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Feasibility Study of Household-Scale Photovoltaic Energy Projects in Commune IV, Bamako

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Abstract: ***Mali faces high electricity costs, with over 40 percent of the population living below the poverty line. Given the country's abundant solar resources, this article explores the feasibility of small-scale photovoltaic (PV) systems tailored to household needs in Commune IV of Bamako. A survey of ten households was conducted, followed by a technical and financial analysis using RETScreen software. The findings show that only two households met all financial indicators, suggesting limited viability for widespread PV implementation under current conditions. This study offers valuable insights into decentralized energy planning and household-level solar adoption in developing regions.***

Keywords: Solar energy, photovoltaic systems, household electrification, financial feasibility, RET Screen

1. Introduction

The country's electricity supply comes primarily from Energy of Mali (EDM-SA), a state-owned industrial and commercial company. This supply is currently provided by three main sources: thermal generation, hydroelectric generation, and electricity imports from neighboring countries such as Côte d'Ivoire and OMVS member states via the Manatali dam.

As of December 2023, the electrification rate in Mali was 55.8%, with a pronounced imbalance between urban centers (86.6%) and rural areas (30.4%). This rate has not changed significantly since 2022 [1]. In the same year, the amount of electricity produced was 2,837,903 MWh. The share of local thermal sources in this production was 1,533,894 MWh, or 54.05%, that of hydroelectric sources 968,909 MWh, or 34.14%, imports represented 254,982 MWh, or 8.98%, and photovoltaics 80,118 MWh, or 2.82% [2].

The number of localities covered by EDM SA was 113 in 2024, corresponding to a coverage rate of 25%. Based on the figures relating to coverage rates, it appears that nearly three-quarters (3/4) of households in Mali do not have electricity [3].

EDM's current production infrastructure is insufficient to meet demand that averages 10% per year [4]. The imbalance between supply and demand is enormous and persistent, leading to power outages during periods of high demand, namely from March to May and from October to November.

Today, the energy challenge is colossal in Mali. Indeed, according to estimates by [5], only 54.5% of the population has access to electricity because the average cost of electricity is estimated at 141 CFA francs/kWh for a country where 43.9% of the population lives below the poverty line [6] [7]. Given this high cost, populations still use conventional sources of electricity, which are inefficient, expensive, polluting, and dangerous to human health. These sources of electricity emit an average of approximately 1,700 kt/year of CO_2 eq according to studies by [8]. Consequently, the essential sectors of health, education, and access to drinking water are the most affected.

To address these problems, the government and international organizations have taken numerous initiatives to make energy affordable and accessible to all. Thus, in 2009, the government's plans for energy development were contained in the Energy Sector Policy Letter, whose objectives were to improve the institutional and regulatory framework and make investments to ensure an adequate supply of affordable electricity in Mali.

Several studies have been conducted by government officials, non-governmental organizations, and civil society.

The goal of all these studies is to identify palliative measures to address conventional electricity shortages and solutions for low-cost clean energy. Unfortunately, these studies, conducted on a medium (village) or large (country) scale, prove insufficient on a small (household) scale to justify the implementation of a renewable energy supply system such as off-grid solar photovoltaic. Furthermore, studies on the cost of PV energy are rarely conducted in developing countries.

The objective is to integrate economic and environmental analysis into preliminary solar energy projects.

The aim is to size a stand-alone photovoltaic system based on the energy needs of each household, then evaluate the costs of the PV system based on the most economical options, then develop a budget based on the most approximate assumptions, and finally decide on the implementation of the project based on profitability parameters.

This article then describes the methodology adopted and the materials used. The third part presents the results obtained and their discussions. Finally, the fourth part provides the conclusion and outlook for this work.

2. Materials and Methods

After conducting solar audits on a few households, we then propose a sizing technique based on a technical and economic approach.

Based on energy needs scaled according to different population segments and taking into account the national grid's electricity pricing based on meter calibration, a solar kit corresponding to each need is proposed. This kit will be established based on sizing following optimization rules based on a technical and economic approach. A quote is then prepared, and the financial viability of the project is discussed based on financial analysis theory using RETScreen software to make a decision on whether to implement the project.

2.1. Geographical location of the study area

Mali, a landlocked country in the Sudano-Sahelian zone between 10° and 25° north latitude and 4° west and 12° east longitude. The country has strong solar potential, with average annual irradiation of around 6 kWh/m²/day. It is an extremely hot and dry area with an average annual temperature of 27.8°C. It covers an area of 1,241,238 km² and borders eight countries: Algeria to the north; Niger to the east; Mauritania and Senegal to the west; and Guinea, Côte d'Ivoire, and Burkina Faso to the south [8]. Figure 1 shows a map of Mali and its neighboring countries.

The total population was estimated at 22,395,489 inhabitants in 2022, with an average annual growth rate of 3.3% per year [8].

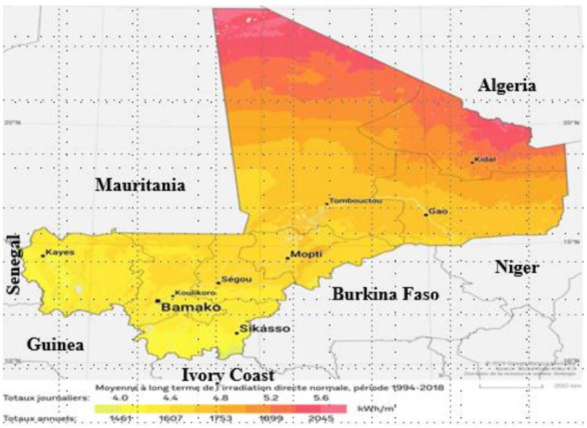

Figure 1: Map of Mali and its neighbors

2.2. Sizing a Stand-Alone Photovoltaic System

2.2.1. Energy Needs Assessment

The user's daily energy needs were rigorously assessed through a detailed inventory of the number of appliances used, their nominal power, and their average duration of use. This was done through a survey conducted in households using 5A, 10A, and 15A meters, also billed monthly and by prepaid meter (ISAGO). In households where electricity consumption is paid for through a monthly bill, average daily electricity needs were estimated from monthly bills. However, in households where consumption is prepaid through the prepaid meter (ISAGO), daily meter readings are taken. Energy needs at the household level are calculated using equation [11].

$$E_{ch,j} = \sum_{i=1}^{n} (P_i \times \Delta t_i) \quad (1)$$

$E_{ch,j}$: is the household's daily electricity consumption (Wh/j);
i: Electrical appliance considered;
n: Total number of electrical appliances in the household;
P_i: Nominal power of the appliance considered (W);
Δt : Average daily operating time of the appliance considered (h/j).

After assessing the household's electricity needs, a state-of-the-art stand-alone photovoltaic system was developed to meet these needs.

2.2.2. Nominal Peak Power of a PV Installation

A photovoltaic module is primarily characterized by its peak power (Pc), the power under standard conditions (1000 W/m² at 25°C). Its expression is given by [11]:

$$P_{PV} = \frac{E_{ch,j}}{PR \times E_{i,def}} \quad (2)$$

- P_{PV} : Peak power (Wp) ;
- $E_{ch,j}$: Daily energy (Wh/j) ;
- P_R : Performance Ratio
- $P_R = \eta_{ond} \times \eta_{reg} \times \eta_{bat} \times \eta_{sys}$

With:
- η_{ond}: Inverter efficiency;
- η_{reg}: Charge/discharge regulator efficiency;
- η_{bat}: Battery efficiency;
- η_{sys} : Average efficiency of the other parameters of the photovoltaic array;
- $E_{i,def}$The daily global solar radiation received in the plane of the modules in the most unfavourable month of the year (kWh/m²/j).

2.2.3. Inverter Sizing

The inverter or DC/AC transformer converts DC voltage into AC voltage. The input voltage of the circuit is the battery voltage, and the output voltage is 220/230V (at a frequency of 50 Hz). The inverter is selected based on its output power, i.e., the power capable of supplying the loads. This power is calculated using equation 3 [11]:

$$P_{n,ond} = \frac{P_{AC}}{\eta_{ond} \times \cos\varphi \times kloss} \quad (3)$$

- $P_{n,ond}$: Inverter's nominal power (W);
- P_{AC} :Total alternating current power demand (W) ;
- η_{ond} : Inverter's efficiency [-] ;
- $\cos\varphi$: Power factor;
- $kloss$: Reduction coefficient for cable losses (transport

Technically, the inverter must be chosen according to a ratio varying from 0.7 to 1.2 between its active power and the assigned power of the PV generator.

2.2.4. Battery Bank Sizing

The batteries store the energy supplied by the photovoltaic generator during the day, allowing the system to operate when there is no sun.

The capacity of the storage battery bank is calculated based on the required consumption and the number of days of autonomy according to equation 4 below:

$$C_{bat} = \frac{E_{ch,j} \times Aut}{\eta_{bat} \times DOD \times U_{bat}} \quad (4)$$

- C_{bat}: Battery bank capacity (Ah);
- $E_{ch,j}$: Daily energy consumption (Wh/j);
- Aut: Number of days of autonomy of the charged battery (j);
- η_{bat}: Average efficiency of the battery during discharge;
- DOD : Permitted depth of discharge of the battery.
- U_{bat}: Battery voltage (V).

2.2.5. Sizing the Charge/Discharge Controller

The controller is a component of the photovoltaic generator whose role is to stop charging the battery when it is already fully charged, thus preventing overcharging, and to cut off power to the devices when the battery charge becomes critical, thus preventing deep discharge [11]. It is sized using the following formula:

$$I_{reg} = \frac{N_{PV} \times P_{PV,j}}{N_{PV,S} \times \eta_{reg} \times U_{mod}} \quad (5)$$

- I_{reg} : Regulator's input current in (A);
- U_{mod} : Nominal voltage of the solar module (V),
- N_{PV} : Total number of PV modules,
- $N_{PV,S}$: Number of PV modules in series,
- $P_{PV,J}$: Nominal power unit.

2.2.6. Cable Cross-Section Sizing

Indeed, too small a cross-section increases the cable's resistance and temperature, which reduces the installation's power. Harsh outdoor conditions including heat, UV exposure, and mechanical stress. They are the only cables capable of ensuring a long service life (over 30 years) while minimizing energy losses. The cross-section of an electrical cable is given by the following equation 8:

$$s = \rho \times 2L \times \frac{I}{\Delta U_{max}} \quad (6)$$

Where:
- S: Ideal cable cross-section in (mm²);
- ρ: Resistivity of the conductive material in (Ωmm²/m);
- L: Conductor length in (m);
- I: Current in (A);
- ΔUmax: Acceptable voltage drop in (V) (less than 3% of the nominal voltage).

2.3. Financial Analysis

Financial viability indicators are automatically calculated by the RETScreen software. Based on the input data, the model provides financial indicators for the analyzed project, facilitating the project evaluation process for project planners and decision-makers.

We assume that the initial investment will be divided into equity (share of the project beneficiary) and financing (borrowed from a bank). Other parameters (incentives and subsidies, income tax analysis, GHG reduction income) will be ignored (considered zero).

The formulas used are based on common financial terminology found in most financial analysis textbooks. The model makes the following assumptions:
- The initial investment year is year 0;
- Costs and credits are given for year 0 and, consequently, the inflation rate and indexation rate are applied starting from year 1;
- The calculation of cash flows is carried out at the end of each year.

Key Model Parameters:
The important financial parameters of the model that allow us to simulate indicators of financial variability include:
- The indexation rate: This is the adjustment of the cost of electricity supplied by the reference case (EDM-SA) over time. Its value is 4% of the chosen fuel.
- The interest rate: This is a rate set by banks when the beneficiary of a project requests loan financing. This interest rate is set at 7.5%.
- The inflation rate: This is a function of consumer prices; its value is 2.3%, simulated by [12].
- The discount rate: This allows us to compare quantities of goods or services that appear in the future at different time horizons, which is very useful for making current decisions about future investments. We use 5%.

2.3.1. Investment Cost

Calculating the cost of the solar kit components and replacing certain electronic components represents a significant investment. Several considerations (technical, economic, commercial, and political) are made based on national and international markets. A quote will be developed using RETScreen software.

This quote is primarily based on the cost of devices on the market. This will be referred to as the total gross cost. Although solar panels often have a lifespan of more than 30 years, the other components of the photovoltaic system must be replaced every few years.

The initial investment cost C_i of the project is determined by formula (7):

$$C_i = P_{PV} \times A + C_{bat} \times B + P_{n,ond} \times C + I_{reg} \times D \quad (7)$$

Where:
- C_i represents the initial investment cost in CFA francs;
- A, B, C, and D are the specific prices chosen for the PV module, battery, inverter, and regulator in CFA francs, respectively.

The costs of other balance of system (BOS) elements, such as cables, switches, and all installation costs, are applied with a weighting factor (δ) to the initial investment cost (C_i). Thus, the total initial investment (C_t) is calculated using equation (8):

$$C_t = (1 + \delta) \times C_{i,syst} \quad (8)$$

Where:
- C_t : Total initial investment in CFA francs;
- δ: Weighting factor for other costs.

Operation and maintenance (O&M) operations are adjusted based on annual costs during the project analysis period. In this project, O&M involves replacing the batteries, inverter, and regulator, and we assumed that the system required no further maintenance during the project's lifetime.

Table 1 shows the costs assumed for the solar kit components and work related to system installation. The unit prices used are the minimum possible to account for the savings to be achieved.

Table 1: Costs retained for the components of the solar kit

Components	Unit Price	Supplier	Unit Price Retained
Module (F CFA/W_c)	2 600	tenesol	978
	978	Suntech	
	2 000	Yandalux	
	1 806	Sharp	
Battery (F CFA /Ah)	328	Phaesun	328
	1 067	Yandalux	
	950	Tenesol	
Inverter (F CFA /W)	190	PHOTON	190
	286	Victron energy	
	300	Power inverter	
Regulator (F CFA /A)	2500	Intigaia	2500
Cable (F CFA /m)	361	Semassou	361
Structure (F CFA /Wc)	131	Intigaia	131

Table 2 shows the estimated average cost per kWh of electricity consumed at the EDM-SA of the selected households.

Table 2: Estimated average cost per kWh of electricity consumed at the EDM-SA of the selected households

Components		Lafia-bougou	Ham-dallaye	Djico-ronipara	Sebeni-coro	Sibiri-bougou	Taliko
Featu	Monthly Bill Type	Facture	Facture	Facture	Compteur Prépayé	Compteur Prépayé	Facture
	Amperage	10A	10A	10A	10A	5A	5A
Electricity	Average Consumption (kWh/month)	162	161	117	93	129	126
	Cost of the 1st installment (FCFA/KWh)	17658	17549	12753	10137	2950	2950
	Cost of the 2nd installment (FCFA/KWh))	0	0	0	0	4700	4700
	Cost of the 3rd installment (FCFA/KWh)	0	0	0	0	3161	2834
	Gross Cost (FCFA/month)	17658	17549	12753	10137	10811	10484
Levy	Meter Maintenance and Rental (FCFA)	540	540	540	540	176	176
	18% TVA Meter Maintenance and Rental (FCFA)	97	97	97	97	32	32
	Street Lighting Fee	592	592	592	592	320	320
	18% TVA Electricity (FCFA)	3179	3159	2296	1825		
	Total Monthly Tax Cost (FCFA)	4408	4388	3525	3054	528	528
Monthly cost price (FCFA)		22066	21937	16278	13191	11339	11012
Monthly cost price per kWh (FCFA)		137	136	140	141	88	87

2.3.2. Levelized Cost of Energy

The production cost of a photovoltaic kWh is calculated using the Levelized Cost of Ownership (LCOE) formula, which, by definition, is the ratio between the sum of the discounted expenses for a project from year 0 to year n, and the sum of the outputs, also discounted, from year 1 to year n.

$$LCOE = \frac{(1-f_d)I+\sum_{n=1}^{N}[C_{an}(1+\lambda)^n+D]}{\sum_{n=1}^{N}E_{an}(1+r)^n} \quad (9)$$

Where:

- r: Energy indexation rate.
- LCOE : Levelized Cost of Ownership in (CFA francs/kWh);
- f_d: Debt ratio;
- N: Project life span in years;
- I: Total capital cost of the project (FCFA);
- n: Year considered;
- Can: Annual expenditure in (FCFA);
- λ: Inflation rate;
- D: Annual debt payment in (FCFA);
- Ean: Annual electricity production [kWh/year];

2.3.3. Choice of model simulation parameters

The PR is 0.75, the assumed efficiency η_{ond} is 92%, the power factor $\cos\varphi$ and the loss coefficient k_{loss} are set at 0,9 and 0,85, respectively. The assumed ($N_{PV,S}$) is 1 and η_{reg} is 95%. The assumed DOD is 80%, the η_{bat} is 85%, and the autonomy is three (3) days. The weighting factor (δ) is set at 12%. Operating and maintenance costs are set at 2,7% per year of the total initial investment.

To conduct the project's financial feasibility analyses, we assumed a 25 year project life. All cash flows are treated in constant currency, with an interest rate of 7.5% for the loan in question. The interest rate is 75% and equity is set at 25%. The inflation rate used is 2,8%, the indexation to the EDM-SA tariff is 4%, and the real discount rate is 5%.

All financial viability parameters, such as the internal rate of return (TRI), simple payback period, simple payback period on equity, and net present value (VAN), are simulated using RETScreen software.

3. Results and discussion

3.1 Average cost of conventional electricity consumed

For the choice of households, we based ourselves on two (2) criteria, the first consists of tracing the cost price of electricity from EDM-SA according to electricity consumption and the second focused on the definition of favorable and unfavorable zones for each meter (5A and 10A) see the figure below.

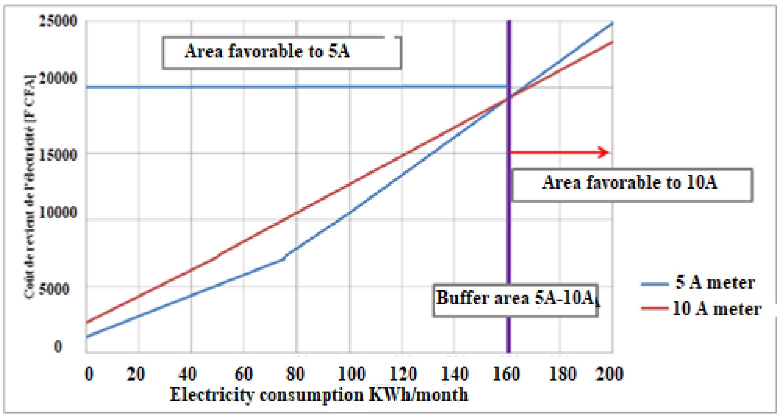

Figure 2: Choice of households based on amperage and the cost of electricity consumed. The cost price of electricity is calculated according to the provisions of the EDM-SA tariff schedule.

The households located in a favorable area are Lafiabougou, Sibiribougou, and Taliko. Those located in an unfavorable area are Djicoroni-para and Sebenicoro.

After determining the cost price per kWh consumed from the national grid (Table 2 below), we note that these two households pay a monthly bill closest to the national average of 141 CFA francs/kWh. This is justified by the fact that these four households are located in an unfavorable zone for their meters.

As for Hamdallaye, it is the only household located in the buffer zone.

In fact, these two households should use 5A meters rather than 10A meters if we wanted to conduct an energy efficiency study.
The Hamdallaye household, despite its high consumption, pays around 136 CFA francs/kWh. This is likely due to its location in the buffer zone.

Lafiabougou, Sibiribougou, and Taliko, meanwhile, pay for electricity at an affordable cost.

3.2. System Component Specifications

Given the needs identified in the households, the voltage selected for all components (modules, regulator, batteries, and inverters) was 24V, taking into account their high consumption, except in Sibiribougou and Taliko, which have lower consumption than the others and for which we opted for 12V.

For all households, we chose polycrystalline silicon solar modules from the manufacturer PHOTOWATT, whose total power output best meets the needs of each household. The RETScreen software provided us with all the parameters for these modules. We opted for a fixed control method and adjusted various system-related losses so that 100% of the electricity supplied is available for use.

The following table shows the characteristics of the components of the solar kits per household.

Table 3: Characteristics of solar kit components per household

Settings	Lafia-bougou	Sibiri-bougou	Ham-dallaye	Djicoroni-para	Sibiri-bougou	Taliko
$E_{ch,j}\,(\frac{Wh}{j})$	5388	4313	5349	3895	3099	4192
$P_{PV}(Wc)$	1390	1112	1382	1006	800	1083
$P_{CA}(W)$	1865	574	1620	575	478	460
$P_{n,Ond}\,(W)$	2000	600	1700	600	500	500
$C_{bat}\,(Ah)$	990	795	985	720	1140	775
$I_{reg}\,(A)$	60	48	58	42	67	45
$U\,(V)$	24	24	24	24	12	24
$L\,(m)$			5			
$\Delta U_{max}(V)$	0,72	0,74	0,74	0,74	0,36	0,74
$\rho\,(\Omega.mm^2/m$			1,81E-08			
$S\,(mm^2)$	16	13	15	12	18	17

3.3. Study of the financial viability of the project

3.3.1. Financial analysis

These results provide decision-makers with various indicators of the financial viability of the project in question. The table below shows the different financial viability values for the project calculated by the RETScreen software.

The table below shows the different financial viability parameters according to RETScreen.

Table 4: Study of financial viability parameters according to RETScreen.

Financial viability	Sebenicoro	Djicoroni para	Ham-dallaye	Lafia-bougou	Sibiri-bougou	Taliko
Internal Rate of Return (TRI) on equity (%)	10,5%	12,7%	6,8%	1,1%	-2,9%	- 6,8 %
Internal Rate of Return (TRI) on assets (%)	7,8%	6,9%	4,8%	-0,7%	-3,6%	-7,5%
Simple Payback Period (years)	14,7	8,8	11,1	9	9,3	7,0
Payback Period on equity (years)	10,7	10,3	15,4	23,7	> projet	> projet
Net Present Value (VAN)	789 004	802 917	340 307	-742 933	-1 053 354	-1 500 559
Annual savings over lifetime	55 982	56 969	24 146	-52 713	-74 738	-106 468
LCOE	130	122	125	140	142	145

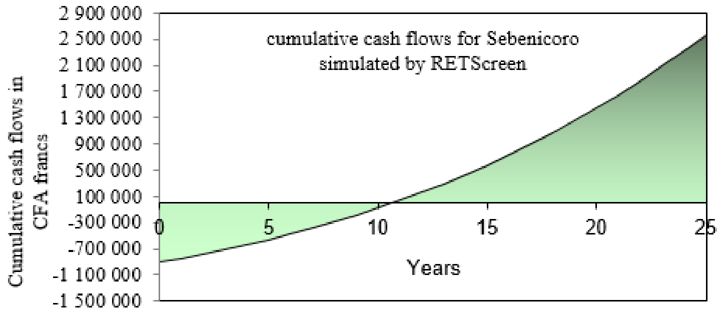

Figure 3: Cumulative cash flows for Sebenicoro simulated by RETScreen

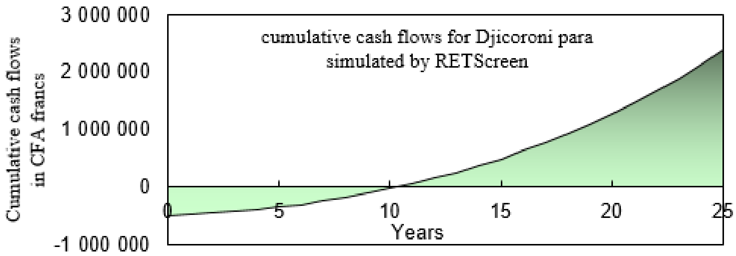

Figure 4: Cumulative cash flows for Djicoroni para simulated by RETScreen

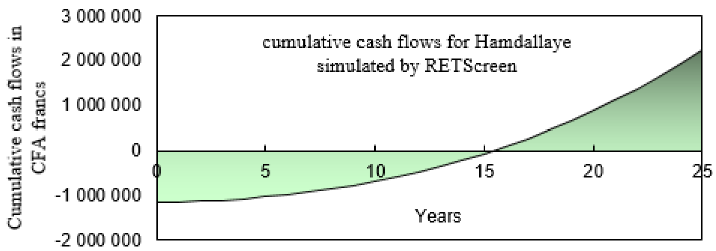

Figure 5: Cumulative cash flows for Hamdallaye simulated by RETScreen

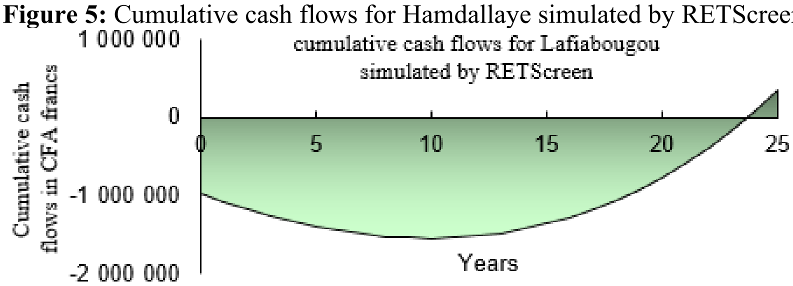

Figure 6: Cumulative cash flows for Lafiabougou simulated by RETScreen

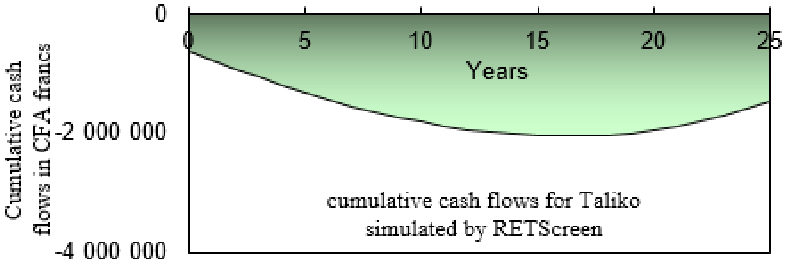

Figure 7: Cumulative cash flows for Taliko simulated by RETScreen

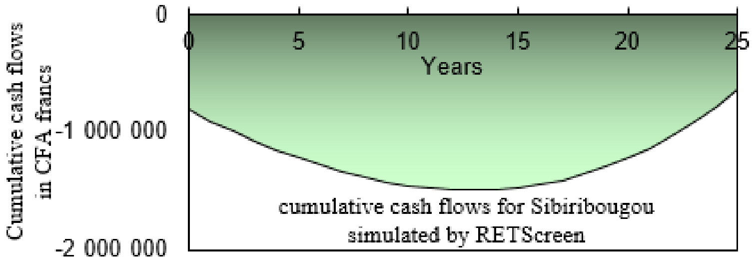

Figure 8: cumulative cash flows for Sibiribougou simulated by RETScreen

3.3.2. Internal rate of return (TRI)

We will show the impact of borrowing on the project's internal rate of return (TRI).

We have defined the equity TRI, which is the rate found when financing is provided through equity and borrowing, and the asset (TRI), which is the rate found when financing is provided solely through equity. We note that the equity TRI is higher than the asset TRI. This is because when the project is financed solely by the beneficiary, its profitability is not easily assured for most projects. With this in mind, we note that only two (2) households, Sebenicoro and Djicoroni para, have an TRI-assets of 7.8% and 6.9% respectively, satisfying the condition that the TRI must be higher than the discount rate of 5%. However, when the loan is taken into account, three (3) households, namely Sebenicoro, Djicoroni Para 2, and Hamdallaye, prove to be profitable. Lafiabougou, Sibiribougou, and Taliko, on the other hand, show negative rates of return, making them projects that are not worth investing in. This is confirmed by the simple returns and returns on equity. The (TRI) calculated appear to be correct since, for all projects, the cumulative cash flows do not go from positive to negative and then back to positive. If this were the case, these indicators would be incorrect in their assessments, as stated in [13]. [11] obtained a payback period of 6.5% over a period of 25 years.

3.3.3. One-way return (RS) and zero flow year

Simple paybacks occur in less than 25 years in all these households. The years of zero cumulative flows are in the same order as the payback periods. For Lafiabougou, Sibiribougou, and Taliko, the situation remains bleak, which is consistent given that the active IRRs are negative. Excluding Lafiabougou, the other two (2) households, namely Sibiribougou and Taliko, have a return on equity time greater than the project age of 25 years. This means that solar PV projects should not be of interest to Lafiabougou, Sibiribougou, and Taliko if these households maintain their electricity consumption. This remains valid if we focus solely on economic profitability and do not take into account the environmental benefits.

3.3.4. Net present value (VAN)

Considering VAN, a key financial indicator in any project [14], only Sebenicoro, Djicoroni Para, and Hamdallaye respond favorably. In these households, the VAN is positive, which means that the project is viable.

In light of these values, the savings indicated by the projects in these households provide information on the savings to be made over the duration of the project. The three other households with negative VAN are not viable.

3.3.5. Total Cost of Ownership (LCOE)

The discounted total costs we calculated show that only the Sebenicoro and Djicoroni para households can benefit from a solar energy project, because only in these households is the energy produced cheaper than conventional consumption.

For all of these projects, the LCOE is between 122 and 145 CFA francs/kWh produced. Only Sebenicoro and Djicoroni para had a higher cost of electricity from the national grid, with respective costs (140 CFA francs/kWh and 141 CFA francs/kWh) compared to their previously calculated LCOE.

The LCOEs estimated by [15] for solar PV projects in Africa range from 101 CFA francs/kWh to 258 CFA francs/kWh. The LCOEs in our study fall within this range. Similarly, considering the work carried out by [16] for six developing countries such as Mali, our LCOEs also fall within its range of 101-177 CFA francs/kWh.

3.3.3. Final decision on the implementation of the project

The financial indicators show that the project will only be profitable in Sebenicoro and Djicoroni Para, which meet all the indicators. Hamdallaye seems well placed to benefit from such a project, but the cost price of the electricity produced would be slightly higher. In Lafiabougou, Sibiribougou, and Taliko, which still show unsustainable indicators, such a project should not take place.

These results do not seem to work based on the work of [13], [17], and [11], which estimate that photovoltaic installations are profitable for small off-grid applications.

By also promoting energy efficiency in each household surveyed, only Hamdallaye, located in the buffer zone, could maintain this result. However, Djicoroni para and Sebenicoro would see their meters changed to 5A instead of 10A for Djicoconi para and 10A instead of 5A for Sebenicoro. Attempts were also made to reduce energy requirements by replacing high-consumption appliances with lower-consumption ones. Unless Hamdallaye maintains its result, no project will be viable.

This result for solar projects has been verified in almost all countries, as shown in [18] for energy supply solutions in rural Africa. This work shows that autonomous photovoltaic systems are not suitable for large-scale electricity production due to storage problems and the inflexibility of the system. In light of the rising costs of energy raw materials [17] compared to the falling prices of solar modules [18] [15] [19], autonomous PV systems using renewable energies appear to be a viable alternative, but not always the most sustainable one.

Conclusion

After conducting solar audits of ten households in Bamako District 4 to set up a solar kit for each home, we selected six households, three of which are located in a favorable usage zone; two in an unfavorable area, and one in a buffer zone in terms of the amperage of their meters. The configuration chosen for the success of the project involves optimizing the energy received by the fixed collectors by tilting them 15° southward. The irradiation on this plane was then obtained using RETScreen software.

We therefore made several technical and financial assumptions in order to size the solar kits to meet the needs of these households.

Finally, using the RETScreen clean energy project analysis model, we assessed the financial viability of each project. The results indicate that only Sebenicoro and Djicoroni para, which use grid energy inefficiently, can benefit from such a project.

The project in Hamdallaye, which is also located in this area, could potentially opt for such a project, but unfortunately the cost of the energy produced is higher than that of the national grid. The other households do not warrant such a project, even though the environmental savings, which could not be quantified, are still relevant.

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