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Mobilising Renewable Energy Investments

Burundi: Small Hydropower and Rural Development

Model Business Case: 100 kW Solar PV-Hydro Hybrid Mini-Grid

INTRODUCTION

Small hydropower (SHP) can benefit rural development through wide-ranging community uses of electricity. With its vast network of rivers, Burundi is endowed with abundant hydropower resources; however, most of this potential remains untapped. Burundi also has many abandoned SHP installations suitable for rehabilitation.

This Model Business Case (MBC) analyses the financial feasibility of a hypothetical 100 kW hybrid solar PV-micro hydropower mini-grid providing power to an off-grid community in rural Burundi ("the Project"). It is assumed that a private developer will finance, construct, operate and maintain the mini-grid system and sell the electricity generated to rural consumers.

The analysis considers the sale of electricity to four customer types: households, small businesses, public buildings and small-scale industrial users. Coupled with a solar PV system, the SHP component provides additional power to the network and serves as network storage (i.e., a "battery bank"). The solar PV system provides electricity to the network during daylight hours (including pumping water up into the SHP reservoir); at night, when the sun is not shining, the SHP generation provides electricity to the network. This analysis also includes battery storage for the solar PV system.

This MBC is based on one such hybrid solar PV-SHP installation already operating in Burundi.

TARGET AUDIENCE

A detailed financial analysis of the Project was conducted to determine its viability and its ability to adequately service debt while providing attractive returns to investors. The target audience of this MBC includes (but is not limited to):

— Project developers who may be interested in pursuing opportunities for solar PV-hydro hybrid mini-grid development in Burundi;

— Potential investors who may be interested in financing hybrid solar PV-hydro mini-grids in Burundi; and

— Policymakers, donor agencies, development partners and DFIs.

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KEY ASSUMPTIONS

This MBC is based on the assumptions described below. The assumptions and key parameters are mainly based on publicly available information gathered through desk research, as well as interviews with local stakeholders in Burundi, including representatives from: (i) the Burundian Rural Electrification Agency (Agence Burundaise de l'Electrification Rurale, ABER); and (ii) the national utility, the Water and Electricity Production and Distribution Company (Régie de Production et de Distribution de l'Eau et de l'Electricité, REGIDESO). A detailed feasibility study would be required to determine the actual applicable costs and parameters for specific projects.

Technical assumptions

Table 1 presents the assumptions related to the mini-grid customer and load characteristics.

TABLE 1. Hybrid solar PV-hydro mini-grid customers and demand[1]

CUSTOMER TYPE[2]	NO. OF CONNECTIONS	AVG. MONTHLY CONSUMPTION PER CONNECTION (kWh)	TOTAL MONTHLY CONSUMPTION (kWh)
Households	540	10	5,400
Small businesses	42	27	1,145
Public connections	4	45	180
Small-scale industrial users	10	149	1,490
Total	**596**	**231**	**8,215**

1) These are hypothetical demand assumptions tailored to the mini-grid system capacity presented in **Table 2**.
2) Small businesses include retail shops, grocers, salons etc.; Public connections include schools, health centres and administrative centres; Small-scale industrial users include welding, carpentry, bakery, milling etc.

Table 2 presents the assumptions related to the technical parameters of the solar-hydro hybrid mini-grid.

TABLE 2. Hybrid solar PV-hydro mini-grid system technical assumptions

HYBRID MINI-GRID SYSTEM PARAMETERS	UNIT	VALUE
Solar PV system parameters		
Base annual yield	kWh/kWp	1,351[3]
Solar PV system capacity	kWp	40[4]
Annual generation, Yr. 1	kWh	54,020[5]
Battery capacity	kWh	148[6]
Inverter capacity	kW	36[7]
Micro-hydro system parameters		
Installed hydro capacity	kW	60[8]
Annual generation, Yr. 1	kWh	261,600[9]
Electro-mechanical equipment lifetime	Years	20[10]
Low voltage distribution network	km	10[11]

Macro-economic assumptions

For this analysis, the Burundian Franc (BIF) to EUR exchange rate is assumed to be 3,037.1, while the annual BIF to EUR depreciation is assumed to be 5.1%.[12] In addition, annual inflation is assumed to be 10.7% over the life of the Project, based on projections for the country.[13]

3) Based on Nyabikere solar/hydro hybrid system design.
4) Based on Nyabikere solar/hydro hybrid system design.
5) Derived by multiplying the base annual yield by the solar PV system capacity.
6) Based on Nyabikere solar/hydro hybrid system design.
7) Based on Nyabikere solar/hydro hybrid system design.
8) Based on Nyabikere solar/hydro hybrid system design.
9) "Zambia: Solar PV and Hydro Mini-Grids: Case Study: Hydropower Mini-Grid at Lwakela Falls," GET.invest Market Insights, (2020): https://www.get-invest.eu/wp-content/uploads/2020/10/GETinvest-Market-Insights_ZMB_Mini-grid_-CS-Hydro_2019.pdf
10) Ibid.
11) Assumption based on the mini-grid customer profile presented in **Table 1**.
12) Calculated based on BIF/EUR exchange rate data.
13) Burundi: Inflation forecast: https://www.theglobaleconomy.com/Burundi/inflation_outlook_imf/

Capital costs

Table 3 presents the capital cost assumptions for the Project.[14] It is assumed that the project assets will be depreciated via straight line depreciation over its 20-year lifetime at a rate of 5% per year.

TABLE 3. Capital cost assumptions

HYBRID MINI-GRID CAPEX

CAPITAL COSTS	UNIT COST (EUR)	TOTAL COST (EUR)
Solar PV cost per kWp	€1,350[15]	€54,000
Battery cost per kWh	€232[16]	€34,267
Inverter cost per kW	€253[17]	€9,091
Development and other costs per kWp	€500[18]	€20,000
Solar PV plant cost per kW	**€2,934**	**€117,358**
Hydropower plant cost per kW	€4,000[19]	€240,000
Low voltage distribution network cost per km	€3,000[20]	€30,000
	Total CAPEX	**€387,358**
	CAPEX per connection	**€650**
	CAPEX per kW	**€3,874**

14) The mini-grid capital costs include the cost of the hydro power generation system (civil works, the penstock, turbine, generator, powerhouse), the cost of the solar PV system (solar PV modules, inverters, battery bank, balance of plant), the low-voltage distribution network, cost of freight, taxes (onshore and offshore), applicable duties, installation costs and development and other costs including costs for studies and design, supervision and contingency.
15) "Republic of Burundi: Solar Energy in Local Communities Project," World Bank, (February 6, 2020): https://documents1.worldbank.org/curated/en/247351583204580950/pdf/Burundi-Solar-Energy-in-Local-Communities-Project.pdf
16) Stakeholder interviews, 2022.
17) Stakeholder interviews, 2022.
18) Stakeholder interviews, 2022.
19) Stakeholder interviews, 2022.
20) Stakeholder interviews, 2022.

Operating costs

Table 4 presents the operating cost assumptions for the Project, including the assumed costs of battery replacement in the 8th and 15th year of operation and inverter replacement in the 16th year of operation.[21] The replacement costs are based on an annual price reduction assumption of 3% compared to the initial investment.[22] It is assumed that the operating costs will increase by 10.7% annually in line with inflation.

TABLE 4. Operating cost assumptions

OPERATING COSTS	UNIT	COST/UNIT	TOTAL COST YEAR 1 (EUR)
O&M costs (solar PV generation)	% of CAPEX	2%[23]	€2,347
O&M costs (hydro generation)	% of CAPEX	4%[24]	€9,600
O&M costs (distribution)	% of CAPEX	4%[25]	€1,200
		Total OPEX	**€13,147**
Battery replacement cost – Year 8[26]			€26,857
Battery replacement cost – Year 15[27]			€21,700
Inverter replacement cost – Year 16[28]			€5,584

Taxes

A corporate income tax rate of 30% was applied to the Project, in line with the applicable tax rate in Burundi, with no tax holiday. In addition, a Value Added Tax (VAT) rate of 18% was applied to the equipment and services used for the Project.[29]

Revenue

The model assumes a uniform mini-grid tariff of EUR 0.32/kWh[30] for all the different types of customers[31] and a one-time connection fee of EUR 32.3 per connection.[32] It is also assumed that the mini-grid tariff will increase by 10.7% annually in line with inflation.

21) Operating expenditure for the mini-grid includes annual operations and maintenance (O&M) costs for both the generation plants and the distribution network, staff salaries, and other operating expenses, including administrative expenses and insurance costs.
22) "Zambia: Solar PV and Hydro Mini-Grids: Model Business Case: Solar PV Mini-Grid for Rural Electrification," GET.invest Market Insights, (2020): https://www.get-invest.eu/wp-content/uploads/2020/10/GETinvest-Market-Insights_ZMB_Mini-grid_-MBC-Solar_2019-1.pdf
23) Stakeholder interviews, 2022.
24) Stakeholder interviews, 2022.
25) Stakeholder interviews, 2022.
26) "Open Sourcing Infrastructure Finance for Mini-Grids," Crossboundary Energy Access, (2020); and Lane, C., "Are lithium-ion solar batteries the best energy storage option?" SolarReviews, (March 17, 2023): https://www.solarreviews.com/blog/are-lithium-ion-the-best-solar-batteries-for-energy-storage
27) Ibid.
28) Kennedy, R., "How long do residential solar inverters last?" PV Magazine, (September 15, 2021): https://pv-magazine-usa.com/2021/09/15/how-long-do-residential-solar-inverters-last/
29) The corporate tax rate in Burundi is fixed at 30%, subject to a minimum of 1% of the turnover if the company makes a loss or if the taxable profit is below 1/30th of the turnover: https://www.eaiinternational.org/public_files/prodyn_img/burundi-1.pdf
30) Stakeholder interviews, 2022. There is no fixed tariff for mini-grids managed by private developers in Burundi. Each developer has to negotiate a tariff with AREEN based on the power generation costs and the income level of its customers.
31) In practice, mini-grid operators might charge SMEs a higher tariff than households, but a uniform tariff is used here to keep the model simple.
32) "Rwanda: Off-grid Sector Status Report 2018," Energising Development (EnDev), 2019: https://www.urwegobank.com/wp-content/uploads/2019/09/EnDev_Off-Grid-Sector-Status-Report_2018.pdf

Financing scenarios and debt assumptions

It is assumed that the Project will be financed by the developer with 40% equity, and it will obtain performance-based grants (PBG) of USD 500 (EUR 460) per connection that will be received during the first year of operation.[33] In addition, it is assumed that the Project will obtain a bridge loan to cover a portion of CAPEX during the period before the PBG is paid out, while the balance of costs will be covered by long-term debt (**Table 5**).

TABLE 5. Capital structure

FUNDING TYPE	% OF CAPEX	TOTAL AMOUNT (EUR)
Long term debt funding	17.3%	€67,198
Equity	40.0%	€154,943
Bridge loan	42.7%	€165,217
Total	**100%**	**€387,358**

Two long-term debt financing scenarios were considered: (i) EUR-denominated debt; and (ii) BIF-denominated debt. **Table 6** presents the project debt assumptions for both scenarios. The long-term debt tenor is assumed to be 7 years under both scenarios, while the bridge loan tenor is assumed to be 1 year.[34] It is also assumed that the required rate of return for equity investors to consider the Project attractive is 15%.[35]

TABLE 6. Project debt assumptions

PROJECT DEBT	UNIT	EUR DEBT	BIF DEBT
Long term debt interest rate	%	8.5%[36]	16%[37]
Bridge loan interest rate	%	10.5%[38]	-

33) Phillips, J., Attia, B., and Plutshack, V., "Lessons from the proliferating mini-grid incentive programs in Africa," Brookings Institution, Future Development, (December 11, 2020): https://www.brookings.edu/blog/future-development/2020/12/11/lessons-from-the-proliferating-mini-grid-incentive-programs-in-africa/

34) Bridge loans typically have short terms of up to 1 year; no grace period assumed on long term debt in order to be conservative; long term debt tenor based on the typical payback period of rural mini-grids of around 7-10 years.

35) "CrossBoundary Energy fully exits first fund at 15% net internal rate of return (IRR), raises $40M to continue to scale financed solar for businesses in Africa," CrossBoundary Energy, (17 November 2020): https://www.sun-connect-news.org/news/details/press-release-crossboundary-energy-fully-exits-first-fund-at-15-net-internal-rate-of-return-irr/

36) Daglish, J., 2019. "A Prefeasibility Analysis of a PV Mini Grid with Ice Plant on Buvu Island in Lake Victoria," KTH School of Industrial Engineering and Management, Stockholm, Sweden, https://upcommons.upc.edu/bitstream/handle/2117/333364/jonathan-daglish-thesis.pdf?sequence=1&isAllowed=y

37) Banque de la République du Burundi: https://www.brb.bi/sites/default/files/BM_June_2022_4.pdf

38) Given that bridge loans typically attract higher interest rates than conventional loans, it was assumed that the bridge loan rate will be 2% higher than the long-term debt rate.

RESULTS

Based on the assumptions described above, the financial analysis yielded the following conclusions:

— Under the EUR-denominated debt scenario, the investment opportunity is attractive, with after-tax equity IRR (EIRR) of 17%, equity payback period of 7 years, equity NPV of EUR 12,794 and a minimum Debt Service Coverage Ratio (DSCR) of 1.21, which is above the threshold of 1.2 typically required by lenders to finance a project.

— Under the BIF-denominated debt scenario, the Project is also attractive, but to a lesser extent, with after-tax EIRR of 16.5%, equity payback period of 7 years and equity NPV of EUR 9,725 due to the high cost of local debt. However, due to insufficient cashflows in the early years, the minimum DSCR is 1.04, which is below the threshold of 1.2 typically required by lenders. This indicates that a debt service reserve account (DSRA) or concessional terms will be required.

The results of the financial analysis are summarised in **Table 7**.

TABLE 7. Financial analysis results

HYBRID MINI-GRID PROJECT RESULTS SUMMARY

INDICATOR	EUR-DENOMINATED DEBT	BIF-DENOMINATED DEBT
Avg. annual revenue	€52,607	
Avg. annual expenses	€23,742	
Avg. EBITDA	€28,865	
Avg. net income	€3,571	€2,933
LCOE	€0.198	€0.204
Total cashflow to equity	€494,901	€493,912
Net cashflow to equity	€339,958	€338,969
After tax equity IRR	17.0%	16.5%
After tax project IRR	13.4%	
Equity NPV	€12,794	€9,725
Initial equity payback period (yrs.)	7	7
Initial project payback period (yrs.)	6	
Avg. DSCR	1.64	1.81
Min. DSCR	1.21	1.04

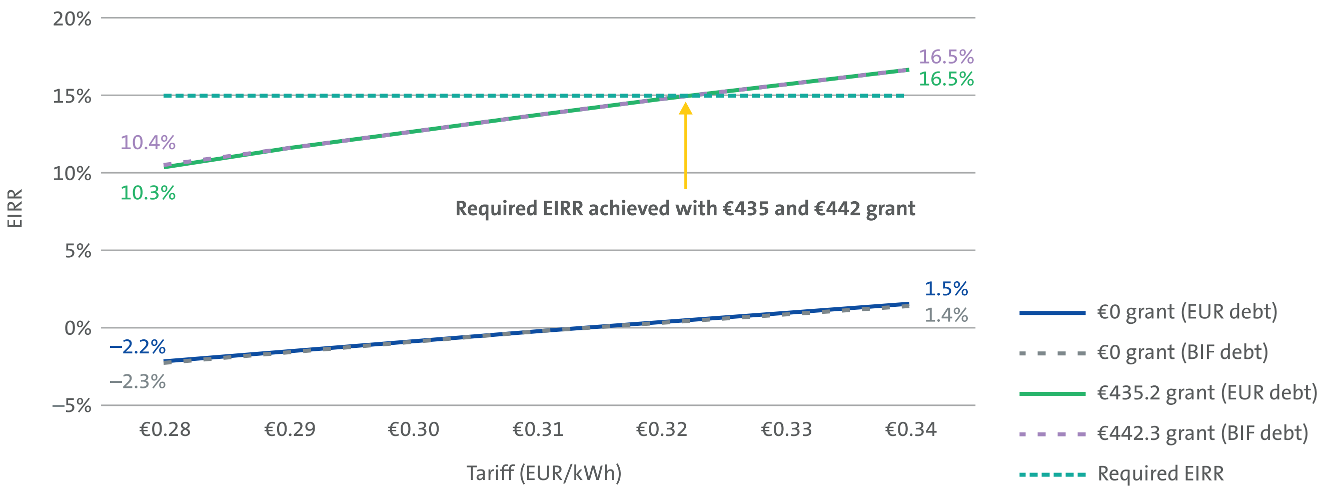
SENSITIVITY ANALYSIS

A sensitivity analysis was conducted to assess the impact of changes in key assumptions on the equity IRR and DSCR as measures of the viability of the Project. The figures below present the results under various scenarios.

Tariff and grant scenarios

Figure 1 illustrates the impact of increases in the tariff and PBG per connection on EIRR. The analysis found that the required EIRR can only be achieved with grants of at least EUR 435 and EUR 442 per connection at the assumed tariff level under the EUR debt and BIF debt scenarios, respectively. Without grants, the Project will require tariffs of EUR 0.677/kWh and EUR 0.68/kWh under the EUR debt and BIF debt scenarios, respectively, to achieve the required equity IRR.

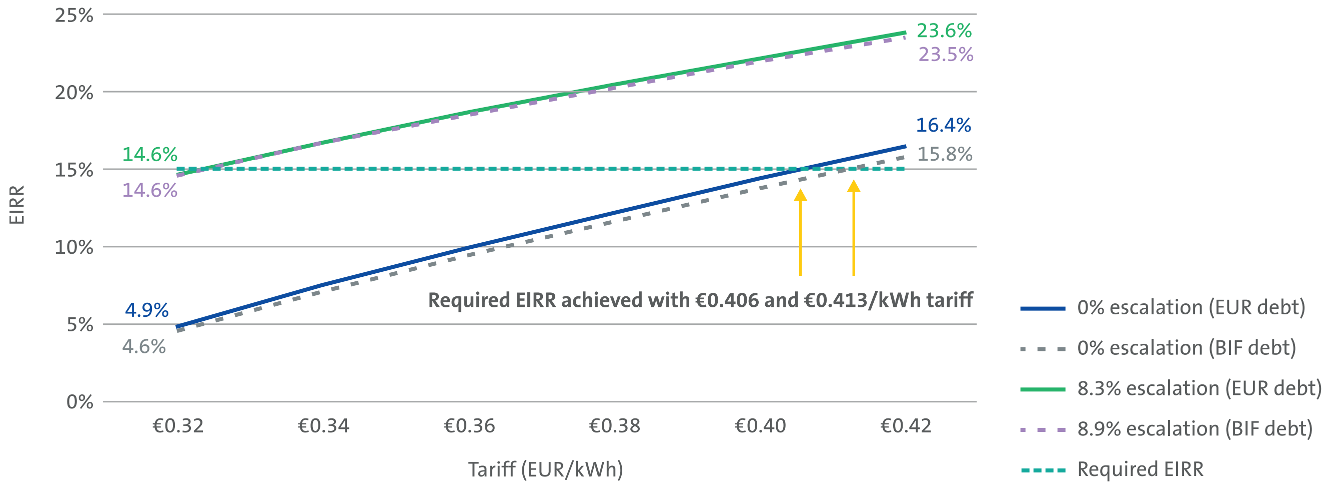
FIGURE 1. Equity IRR at various tariff and grant levels



Tariff and inflation scenarios

Figure 2 illustrates the impact of increases in the tariff and inflation rate on EIRR. The results show that the required EIRR will only be achieved if the assumed tariff of EUR 0.32/kWh escalates annually by at least 8.3% and 8.9% under the EUR debt and BIF debt scenarios, respectively. Without tariff escalation, the Project will require tariffs of EUR 0.406/kWh and EUR 0.413/kWh under the EUR debt and BIF debt scenarios, respectively, to achieve the required equity IRR.

FIGURE 2. Equity IRR at various tariff and escalation levels



Debt interest rate scenarios

Figure 3 and **Figure 4** illustrate the impact of increases in both the EUR-denominated and BIF-denominated debt interest rates on EIRR and DSCR, respectively. The results show that the required EIRR will be achieved at the interest rates considered under the BIF-denominated debt scenario; however, under the EUR-denominated debt scenario, it will only be achieved if interest rates do not exceed 16.4% (well above the assumed rate of 8.5%). More importantly, it also reveals that the minimum DSCR threshold can only be achieved with EUR debt priced below 8.8% (above the assumed 8.5% rate) and BIF debt priced below 11.5% (below the assumed 16% rate). This indicates that the Project will require concessional debt terms if financed with BIF debt.

FIGURE 3. Equity IRR at various debt interest rates

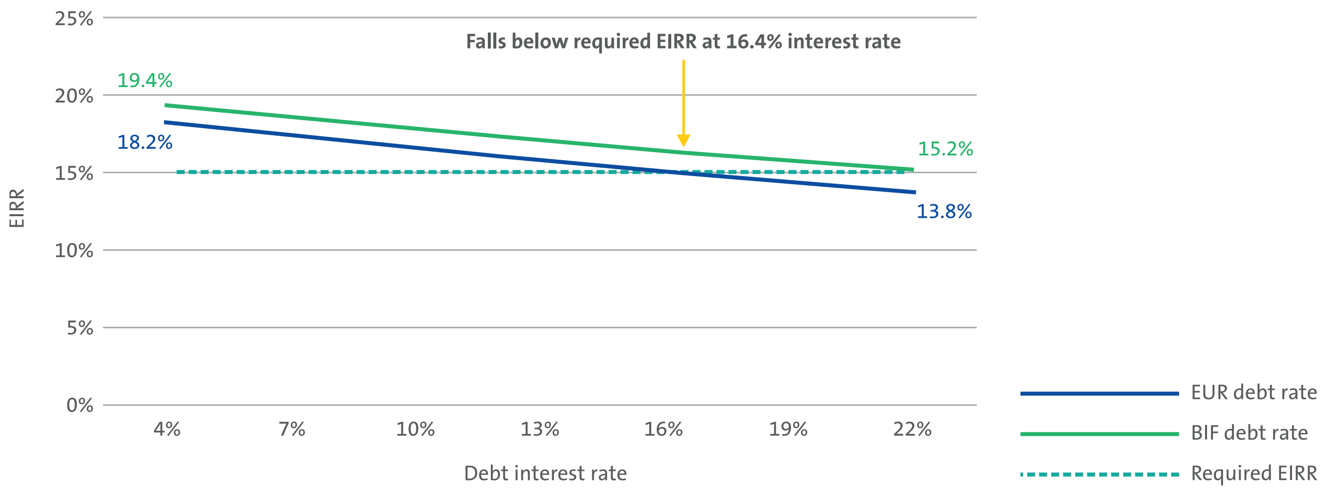
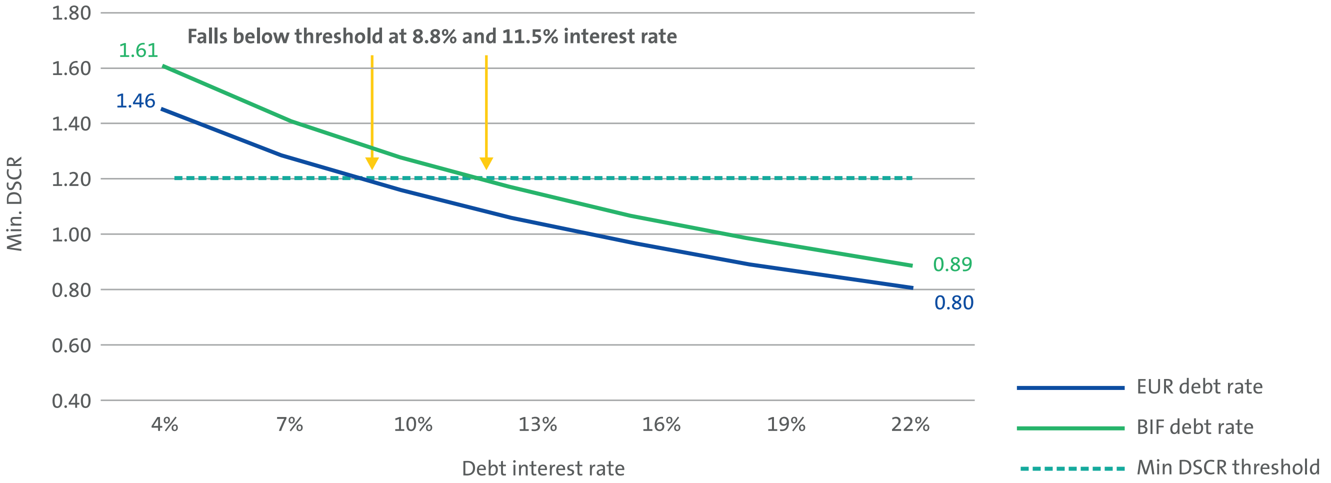


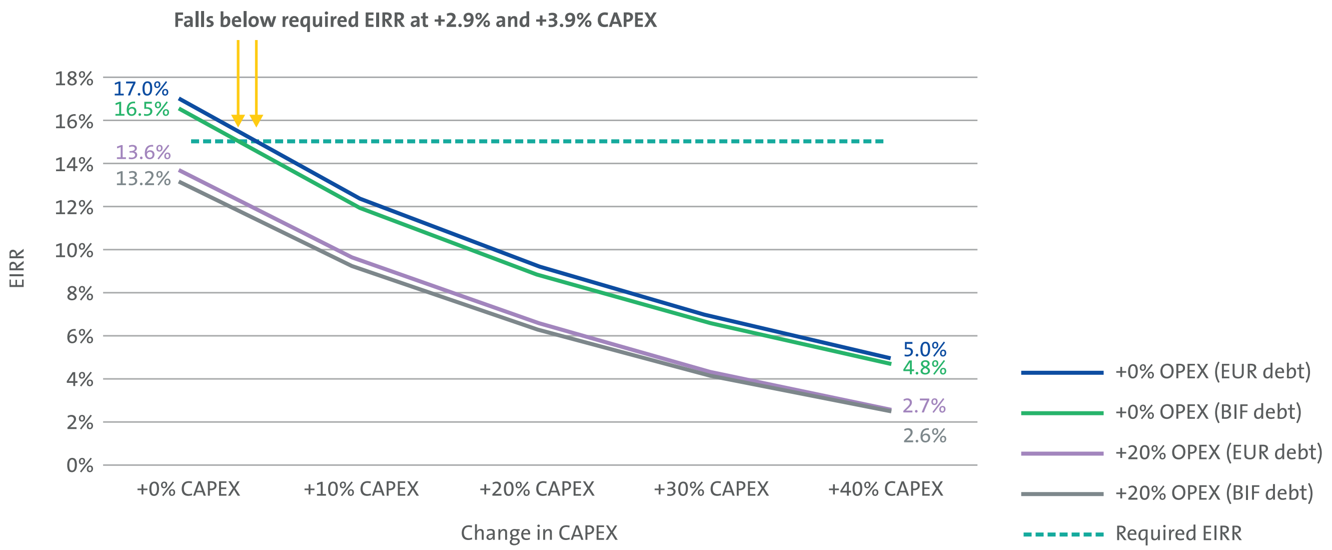
FIGURE 4. Minimum debt service coverage ratio at various debt interest rates



CAPEX and OPEX scenarios

Figure 5 shows the impact of changes in CAPEX and OPEX on EIRR. The analysis found that if OPEX remains unchanged, the required EIRR will be achieved unless CAPEX increases slightly by more than 2.9% and 3.9% under the BIF debt and EUR debt scenarios, respectively, indicating that the viability of the Project is highly sensitive to minor capital cost overruns.

FIGURE 5. Equity IRR at various CAPEX and OPEX levels



CONCLUSIONS AND KEY TAKEAWAYS

In conclusion, based on the assumptions in this Model Business Case, the hybrid solar-SHP mini-grid Project is estimated to be attractive with an after-tax EIRR of 17% and 16.5%, when financed with EUR debt and BIF debt, respectively. However, the viability of the Project will depend on the ability of the developer to identify a community with sufficient electricity demand. The Project will also require an annual tariff escalation of at least 8.3% (at the assumed EUR 0.32/kWh initial tariff) or an increased initial tariff of at least EUR 0.41/kWh (without escalation). It is recommended that the developer adopts a higher tariff from the onset rather than increasing the tariff annually to prevent customer pushback.

In addition, the Project will require grant funding of at least EUR 435 per connection (at the assumed EUR 0.32/kWh tariff) or a tariff of EUR 0.68/kWh (without grants) in order to be attractive. Project viability also depends on the ability of the developer to manage capital costs (one way of reducing capital costs is to identify and rehabilitate an existing non-functional micro hydro plant). In addition, the Project will require concessional debt terms or a DSRA if financed with local currency debt.

KEY DEFINITIONS

Avg. annual revenue is the average annual revenue generated over the life of the Project.

Avg. annual expenses is the average annual operating expenses incurred over the life of the Project.

Avg. EBITDA is the average earnings before interest, taxes, depreciation, and amortisation over the life of the Project.

Avg. net income is the average net income generated over the life of the Project.

LCOE (levelised cost of energy) is the net present value of the total costs incurred by the Project over its lifetime divided by the net present value of the total power generated over its lifetime.

Total cashflow to equity refers to the total cash flow distributed to the equity investor over the life of the Project.

Net cashflow to equity refers to the Total Cashflow to Equity less the equity investment in the Project.

After tax equity IRR is the post-tax internal rate of return on equity investment after taking account of debt service.

After tax project IRR is the post-tax internal rate of return on the Project. It is the discount rate at which the net present value (NPV) of the Project is equal to zero.

Equity NPV is the net present value of the free cash flows to the equity investor using the required equity rate of return as the discount rate.

Initial equity payback period (yrs.) refers to the number of years it takes to recover the equity investment in the Project.

Initial project payback period (yrs.) refers to the number of years it takes to recover the initial capital cost of the Project.

Avg. DSCR is the average debt service coverage ratio over the life of the Project.

Min. DSCR is the minimum debt service coverage ratio over the life of the Project.

ABOUT GET.INVEST MARKET INSIGHTS

The first series of GET.invest Market Insights was published in early 2019 covering four renewable energy market segments in three countries, namely: renewable energy applications in the agricultural value-chain (Senegal), captive power (behind the meter) generation (Uganda), mini-grids (Zambia) and stand-alone solar systems (Zambia).

A **Developer Guide** aims at informing project developers, private sector technology suppliers, innovators and entrepreneurs about opportunities for small hydropower (SHP) development in Burundi. The Guide is organised into four main sections: **1)** introduction; **2)** context for SHP development in sub-Saharan Africa; **3)** role of small hydropower in supporting local communities or industries in rural areas of Burundi; and **4)** "Route-to-market" – i.e., how to leverage the market research presented in the Guide to contribute to SHP development in Burundi.

Accompanying the Guide are two corresponding Model Business Cases, which provide financial analyses for concrete business examples. The two **Model Business Cases** included in this package analyse: **1)** a tea factory that develops a SHP project to power its operations; and **2)** a hybrid solar PV-small hydropower mini-grid that provides electricity to an off-grid community in rural Burundi.

The GET.invest Market Insights summarise a considerable amount of data that may inform early market exploration and pre-feasibility studies. It is therefore recommended to cross-read this Developer Guide and the Model Business Cases for a comprehensive overview. The products are accessible at www.get-invest.eu.

ABOUT GET.INVEST BURUNDI

GET.invest is a European programme that mobilises investment in renewable energy, supported by the European Union, Germany, Sweden, the Netherlands, and Austria.

Since October 2021, the programme has been operating a country window in Burundi funded by the European Union and implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). Find out more at GET.invest Burundi.

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We welcome your feedback on the Market Insights by sharing any questions or comments via email at info@get-invest.eu.

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