEB	EB
HOUSEHOLDS									**604**	
Musarara [S1]	290		0.33	0.96		1	5.55		511	
Musarara [S2]	210	0.25	“	“		“	“		93	
MSEs									**5684**	
Shops	44		0.2	0.93		5000	0.016		678	
Bars/ Restaurants	136		“	“		“	“		2097	
Barber Shops	18		0.5	0.44		“	0.083		1641	
Mills	8		“	“		“	“		729	
Tailor Shops	2		0.1	0.93		“	0.16		154	
Carpenter Workshops	5		“	“		“	“		385	
SOCIAL INFRASTRUCTURE									**10865**	
Health Center									**8629**	
Gatonde					1.086	22702		0.35	8629	7946
Primary Schools									**130**	
Gatonde			0.1		1.039	1126	3.43	0.175	70	676
Rusasa			0.1		“	958	“	“	60	575
Secondary Schools									**966**	
Gatonde				0.5	1.33	590	16.06	0.175	829	1658
Nkunduburezi		0.25		0.25	“	780	“	“	137	2192
Sector Offices									**1140**	
Rusasa				0.25	1.086	~ 20000		0.21	1140	4200
Churches									*irrelevant*	

A7.3 Nyaruguru [NY]

Beneficiary	#	GC	CO	ES	CAG	CA	CAF	AS	EEB	EB
HOUSEHOLDS									**546**	
Nyaruguru [S1]	310		0.33	0.96		1	5.55		546	
MSEs									**2781**	
Shops	46		0.2	0.93		5000	0.016		709	
Bars/ Restaurants	49		"	"		"	"		755	
Barber Shops	2		0.5	0.44		"	0.083		182	
Mills	4		"	"		"	"		365	
Tailor Shops	5		0.1	0.93		"	0.16		385	
Carpenter Workshops	5		"	"		"	"		385	
SOCIAL INFRASTRUCTURE									**5571**	
Health Center									**5057**	
Ruheru					1.086	20700		0.35	*	7245
Muganza				0.5	"	21934		"	*	7677
Nyabimata				0.5	"	26610		"	5057	9314
Primary Schools									**145**	
Bigugu			0.1		1.039	1208	3.43	0.175	75	725
Muganza			0.05		"	1164	"	"	*	699
Nyabimata			0.05		"	1836	"	"	57	1102
Ruheru			0.3		"	1693	"	"	*	1016
Ruhinga		0.25	0.05		"	411	"	"	3	247
Rwishywa		0.25	0.05		"	1100	"	"	*	660
Sekera		0.25	0.3		"	1824	"	"	*	1095
Secondary Schools									**379**	
Bigugu				0.25	1.33	540	16.06	0.175	379	1518
Mutovu		0.25			2	112	"	"	*	315
Sector Offices									**0**	
Muganza *(Mutovu)*		0.25			1.086	17515		0.21	*	3678
Ruheru *(Gambiriro)*				0.50	"	~ 21000		"	*	4410
Churches									*irrelevant*	

** = according to the latest grid planning from beginning 2009, these areas will not be served for the time being*

A8 Daily Load Curve

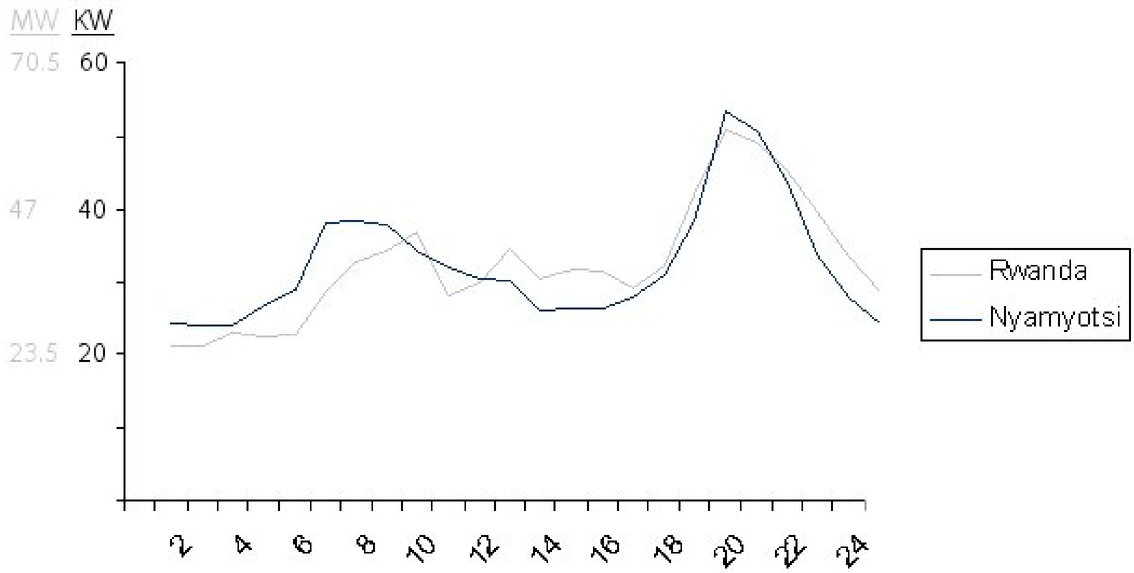


Chart A1: Daily Load Curve for Rwanda and Nyamyotsi MHP

The curve for Rwanda is taken from LAHMEYER 2004*, the one from Nyamyotsi [NY_c] depicts the average of two representative days in June/ July 2007.

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* Lahmeyer International. 2004. *Analysis and Projection of Rwanda's Electricity Demand.*

Electronic Annex

Soft copies of the following documents are available on request.

E1 Photographs

E2 Household Questionnaire (French)

Annotations on the Household Questionnaire of the PSP Hydro Baseline for future baseline surveys can be found in the electronic annex E5.

E3 STATA Codes

E4 Survey Contacts

E5 Annotations on the Household Questionnaire

E6 EnDev Beneficiary Projection (Excel Sheet)

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