CAN RURAL ELECTRIFICATION STIMULATE THE LOCAL ECONOMY?

Constraints and prospects in south-east Mali

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Batteries of the power plant in Koury
Source: GERES

Protecting the environment and limiting climate change and its consequences while also improving living conditions for the poorest: these are the challenges that GERES seeks to tackle through development engineering and specialist technical expertise. Energy efficiency, renewable energy and local economic development are at the heart of its activities.

Providing rural electrification with solar solution to small businesses requires a specific design adapted towards their equipment and the impact of the use of their equipment on an isolated mini-grid has to be diagnosed and assessed before providing a localized solution to meet their consumption needs. Therefore, the need for an Electrified Activities Zone (ZAE) that is complimentary to the existing solution for household electrification.

KEYWORDS

- RURAL ELECTRIFICATION
- BUSINESSES
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Victor Béguerie: GERES is actively involved with rural electrification projects in Mali. Can you start by describing the rural electrification situation there?

Benjamin Pallière: To improve access to electricity in rural areas, the Malian government has decided to turn to structures such as private businesses, economic interest groups and non-profit organizations that are independent from the incumbent electricity company that operates decentralized power plants used to supply mini-grids. These structures are almost exclusively businesses that are regulated by the Malian Agency for the Development of Household Energy and Rural Electrification (AMADER). They operate in areas not served by the national utility company, Electricité Du Mali (EDM). At present, these companies operate under renewable 15-year licenses, and the State generally co-funds a portion of the initial investment costs. They are free to define their own business models, although operators that receive State funding have their tariffs set by AMADER. This strategy was adopted around the turn of the millennium and has increased the rate of rural electrification from 1% in 2006 to 11.9% in 2012[1] and 18% in 2014[2]. During the first decade the focus was on diesel-fired solutions but the second phase, post-2010, saw these solutions hybridized with the arrival of photovoltaic panels (PV). GERES works with one of the private rural electrification operators, Yeelen Kura. This Malian decentralized services company was founded in 2001 and, by 2015, was operating decentralized power plants in 10 locations in south-east Mali, nine of them hybrid solar-fossil fuel.

V.B.: One of these 10 locations is the town of Koury, a place where GERES has been operating for almost a decade and where Yeelen Kura operates the local mini-grid and hybrid solar-fossil fuel power plant. What are the key features of Koury?

B.P.: Koury is the main town in the Sikasso region, with a population of 14,915 in 2009[3]. It is accessible via a paved road (1 hour 15 minutes, 110 km) from Koutiala, Mali's second largest manufacturing city and the capital of its cotton industry. Koury borders Burkina Faso and is the second most important crossing point between the two countries. Koury is the largest town in the Yorosso Cercle, which had a population of 211,000 in 2009. Its location in Mali's cotton-growing region makes it a particularly dynamic place.

V.B.: What's your assessment of the economic impact of AMADER's actions?

B.P.: Mali's rural electrification program aims at several targets: households, street lighting, businesses and community facilities. Productive use of electricity is supposed to generate revenues that will improve people's living conditions. Among other things, these revenues should enable people to afford electricity for home

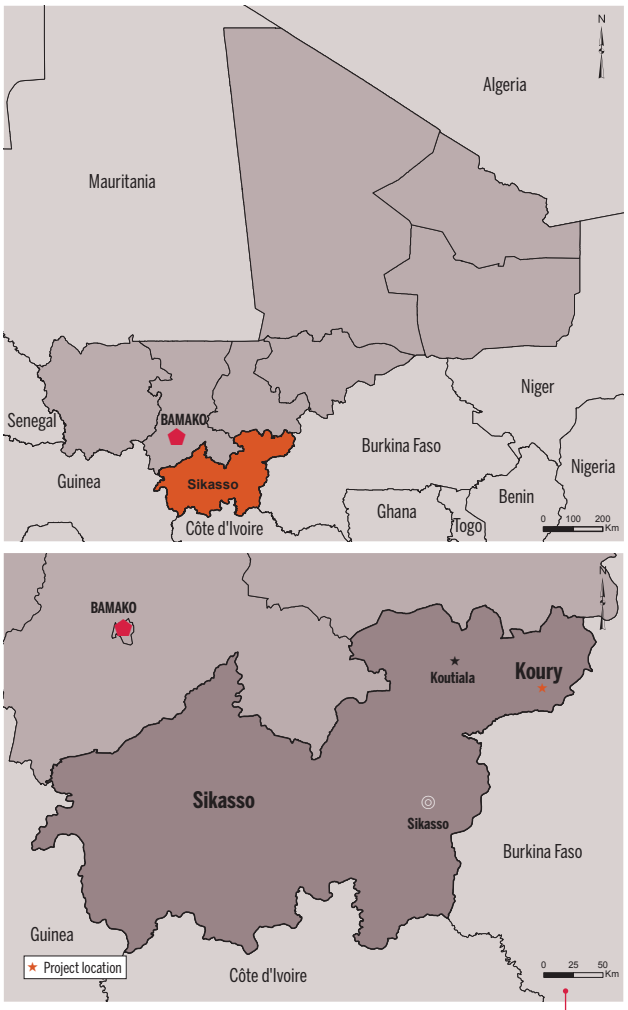

Figure 1. Project location - Source: FERDI

comforts. But feedback from the field shows that the reality fails to match these assumptions. Although encouraging progress has been made in terms of household use of electricity, street lighting and electrification of community facilities, electrification has not had much of an impact on the growth of micro-businesses[4,5]: households' electricity bills are not being financed by these new activities, and electricity suppliers are not finding a decisive income stream from producer customers. Productive uses of electricity appear limited, or even impossible for certain types of activity, since they lead to outages or deterioration in the quality of supply from the mini-grid. In 2014, in three of the areas where Yeelen Kura operates that have a sustained business environment (Bla, Koury and Yorosso), only 10% of electricity generated was used by producer customers.

1 World Bank (2015), Databank, http://data.worldbank.org/country/mali

2 Toure, H. (2014), Malian presentation at the Regional Discussion and Capacity-Building Workshop for the Program for Energy Access in Africa, AMADER

3 INSTAT (2013), 4th General Population and Housing Census

4 Mayer-Tasch, L., Mukherjee, M., Reiche K. (2013), *Measuring Impacts of Electrification on Small and Micro-Enterprises in sub-Saharan Africa, GIZ*

5 Shanker, A. (2012), *Accès à électricité en Afrique subsaharienne : retours d'expérience et approches innovantes [Access to electricity in sub-Saharan Africa: feedback and innovative approaches*], Agence Française de Développement working document.

V.B.: To help us better understand the divide that exists between the technical and economic solutions introduced and the actual needs of producer customers, can you talk us through the technical and economic solutions that Yeelen Kura runs in Koury, as an example.

B.P.: Koury has a hybrid solar-fossil fuel power plant (100 kWp of PV and a 275 kVA generator unit) and a decentralized mini-grid that is not connected to the sub-regional interconnection and operates daily from 4 pm to 1 am. The tariff per kWh is FCFA 250, equivalent to EUR 0.38/kWh, to which are added fixed charges for meter hire and a contribution to the cost of street lighting. Once these charges are factored in, the cost is FCFA 335/kWh (EUR 0.51/kWh). In 2013, the 20.5 km low voltage mini-grid covered 31% of the inhabited area of the town of Koury. Every customer has the choice between single- or three-phase supply, but high power (several kW) is not available.

To guarantee a good quality electricity supply you need a suitable power plant, but you also have to have a suitable distribution grid. In a newly electrified area experiencing strong demographic growth, grid maintenance demands that adjustments are made from time to time, both to limit distribution losses and to ensure a quality electricity supply. This was something that Yeelen Kura did in 2014.

However, because the power plant and mini-grid were designed with household customers in mind, the work done on the mini-grid was not necessarily enough for all its customers, particularly potential business customers.

V.B.: What are the main economic constraints facing a rural electrification operator running a hybrid solar-fossil fuel power plant?

B.P.: The constraints relate to each energy source: solar PV on the one hand, the fossil-fired generator on the other. The advantage of hybrid solutions generally relates to profiting from the strengths of each technology, but only if you also avoid their weaknesses.

Solar PV has become highly competitive for what's known as direct injection. This refers to electricity that is used directly rather than stored. Because although the price of PV panels has fallen enormously, batteries remain expensive. Allowing for the fall-off in battery performance once temperatures exceed 25 °C, storage costs in Mali are from FCFA 150 to 250/kWh. These costs have to be added to other production factors.

A fossil-fired generator unit works most efficiently at about 70% of its nominal operating load. Ignoring staff and equipment replacement costs, to produce 1 kWh in Mali under these conditions, with diesel or a substitute vegetable oil costing FCFA 660 per liter and remembering that generators require regular maintenance, costs a minimum of FCFA 246/kWh. This marginal cost represents the opportunity cost of using fossil to generate an additional 1 kWh.

These two factors lead or force operators to prefer operating during daylight hours and adapt use of their batteries to correspond to their generators. But this presupposes that customers want to consume during the day.

V.B.: What are the specific features of micro-businesses that lead to the mismatch between their needs and the technical and economic solutions implemented?

B.P.: There are two types of micro-businesses. There are those that provide services using equipment whose power or quality is no different to conventional household uses and that, apart possibly from their operating times, have no specific needs. These might be hairdressers, storekeepers or tailors. And then there are micro-businesses that produce goods, such as bakeries, carpentry workshops, engineering services and water supply, or services, like millers, computer centers and local radio stations. We're going to talk about this second category.

Micro-businesses need an electricity supply that provides them with enough power (from 1 to 5 kW) and that meets their quality requirements (no blackouts or brownouts or load-shedding) at the times they need: 24 hours a day for some of them, daytime only for others. The price of the electricity is not a major constraint. This is demonstrated by the fact that all businesses of this type equip themselves with alternative sources of energy to compensate for the weaknesses of the supply from Yeelen Kura.

It's very tough for a rural electrification operator to meet these needs, all the more so where its priority is to bring electricity to households (at least, that is what is expected of them). There are two problems that immediately arise: the operating times of the mini-grid and its sizing. Where power plants have only limited generating capacity, the situation will quickly arise that all electricity used comes from fossil-sourced electricity, which is more expensive. The second point is that the mini-grid has to be scaled to match demand. For large customers it is important to run cables with a greater section in order to reduce voltage drops and line losses, as well as on occasion fitting hardware to manage electrical disturbances. One issue here is reactive power caused by induction components in machinery that contributes to increasing the current transiting the grid. Reactive power can be reduced using a compensation capacitor bank. The second type of disturbance, rarer under normal circumstances, is the creation of harmonics, which are electrical signals with a frequency that is a multiple of 50 Hz. Harmonics disturb the sinusoidal shape of the electrical signal and can damage some types of equipment. They can be created by inverters and

converters, and amplified by certain types of grid equipment. This makes it necessary to fit harmonic filters. However, a rural electrification operator, faced with a challenging business model and limited investment capacity, will prefer to focus its mini-grid on household customers, particularly in places where micro-businesses were not originally established.

However, and I'll end my answer with this, rural businesses may be ready to pay the real costs for their electricity. A bakery must have electricity to operate the kneader. Instead of being restricted to a few dozen loaves a day, it can make one or two thousand with a reliable power supply. At an all-in cost of FCFA 300/kWh, the electricity used to knead dough will represent just 3% of the bakery's revenue.

"THE SOLUTION COMPRISES GROUPING TOGETHER MICROBUSINESSES AND ARTISANS IN A LOCATION THAT OFFERS ACCESS TO ELECTRICITY THAT MEETS THEIR NEEDS AT SPECIFIC TIMES OF THE DAY AND UNDER CONDITIONS THAT VARY ACCORDING TO THE TYPE OF ACTIVITY."

V.B.: What solutions have GERES and Yeelen Kura developed to improve the productive use of electricity for micro-businesses?

B.P.: Developments in the power supply industry, particularly the arrival of hybrid solar-fossil fuel power plants, represent a great opportunity to reach out to this very distinct group of customers as soon as the process of sizing the grid technically and economically begins.

In the past, Malian rural electrification companies would have built and operated their grid with household customers in mind first and foremost. On top of taking notice of the needs of rural businesses in terms of power supply and of the disruptions that can be generated by their machines, there are three further key points that arise: operating hours, location and pricing.

The question of operating hours needs to be looked at in conjunction with solar generation. It takes a smaller investment to supply daytime customers than nighttime ones. The difference is significant. Increasing the daytime customer base will be one of the key factors for the future viability of decentralized hybrid solar-fossil generating systems, for although household customers cannot easily switch their energy use to daytime, it is naturally much easier for business customers.

The second issue is location. Taking on board the fact that two different types of grid are needed, it becomes clear that having rural businesses widely dispersed across the area will greatly increase the additional expenditure requirements. And a good many of these producer customers could relocate, and could well benefit from being located close together. Economies of scale achieved by grouping these customers close to one another lower the overall cost of establishing the mini-grid. This holds good not just for the grid operator but also for the municipality and all other stakeholders involved in a program to support the development of entrepreneurship.

The final point is pricing. Rural businesses understand that their service needs are different from those of households and that differential pricing may apply, so long as this is justified. This is absolutely not about getting businesses to pay more while offering them nothing in return.

If we incorporate new town planning techniques and zoning practices into the points cited above, a solution worth developing emerges quite naturally: the provision of an electricity supply suitable for micro-businesses in appropriately located and serviced areas. This solution comprises grouping together micro-businesses and artisans in a location that offers access to electricity that meets their needs at specific times of the day and under conditions that vary according to the type of activity. This is the thought process behind the idea of the Electrified Activities Zone (ZAE).

V.B.: Can you tell us a bit more about GERES' work in and around Koury that led you to introduce the Electrified Activities Zone (ZAE)?

B.P.: Setting up the ZAE project took place in two distinct phases, designed to clearly identify the constraints and problems to address and to build local partnerships for the future project.

- The first phase, from 2007 to 2011, focused on observation. It led to an understanding of which rural businesses had the possibility of connecting to the local electricity mini-grid and which of them were interested in doing so. This phase also helped us to understand how Yeelen Kura worked.
- The second phase was an opportunity to combine targeted actions with accurate measurements to create a precise picture of the needs and economic interactions between this type of customer and the electricity operator. This involved in-depth studies of the project's impacts on electrified micro-businesses and the electricity grid respectively, and setting up a center to demonstrate and train people in the use of electrical equipment.

By 2014, GERES and its partners had drawn conclusions from this two-stage analysis and together they proposed a program to develop an Electrified Activities Zone, a process that only really took off in 2016.

V.B.: Can you talk us through the two initial phases of the project, which focused on observation and analysis?

B.P.: The team used an energy assessment tool that combines energy metering with interviewing actors on both sides, electricity suppliers and users[6] (see Figure 2). Energy assessment is designed to provide a comprehensive picture at the level of a rural municipality or district, aiming to highlight the position of all energy consumers, the value chain they belong to and the barriers they face in moving toward sustainable, clean solutions. This tool, and its use in other districts, will generate technical information and development ideas for newly electrified areas.

An energy assessment is based on the principle of combining comprehensive mapping with an understanding of the target stakeholders, using energy metering and qualitative interviews. The team has a toolbox that includes metering equipment and comparative benchmarks, as well as surveys with model questionnaires and interview frameworks. For each assessment, only the most appropriate tools are retained. Having access to benchmarks from other locations is a key prerequisite for a successful assessment.

V.B.: Which stakeholders were involved in setting up the ZAE?

B.P.: Three major stakeholders were involved:

• **The rural electrification operator**
The key stakeholder in all this is the rural electrification operator, because rolling out the solutions requires the operator's agreement and support. But this does not necessarily mean that the electrification operator has to be the project's driver or promoter. In the Malian example, Yeelen Kura's role is to support the process for this pilot project by being wholly transparent about its strategy (and how this will evolve), its objectives and constraints, and by welcoming and assisting any surveys or other operations that may be needed. There are two reasons for this: (i) Yeelen Kura views itself as a development actor, and (ii) solving the electrification problems of micro-businesses will make its work easier at the same time as meeting donors' expectations.

6 GERES (2014), Rural energy assessment, http://www.geres.eu/images/publications/rural-energy-assessment-2.pdf

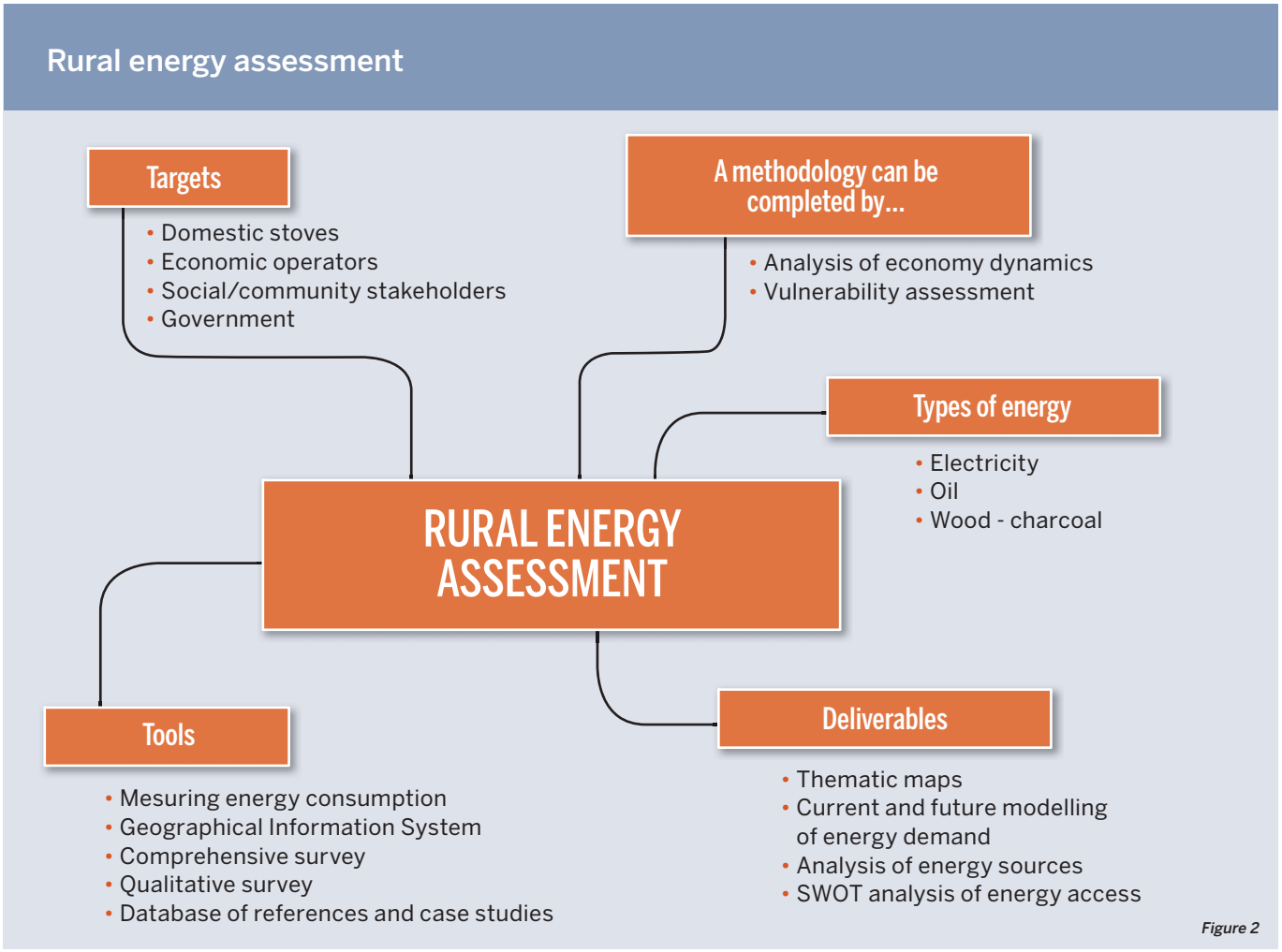

Figure 2

• **A body that unites and represents producer customers**
Micro-businesses are represented by an association of artisans (ASAOK). This long-established body was set up to facilitate discussions between businesses and artisans on specific themes (such as harmonized prices for milling cereals) and to act as a point of entry for various programs (such as training). GERES has worked with this association for a number of years at the municipal and Cercle levels. The ZAE may mean the association will have to adapt its mandate.

• **Decentralized state representatives (the mayor's office in this case)**
The mayor's office plays a pivotal role in the work in Koury, both through its role in driving and ensuring continuity and through its ability to provide locations and plots for this type of project. GERES was keen to find ways to increase the involvement of the mayor's office, particularly during the pre-project phase. A ZAE can also show a mayor's office how to take ownership of an issue, energy in this case, that was previously thought to be the sole responsibility of the national government in Bamako.

By the end of 2015, fund-raising was completed and work should be getting under way in mid or late 2016.

V.B.: What are the key components of this ZAE?

B.P.: The ZAE is intended to provide a quality electricity supply (energy component) in an environment designed for business activities (real estate component) and that provides non-financial support for the ZAE's micro-business customers (business support component). These three components are absolutely vital.

In practical terms, this means first of all adding an additional 25 kWp capacity to Yeelen Kura's mini-grid, running a direct feed from its power plant to the ZAE (so that the ZAE supply can be managed separately from the rest of the mini-grid) and, lastly, installing a storage battery bank at the ZAE. This solution means that Yeelen Kura's role will be limited to supplying daytime electricity, and the ZAE will be in charge of electricity storage and management of any disruptions to the supply. The additional costs of all this will be billed directly to the micro-businesses, which will pay different rates during the day than at nighttime. At the moment, the idea is to have a daytime rate of FCFA 250/kWh, and FCFA 400/kWh at night. Bear in mind, for example, that for a bakery with an electric kneader (the oven is wood-fired), these electricity costs represent 2% of the final sales price for a loaf. But a 24-hour electricity supply means it can bake more often.

The second key point is providing an environment where people and machines can work comfortably. In a country as hot as Mali, this means constructing bioclimatic buildings. GERES has partnered with a non-profit organization called Voute Nubienne for the construction component. Between 500 and 600 m² of floor area, just under a quarter of the total available, will be connected to the mini-grid. The cost of renting space is projected to be FCFA 500 per square meter. Management of the buildings, as well as the ultimate distribution of the electricity supply to the ZAE site, will be delegated, remembering that the land and buildings are, and will remain, the property of ASAOK, Koury's association of artisans that GERES has worked with for several years. All the prices will include an element to cover the costs of running the ZAE team (watchman and manager) and any minor maintenance and repairs, as well as an element designed to build up a fund for future major equipment overhauls or replacements. We already have a rough breakdown of the costs, and we will renegotiate some elements once the program is up and running. These prices and the cost breakdown both include allowances for annual inflation. The fact that there's now a bank and microfinance provider in place makes it much easier to maintain a measure of oversight over the delegated management.

The third point is fostering businesses. Although a handful of business people (the wealthiest and best-trained) do not need any support, others do. This is especially true of women, who are less practiced in setting up a business, and young people. This support covers both the preparation (thinking about the business model, helping to obtain a loan) and the operational stage (bookkeeping and business development, specialist training, such as hygiene and taxes). GERES does not want to become involved in financing equipment for projects of this nature.

V.B.: In more general terms, what do you think will be the future benefits of creating the ZAE in Koury?

B.P.: Ultimately, what's really interesting about it is how the question of energy acts as a facilitator. New arrangements and opportunities become possible thanks to the obligation micro-businesses have to group together spatially. I can give you three examples of the effects we hope to see, and that have been observed elsewhere. The dispersion of economic actors (not small traders) is frequently cited as a constraint for any microfinance institution. Having 5 to 10 micro-businesses gathered in a single location provides a new approach to how they can be managed. The second point is that the micro-businesses will naturally become each other's customers. Bakeries need ice while they are kneading their dough. Employees will be very happy to use a catering service. A radio station is a fabulous provider of cost-effective advertising. Lastly, success attracts success. Psychologically, it is easier to set up in a location where several businesses are already operating than somewhere empty and lifeless. And confidence is a key to success in business.