Uganda: Renewable Energy Cooling and Processing for the Food Industry

Model Business Case: Fish Cooling Under the Keymaker Model

INTRODUCTION

This Model Business Case (MBC) analyses the financial feasibility of a 60 kWp mini-grid project running on a solar PV-battery-diesel hybrid system on an island on Lake Victoria (the Project). The green mini-grid (GMG)[1] can provide basic electricity needs to approximately 450 off-grid households and 35 small and medium-sized enterprises (SMEs). This MBC examines the KeyMaker Model (KMM) for fish cooling on the Ugandan side of Lake Victoria.[2]

In order to ensure the long-term financial viability of a mini-grid project, developers typically must rely on either a large number of electricity consumers or some form of sustained economic activity with higher levels of capacity utilisation, referred to as productive use of energy (PUE), which provides developers with more predictable power demand and stable revenues. As PUE increases, it becomes more economical for mini-grid developers to generate electricity. Given that the customer base for a rural mini-grid is mainly village households with limited electricity needs, developers usually prioritise sites with 'anchor loads' or that have SMEs or other productive users.[3] This arrangement is a win-win for both the mini-grid

1) In a hybrid solar PV-diesel mini-grid, the diesel is rarely used for generation (or when there is more night-time load or daytime peak load than expected or during rainy season); it is primarily used to charge the system's batteries on a monthly basis in order to ensure their longevity.

2) "JUMEME's business model for mini-grids reaping multiple benefits in Tanzania," Sustainable Energy for All (SEforALL), (27 May 2020): https://www.seforall.org/news/jumemes-business-model-for-mini-grids-reaping-multiple-benefits-in-tanzania and "JUMEME launches its first solar powered mini-grid on the lake Victoria island of Ukara, Tanzania," Energy4Impact, (5 April 2016): https://energy4impact.org/news/jumeme-launches-its-first-solar-powered-mini-grid-lake-victoria-island-ukara-tanzania

3) Mini-grid electrification models have been deployed with varying degrees of success. One common example is the Anchor-Business-Community (ABC) business model, whereby developers serve rural areas by leveraging the continuous demand from 'anchor' customers (e.g., telecommunications tower, institutional facility, mining operation, etc.) to provide a reliable revenue stream for their project.

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developer and the community. For the developer, a productive user represents a dependable client that uses and pays reliably for larger volumes of electricity. For the community, PUE businesses represent local income, job creation, economic growth and development.

A common challenge with this model is that PUE businesses do not emerge spontaneously in villages that have never had electricity before. As a result, the success of a mini-grid project often depends on how well a developer is able to engage with the beneficiary community to nurture local business start-ups and provide associated training and microfinance to village entrepreneurs. The KeyMaker Model is an innovation that builds on this process by having the mini-grid developer take responsibility for directly developing a PUE business in the village, thus simultaneously becoming the electricity provider and an electricity consumer, while adding value and commercialising a product that is indigenous to the community.

Under the KeyMaker Model presented in this Model Business Case, the mini-grid developer purchases freshwater fish from local fisherfolk, cleans and deep-freezes the fish on site using electricity from the mini-grid, and transports the frozen product to wholesale offtakers in urban areas. The fish is sold at significantly higher prices (and with fewer losses due to spoilage) than in rural areas and neighbouring communities in and around the lake.[4] The fish processing and storage business is the number one consumer of the GMG, owned by the same entrepreneur (who realises savings by sharing administrative costs between the two businesses). The KeyMaker Model was conceptualised and implemented by JUMEME, a mini-grid developer, and its consulting arm, INENSUS GmbH. JUMEME owns and operates 23 mini-grids on islands in Lake Victoria and on the banks of Lake Tanganyika.

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) (i) project developers, who may be interested in pursuing opportunities for solar PV mini-grid development in Uganda (or elsewhere) adopting the KMM; and (ii) potential investors, development partners, governments and DFIs, who may be interested in financing solar PV mini-grids in Uganda.

KEY ASSUMPTIONS

This MBC is based on several assumptions described below. The assumptions and key parameters of the analysis are mainly based on publicly available information gathered through desk research, as well as interviews with local stakeholders in Uganda, including representatives from: (i) the Ministry of Agriculture, Animal Industries and Fisheries (MAAIF); (ii) the Directorate of Fisheries Resources; (iii) the Uganda Fish Processors and Exporters Association (UFPEA); and (iv) fish traders at the Kiyindi Landing Site on Lake Victoria. This MBC was also reviewed by JUMEME. 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, while **Table 2** and **Table 3** present the assumptions related to the technical parameters of the solar PV mini-grid and the KeyMaker Model, respectively.

4) Grandón, T. and Peterschmidt N., "KeyMaker Model Fundamentals: Mini-grids as a tool for inclusion of deep rural communities," Green Mini-Grid Help Desk, SEforALL Africa Hub, AfDB, (November 2019): https://greenminigrid.afdb.org/sites/default/files/kmm_fundamentals.pdf

TABLE 1. Solar PV mini-grid customers and demand[5]

CUSTOMER TYPE[6]	NO. OF CONNECTIONS	AVERAGE MONTHLY CONSUMPTION PER CONNECTION (kWh)	TOTAL MONTHLY CONSUMPTION (kWh)
	MINI-GRID ONLY DEMAND		
Households	450	10	4,500
Small businesses	35	27	954
Public connections	4	45	180
Small-scale industrial users	8	149	1,192
Total (excluding KeyMaker)	497	231	6,826
	ADDITIONAL DEMAND UNDER KMM		
Anchor customer – KeyMaker	1	91[7]	91
Total (including KeyMaker)	498	322	6,917

TABLE 2. Solar PV mini-grid system technical assumptions

SOLAR PV SYSTEM PARAMETERS	UNIT	VALUE
Base annual yield	kWh/kWp	1,534[8]
Solar PV system capacity	kWp	60[9]
Annual generation, Yr. 1	kWh	92,040[10]
Battery capacity/size	kWh	240[11]
Inverter capacity	kW	54[12]
Low voltage distribution network	km	7[13]
Diesel gen capacity	kVA	33[14]
Diesel usage	Litres/Year	5,500[15]

5) These are hypothetical demand assumptions tailored to the mini-grid system capacity presented in Table 2.
6) 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.
7) A detailed breakdown is provided in Table 3.
8) Solargis: https://solargis.com/maps-and-gis-data/download/uganda
9) Based on JUMEME's pilot mini-grid on the Lake Victoria island of Ukara, Tanzania.
10) Derived by multiplying the base annual yield by the solar PV system capacity.
11) Based on JUMEME's pilot mini-grid on the Lake Victoria island of Ukara, Tanzania.
12) Based on JUMEME's pilot mini-grid on the Lake Victoria island of Ukara, Tanzania.
13) Based on JUMEME's pilot mini-grid on the Lake Victoria island of Ukara, Tanzania; and Theron, A., "Solar hybrid mini-grids to uplift Tanzanian economy," ESI-Africa, (April 18, 2016): https://www.esi-africa.com/regional-news/east-africa/solar-hybrid-mini-grids-to-uplift-tanzanian-economy/
14) Based on JUMEME's pilot mini-grid on the Lake Victoria island of Ukara, Tanzania.
15) Based on a 7% usage level per year for the diesel genset and a diesel consumption rate of 0.35 litre per kWh.

TABLE 3. KeyMaker Model technical assumptions

PARAMETER	UNIT	VALUE
Quantity of fresh fish procured (annually)	Kg/year	52,000[16]
% Fresh fish lost due to cleaning and transport/handling[17]	%	2%[18]
Quantity of marketable frozen fish	Kg/year	50,960[19]
Typical freezer volume	m^3	0.57[20]
Max. quantity of frozen fish per freezer	Kg/day	222[21]
Number of freezers required	#	2[22]
Power demand/capacity per freezer	kW	0.35[23]
Number of hours for freezing	Hrs/day	5[24]
Electricity required daily per freezer	kWh/day	1.75[25]
Total electricity required per month	kWh/month	91[26]

Macroeconomic assumptions

The Euro (EUR) to Ugandan Shilling (UGX) exchange rate is assumed to be UGX 3,929.1.[27] Annual inflation is assumed to be 5% based on projections for Uganda,[28] while the annual UGX/EUR depreciation is assumed to be 2%.[29]

16) Based on JUMEME delivering 52 tons of Tilapia per year (Source: Grandón and Peterschmidt, 2019). Local stakeholder interviews revealed that while fish stocks have dwindled and harvested volumes are currently unstable, 52,000 kg of fish per year is a realistic estimate. It is also worth noting that in Uganda, fisherfolk are banned from the lakes to allow for the recovery of the fish stocks from time to time. This may happen once every two years and may last for a period of about 4-6 months. However, these are not usually planned. The analysis assumes an off-season period of 3 months every year.
17) Refers to the portion of the fish procured by the KeyMaker that is lost during cleaning, inspection, transport or handling.
18) Stakeholder interviews, 2022.
19) Derived by accounting for losses during cleaning and transportation.
20) Blackstone, V., "How Many Watts Does the Average Freezer Require?" (16 April 2020): https://www.hunker.com/13408418/how-many-watts-does-the-average-freezer-require
21) Based on the assumption that 1 cubic foot of freezer space accommodates approximately 35 pounds of food (source: https://www.lowes.com/n/buying-guide/freezer-buying-guide) and each freezer is kept 70% full at maximum to ensure proper air circulation while optimising energy efficiency (source: https://www.searshomeservices.com/blog/5-most-common-freezer-problems-and-solutions)
22) Derived by dividing the quantity of fresh fish procured daily by the maximum quantity of frozen fish per freezer.
23) Blackstone, 2020.
24) Grandón and Peterschmidt, 2019; and https://www.fao.org/3/v3630e/v3630e03.htm
25) Derived by multiplying the freezer power demand by daily fish freezing hours.
26) Based on the following assumptions (derived from local stakeholder interviews): station operating time of 6 days/week and 39 weeks/year.
27) Currency conversion as of January 10, 2023.
28) Trading Economics: Uganda Inflation Rate: https://tradingeconomics.com/uganda/inflation-cpi
29) Calculated based on UGX/EUR historical exchange rate data.

Capital costs

Table 4 presents the capital cost assumptions for the Project. The estimated costs are based on data from similar mini-grid projects obtained via desk research. The mini-grid capital expenditure (CAPEX) includes the cost of the power generation system (solar PV modules and inverters), the battery bank, balance of plant (mounting structures, cables, collection boxes, etc.), the low-voltage distribution network including smart meters, project development costs (which include expenses for identifying and securing the project site and obtaining regulatory approvals), as well as design and installation costs. The capital costs of the fish cooling operation comprise the cost of freezers and cooler boxes (for transporting the frozen fish) and the construction of a small fish freezing station where the fish cleaning, freezing and handling will be carried out on site. All cost estimates provided are inclusive of applicable import duties and Value-Added Tax (VAT). 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 4. Capital cost assumptions

MINI-GRID CAPEX		
CUSTOMER TYPE	NO. OF CONNECTIONS	AVERAGE MONTHLY CONSUMPTION PER CONNECTION (kWh)
Solar PV cost per kWp, including racking	€1,308[30]	€78,485
Lead acid battery cost per kWh	€280[31]	€67,272
Diesel gen cost per kVA	€407[32]	€13,438
Inverter cost per kW	€150[33]	€8,100
Low voltage distribution network cost per km	€3,000[34]	€21,000
Development costs per kWp	€500[35]	€30,000
	Total mini-grid only CAPEX	**€218,295**
	Mini-grid only CAPEX per connection	**€438**
	Mini-grid only CAPEX per kWp	**€3,638**

30) Daglish, J. "A Prefeasibility Analysis of a PV Mini Grid with Ice Plant on Buvu Island in Lake Victoria," KTH Unit of Energy Systems Analysis, Stockholm, Sweden, (2019): https://www.diva-portal.org/smash/get/diva2:1372692/FULLTEXT01.pdf
31) Ibid.
32) Based on local prices of diesel generators in Uganda.
33) GET.invest Market Insights, 2020. "Uganda: Captive Power - Model Business Case: Solar PV for Commercial and Industrial Facilities," https://www.get-invest.eu/wp-content/uploads/2020/11/GETinvest-Market-Insights_UGA_Captive_MBC-Facilities_2019.pdf
34) Stakeholder interviews, 2022.
35) Stakeholder interviews, 2022.

TABLE 4. Capital cost assumptions (Continued)

KEYMAKER MODEL CAPEX		
CAPITAL COSTS	UNIT COST (EUR)	TOTAL COST (EUR)
Freezers	€754[36]	€1,508
Construction of freezing station	€4,500[37]	€4,500
Cooler boxes for transport	€51[38]	€608
	Total KeyMaker CAPEX	**€6,616**
	Overall total mini-grid with KeyMaker CAPEX	**€224,911**

COGS and operating costs

Table 5 presents the Cost of Goods Sold (COGS) and operating cost assumptions for the Project. Operating expenditure (OPEX) for the mini-grid includes annual operations and maintenance (O&M) costs for both the generation plant and the distribution network, staff salaries, diesel cost, and other operating expenses, including administrative expenses and insurance costs. The assumed costs of diesel generator and battery replacements in the 8th and 15th year of operation and inverter replacement in the 16th year are also presented. The battery and inverter replacement costs are based on an annual price reduction assumption of 3% compared to the initial investment, while no cost reduction was assumed for the diesel gen replacement.[39] For the KeyMaker Model, COGS and OPEX includes the cost of fresh fish purchased from local fisherfolk, transportation costs, equipment, O&M, additional labour and sales staff costs, and other administrative costs. It is assumed that the COGS and operating costs will escalate by 5% annually in line with inflation.

36) Based on local prices of Chest Freezers in Uganda.
37) Daglish, 2019
38) Based on the local price of 34.5L cooler boxes; Number of cooler boxes required (12 units) is derived by dividing the quantity of marketable frozen fish by the product of density of frozen fish and cooler box volume.
39) GET.invest Market Insights, 2019. "Zambia - Solar PV and Hydro Mini-Grids: Model Business Case: Solar PV Mini-Grid for Rural Electrification," https://www.get-invest.eu/wp-content/uploads/2020/10/GETinvest-Market-Insights_ZMB_Mini-grid_-MBC-Solar_2019-1.pdf

TABLE 5. COGS and operating costassumptions

OPERATING COSTS	UNIT	COST/UNIT	TOTAL COST YEAR 1 (EUR)
	MINI-GRID ONLY OPEX		
O&M costs (generation and distribution)	% of CAPEX	2%[40]	€4,366
Diesel cost	EUR/litre	€1.49[41]	€8,196
		Total Mini-Grid Only OPEX	**€12,562**
	KEYMAKER MODEL COGS AND OPEX		
Cost of fresh fish (excl. transport)	EUR/kg	2.04[42]	€105,876
Transport costs	EUR/kg	0.13[43]	€6,617
Equipment O&M	% of CAPEX	10.0%[44]	€662
Labour (non-payroll)	EUR/man-day	4.04[45]	€4,723[46]
Payroll (sales/marketing manager)	EUR/year	-	€4,767[47]
Other SG&A	EUR/year	-	€1,000[48]
Total KeyMaker COGS and OPEX			**€123,646**
Overall total mini-grid with KeyMaker COGS and OPEX			**€136,208**
Diesel gen replacement cost – Year 8[49]			€16,760
Diesel gen replacement cost – Year 15[50]			€20,335
Battery replacement cost – Year 8[51]			€52,724
Battery replacement cost – Year 15[52]			€42,600
Inverter replacement cost – Year 16[53]			€4,975
Freezer replacement cost – Year 11[54]			€2,579
Cooler box replacement cost – Year 11[55]			€1,039

40) Daglish, 2019.
41) Link: https://www.globalpetrolprices.com/Uganda/diesel_prices/
42) UGX 5000-8000 per Kg (Source: Stakeholder Interviews, 2022).
43) UGX 300-500 per Kg (Source: Stakeholder Interviews, 2022).
44) Grandón and Peterschmidt, 2019.
45) Link: https://tradingeconomics.com/uganda/wages-low-skilled.
46) Based on the following assumptions derived from local stakeholder interviews: 5 labourers handling 50kg of fish per day, station operating time of 6 days per week and 39 weeks per year.
47) Link: https://www.paylab.com/ug/salaryinfo/marketing-advertising-pr/marketing-specialist?lang=en
48) Grandón and Peterschmidt, 2019.
49) GET.invest Market Insights, 2019.
50) Ibid.
51) "Open Sourcing Infrastructure Finance for Mini-Grids," Crossboundary Energy Access, (2020); and Lane, C. "Are lithium-ion solar batteries the best energy storage option?" Solar Reviews, (October 5, 2023): https://www.solarreviews.com/blog/are-lithium-ion-the-best-solar-batteries-for-energy-storage
52) Ibid.
53) 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/
54) US Department of Energy; and https://www.thespruce.com/freezer-chest-versus-upright-freezer-1908647
55) Link: https://engelcoolers.com/pages/warranty.

Taxes

A corporate income tax rate of 30% was applied to the Project (the applicable tax rate in Uganda) with no tax holiday. The solar PV system was considered to be VAT-exempt in line with Ugandan policy, while a standard VAT rate of 18% was incorporated into the capital costs of the other components of the Project.[56]

Revenue

The model assumes a uniform mini-grid tariff (VAT exclusive) of UGX 1,000/kWh (EUR 0.25/kWh)[57] for all the different types of customers,[58] and a one-time connection fee of UGX 140,000 (EUR 35.63) per connection.[59] The wholesale price of frozen fish in urban areas is assumed to be UGX 12,000 (EUR 3.05)/kg.[60] It is also assumed that the mini-grid tariff and fish price will escalate by 5% annually in line with inflation.

Financing scenarios and debt assumptions

It is assumed that the Project will be financed with 30% equity, and it will obtain performance-based grants (PBG) of EUR 350 per connection,[61] which will be received during the first year of operation. 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 are covered by long-term debt (**Table 6**).

56) PwC: Uganda Taxes on Corporate Income (20 August 2021): https://taxsummaries.pwc.com/uganda/corporate/taxes-on-corporate-income; PwC: Uganda Value Added Tax (VAT), (20 August 2021): https://taxsummaries.pwc.com/uganda/corporate/other-taxes
57) In theory, there is no restriction on allowable mini-grid tariffs in Uganda, although in practice, based on stakeholder interviews, around 1,000 Ugandan shillings per kWh is the political upper limit. The Electricity Regulatory Authority reported that it has allowed $0.3 to 0.5/kWh for unregulated tariffs to be charged, although there is only one known example of this taking place - Absolute Energy, Kitobo Island. "Mini-Grid Market Opportunity Assessment: Uganda," Green Mini-Grid Market Development Programme: SEforALL Africa Hub & African Development Bank, (May 2018): https://greenminigrid.afdb.org/sites/default/files/uganda-2.pdf
58) In practice, mini-grid operators might charge SMEs a higher tariff than households, but a uniform tariff is used in this analysis for simplicity.
59) Sendegeya, A., "PV Mini Grids in Uganda – Best Practices," Department of Electrical and Electronics Engineering, Faculty of Engineering, Kyambogo University, Uganda, (2019)
60) Stakeholder interviews, 2022.
61) Phillips, J., Attia, B. and Plutshack, V., "Lessons from the proliferating mini-grid incentive programs in Africa," Brookings Institution, (December 11, 2020): https://www.brookings.edu/blog/future-development/2020/12/11/lessons-from-the-proliferating-mini-grid-incentive-programs-in-africa/

TABLE 6. Capital structure

	MINI-GRID ONLY		KEYMAKER MODEL	
FUNDING TYPE	**% OF CAPEX**	**TOTAL AMOUNT (EUR)**	**% OF CAPEX**	**TOTAL AMOUNT (EUR)**
Long term debt funding	22%	€48,437	24%	€53,068
Equity	30%	€65,489	30%	€67,473
Bridge loan	48%	€104,370	46%	€104,370
Total	**100%**	**€218,295**	**100%**	**€224,911**

Two debt financing scenarios were considered: (i) EUR-denominated debt; and (ii) UGX-denominated debt. **Table 7** presents the project debt assumptions for both scenarios. The long-term debt tenor is assumed to be seven years under both scenarios while the bridge loan tenor is assumed to be one year.[62]

TABLE 7. Project debt assumptions

PROJECT DEBT	UNIT	EUR DEBT	UGX DEBT
Long term debt interest rate	%	8.5%[63]	17%[64]
Bridge loan interest rate[65]	%	10.5%	

RESULTS

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

- Under the KeyMaker Model with EUR-denominated debt, the investment opportunity is very attractive, with an after-tax equity IRR of 37.1%, equity NPV of EUR 36,296, and minimum Debt Service Coverage Ratio (DSCR) of 1.4, which is above the threshold of 1.2 typically required by lenders to finance a project.
- Under the KeyMaker Model with UGX-denominated debt, the results are quite similar, and the Project is also attractive, albeit with lower investor returns with an after-tax equity IRR of 32.3% and equity NPV of EUR 31,127 due to the high cost of local debt. The minimum DSCR is 1.17, which is slightly below the required threshold.
- Indicating the need for a debt service reserve account (DSRA) or concessional terms.
- Under the mini-grid only scenario with EUR-denominated debt, the Project is not attractive, with an after-tax equity IRR of 2.8%, negative equity NPV of EUR -13,002, and minimum DSCR of 0.76 due to the low tariff and revenues in addition to the effect of equipment replacement costs.
- Under the mini-grid only scenario with UGX-denominated debt, the Project is more unattractive due to the high cost of local debt, with an after-tax equity IRR of 0.5%, negative equity NPV of EUR -20,078 and minimum DSCR of 0.6.

62) Bridge loans typically have short terms of up to 1 year; long-term debt tenor based on the typical payback period of rural mini-grids of around 7-10 years; No grace period assumed in order to be conservative
63) Daglish, 2019.
64) Bank of Uganda - Commercial Bank interest rates and charges
65) 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.

The results of the financial analysis are summarized in **Table 8**.

TABLE 8. Financial analysis results

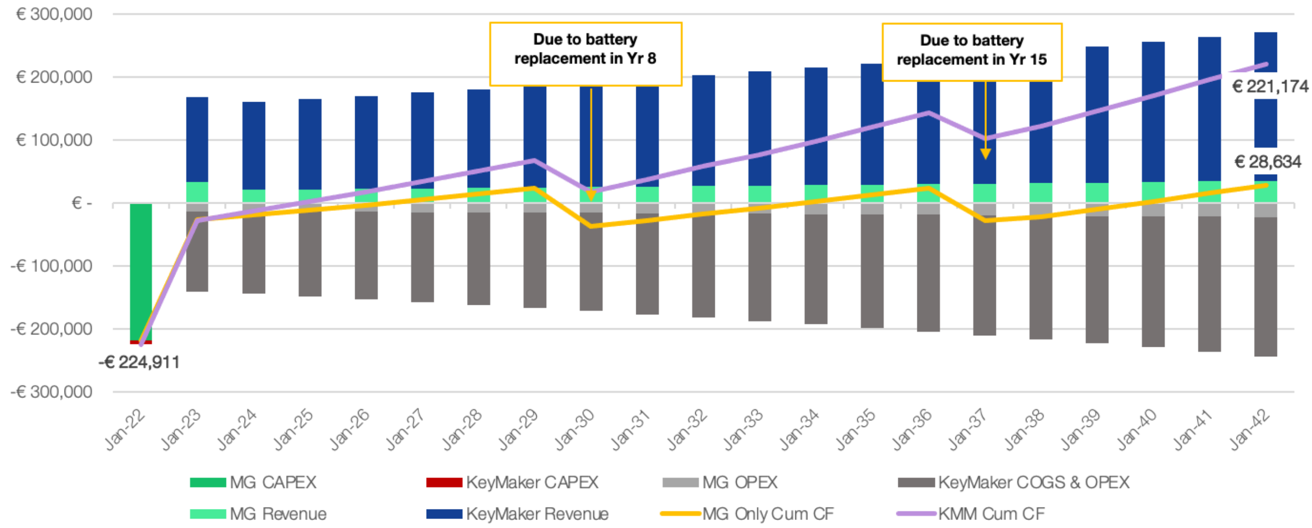
UGANDA MINI-GRID PROJECT RESULTS SUMMARY

	MINI-GRID ONLY		KEYMAKER MODEL	
INDICATOR	**EUR-DENOMINATED DEBT**	**UGX-DENOMINATED DEBT**	**EUR-DENOMINATED DEBT**	**UGX-DENOMINATED DEBT**
Avg. annual mini-grid revenue	€27,926		€27,926	
Avg. annual KeyMaker revenue	€0		€181,330	
Avg. annual expenses	€17,270		€187,257	
Avg. EBITDA	€10,657		€22,000	
Avg. net income	€-7,507	€-8,149	€2,232	€1,716
LCOE	€0.47	€0.49	€0.47	€0.49
Total cashflow to equity	€76,991	€67,806	€273,761	€267,441
Net cashflow to equity	€11,503	€2,317	€206,287	€199,968
After tax equity IRR	2.8%	0.5%	37.1%	32.3%
After tax project IRR	4.3%		17.4%	
Equity NPV	€-13,002	€-20,078	€36,296	€31,127
Initial project payback period (Yrs.)[66]	5	5	3	3
Avg. DSCR	1.07	1.01	1.73	1.67
Min DSCR	0.76	0.60	1.44	1.17

Figure 1 illustrates the difference in the mini-grid developers' cashflows with the adoption of the KeyMaker Model under the EUR-denominated debt scenario. The Project's total cumulative cashflow under the KMM is more than seven times higher than the total cumulative cashflow under the mini-grid only scenario due to the additional operating income generated from the fish freezing operation.

66) The initial project payback period under both scenarios is shorter than the typical rural mini-grid payback period of 7-10 years due to the payback period obtained during the first year of operation.

FIGURE 1. KeyMaker Model vs mini-grid only project cashflows



It is worth noting that in an alternative scenario, where the fish cooling business is operated by a separate third party, the results are similar to the mini-grid only scenario with an after-tax equity IRR of 4.1%, after-tax project IRR of 4.9%, and negative equity NPV of EUR -11,496, because the additional revenue generated by the mini-grid developer from supplying electricity to the fish freezers is minimal.

SENSITIVITY ANALYSIS

A sensitivity analysis was conducted to determine the impact of change in key assumptions on the equity IRR and DSCR as a measure of the viability of the Project. The figures below present the results under various scenarios assuming the Project is financed with EUR-denominated debt.[67] It is assumed that the required rate of return for equity investors to consider a project attractive is 15%.[68]

Tariff and grant scenarios

Figure 2 and **Figure 3** illustrate the impact of increases in the tariff and PBG per connection on equity IRR. The results show that the required equity IRR can only be achieved with grants of at least EUR 255 and EUR 383 per connection at the assumed tariff level under the KMM scenario and mini-grid only scenario, respectively. Without grants, the Project will require tariffs of EUR 0.5/kWh (UGX 1,952/kWh) and EUR 0.6/kWh (UGX 2,327/kWh) under the KMM scenario and mini-grid only scenario, respectively to achieve the required equity IRR.[69] These are significantly above the political upper limit of UGX 1,000/kWh stated earlier, indicating that the government needs to make efforts to enable operators charge competitive cost-reflective tariffs.

67) The debt interest rate scenarios show sensitivity analysis results for both the EUR-denominated debt and UGX-denominated debt.

68) 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/

69) At these tariff levels without grants, the Project has a payback period of 9 years under both scenarios.

FIGURE 2. Tariff and grant scenarios - KeyMaker Model scenario

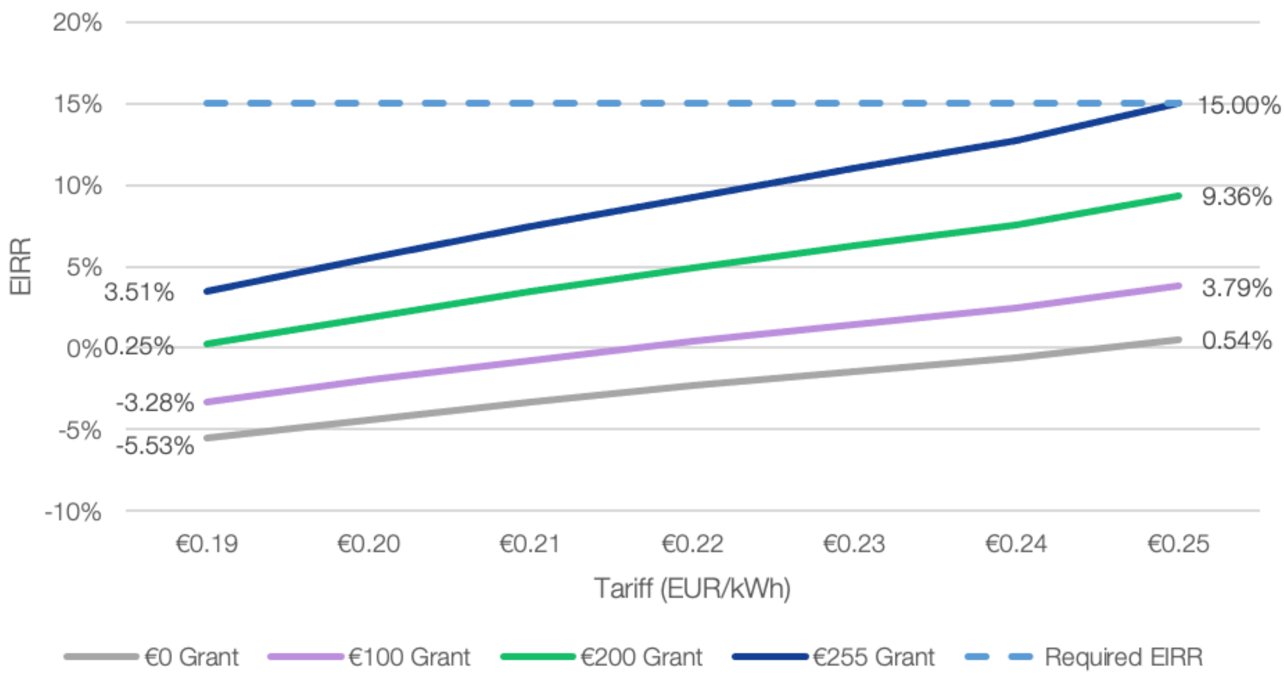
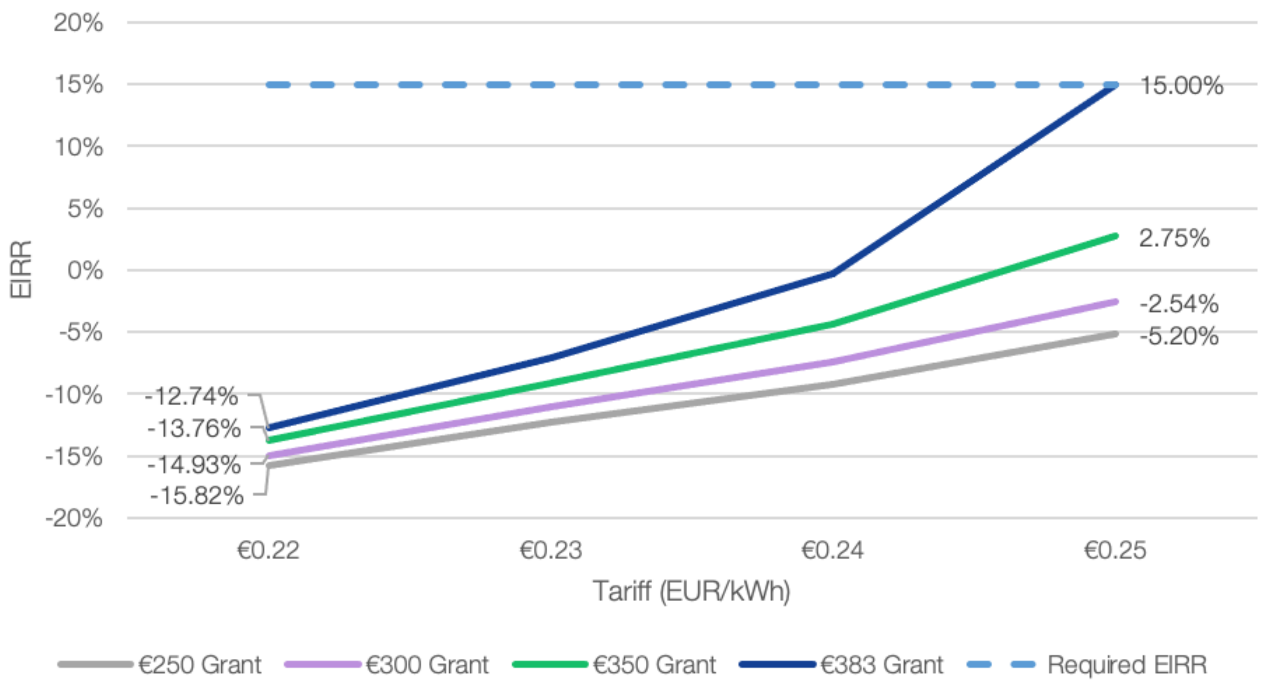


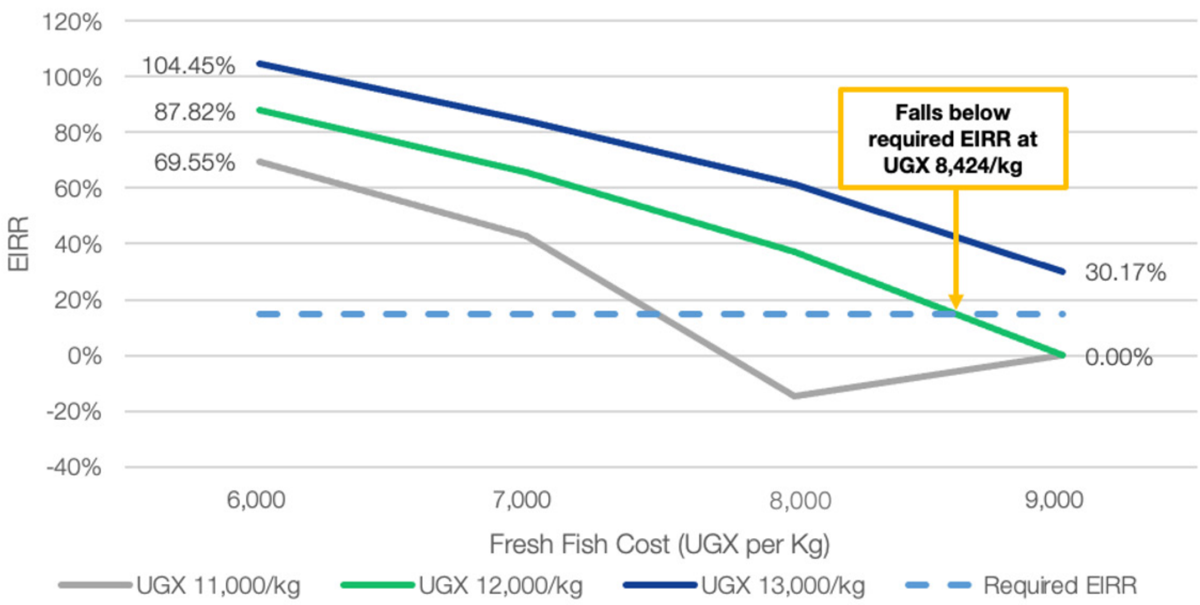
FIGURE 3. Tariff and grant scenarios - Mini-grid only scenario



Fish price and cost scenarios

Figure 4 illustrates the impact of increases in the wholesale price of frozen fish and the cost of fresh fish on equity IRR. The results show that at the assumed wholesale price of UGX 12,000 (EUR 3.05) per kg, the required equity IRR can only be achieved if the cost of fresh fish from the fisherfolk does not exceed UGX 8,424 (EUR 2.14) per kg (slightly above the assumed cost of UGX 8,000 per kg). This reveals that the viability of the Project under the KMM relies heavily on the fish operation's sales margins.

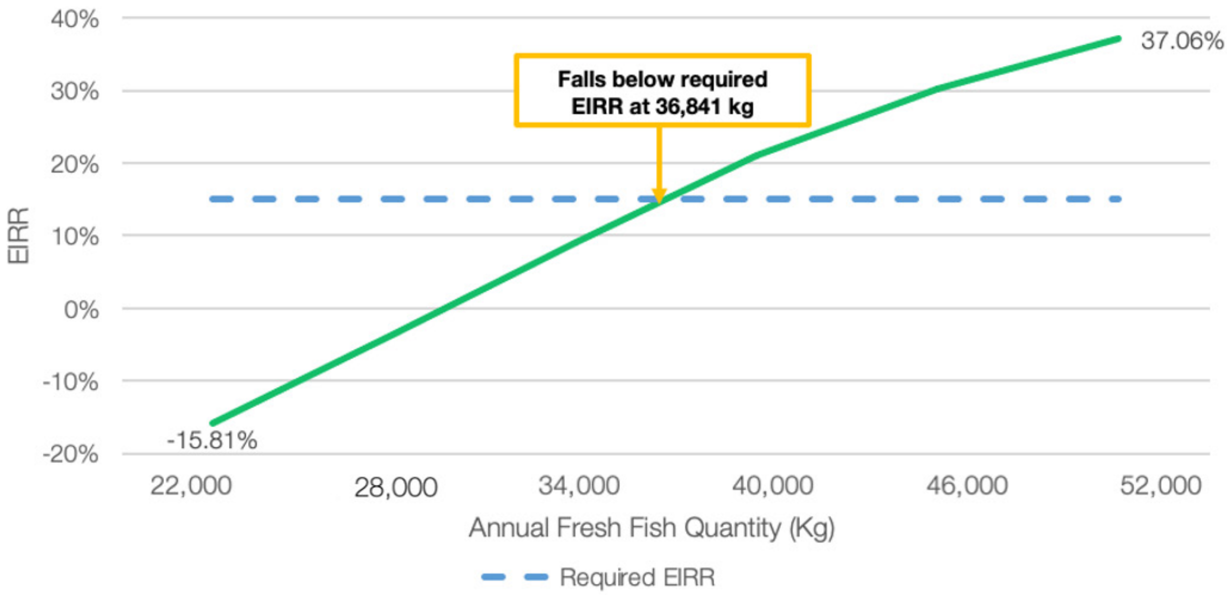
FIGURE 4. Fish price and cost scenarios



Fish quantity scenarios

Figure 5 illustrates the impact of changes in the quantity of fresh fish procured from local fisherfolk on equity IRR. The results show that the required equity IRR will still be achieved if the quantity of fish processed annually drops by 29.2% to 36,841kg from the assumed level of 52,000kg. This indicates that the viability of the Project under the KMM depends on the ability of the operator to procure at least 37 tons of fresh fish for processing and subsequent sales.

FIGURE 5. Fish quantity scenarios



Debt interest rate scenarios

Figure 6 and **Figure 7** illustrate the impact of increases in both the EUR-denominated and UGX-denominated debt interest rates on equity IRR and DSCR, respectively. The results show that the required equity IRR will be comfortably achieved at the interest rates considered under KMM, while it will not be achieved under the mini-grid only scenario, even with concessional interest rates. The results also reveal that the minimum DSCR threshold can be achieved under KMM with EUR debt priced below 14.7% (which is well above the assumed 8.5% rate) and UGX debt priced below 16.1% (slightly below the assumed 17% rate), while it will not be achieved under the mini-grid only scenario, even with concessional interest rates. This indicates that the Project will require a combination of lower debt burden, DSRA and higher tariff under the mini-grid only scenario to be viable. It is worth noting that at the same interest rate, UGX-denominated debt will result in higher returns than EUR-denominated debt, as the effect of currency depreciation would be avoided.

FIGURE 6. Debt interest rate scenarios

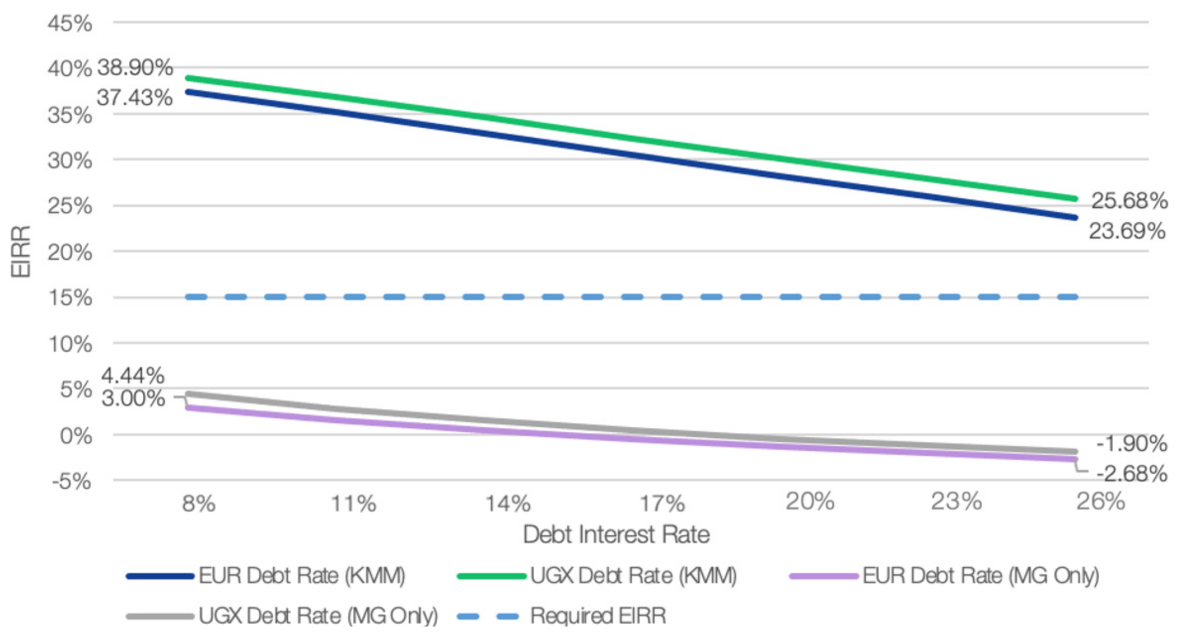
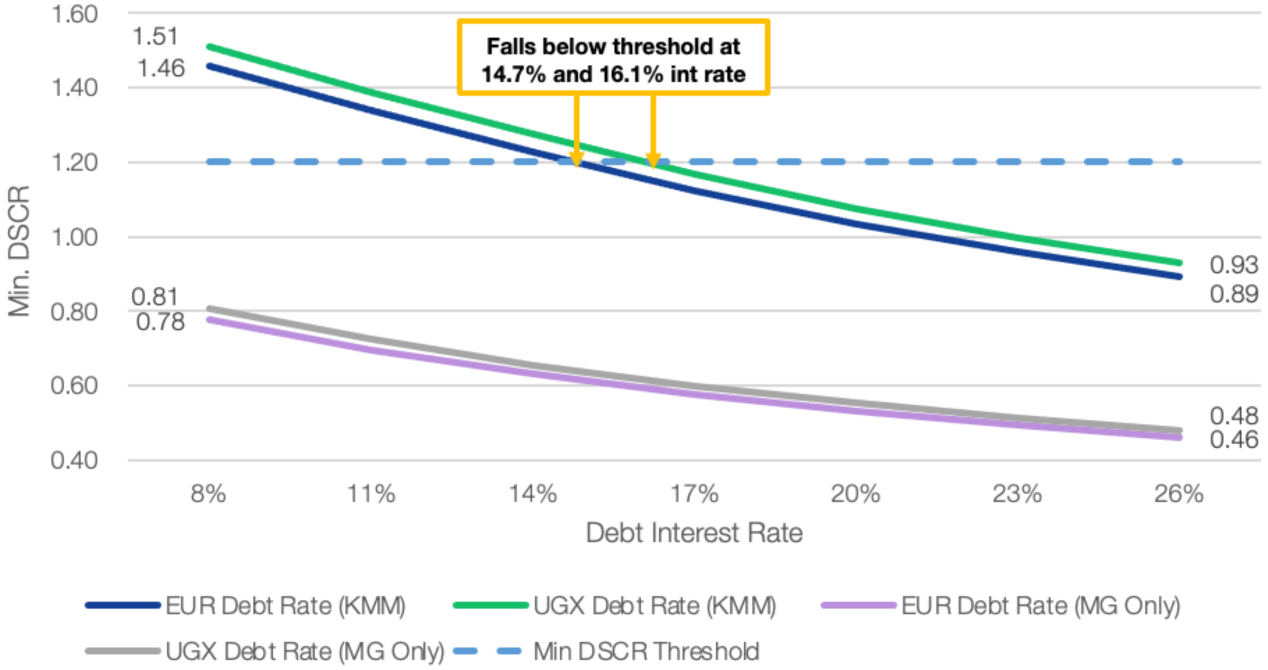


FIGURE 7. DSCR at various debt interest rates



Mini-grid CAPEX and OPEX scenarios

Figure 8 and **Figure 9** show the impact of changes in mini-grid CAPEX and OPEX on equity IRR. The analysis shows that if OPEX remains unchanged, the required equity IRR will be achieved under the mini-grid only scenario if CAPEX reduces by 6.1%. The required equity IRR will be comfortably achieved under the KMM scenario, except when CAPEX increases by more than 18.7%. This indicates that the Project can become attractive under themini-grid only scenario with modest capital cost reductions, while the viability of the Project under the KMM is not sensitive to minor capital cost overruns.

FIGURE 8. Mini-grid CAPEX and OPEX scenarios - KMM scenario

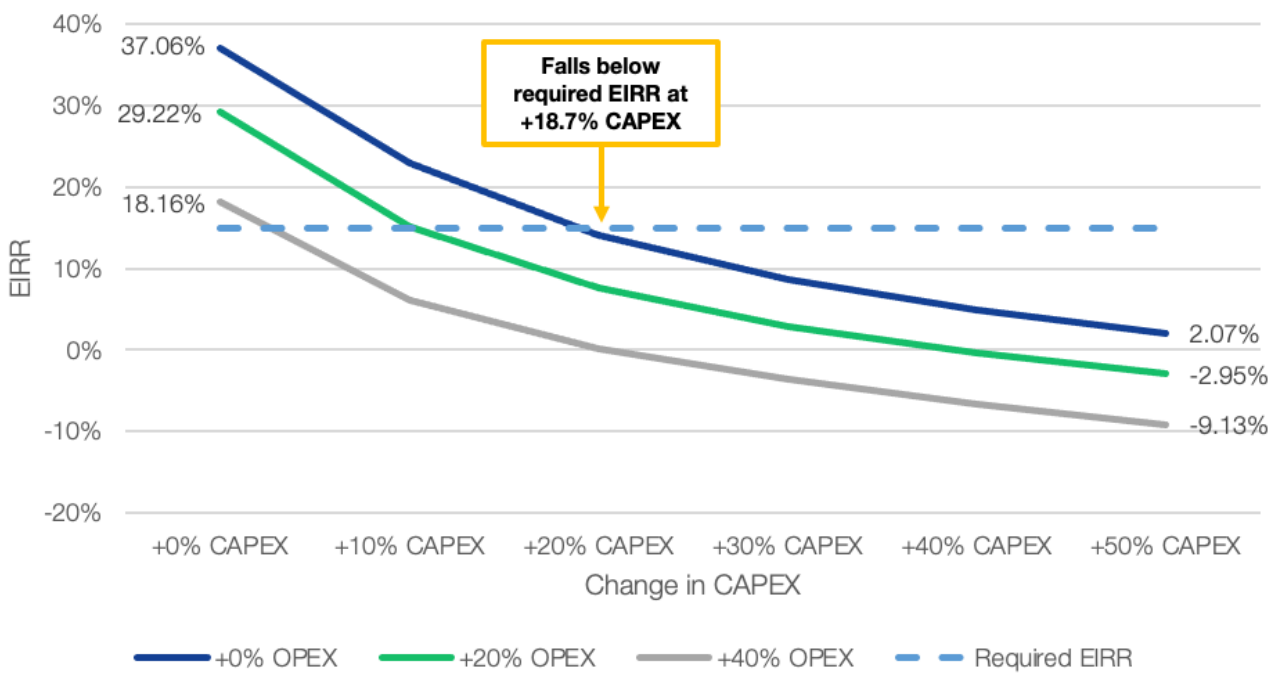
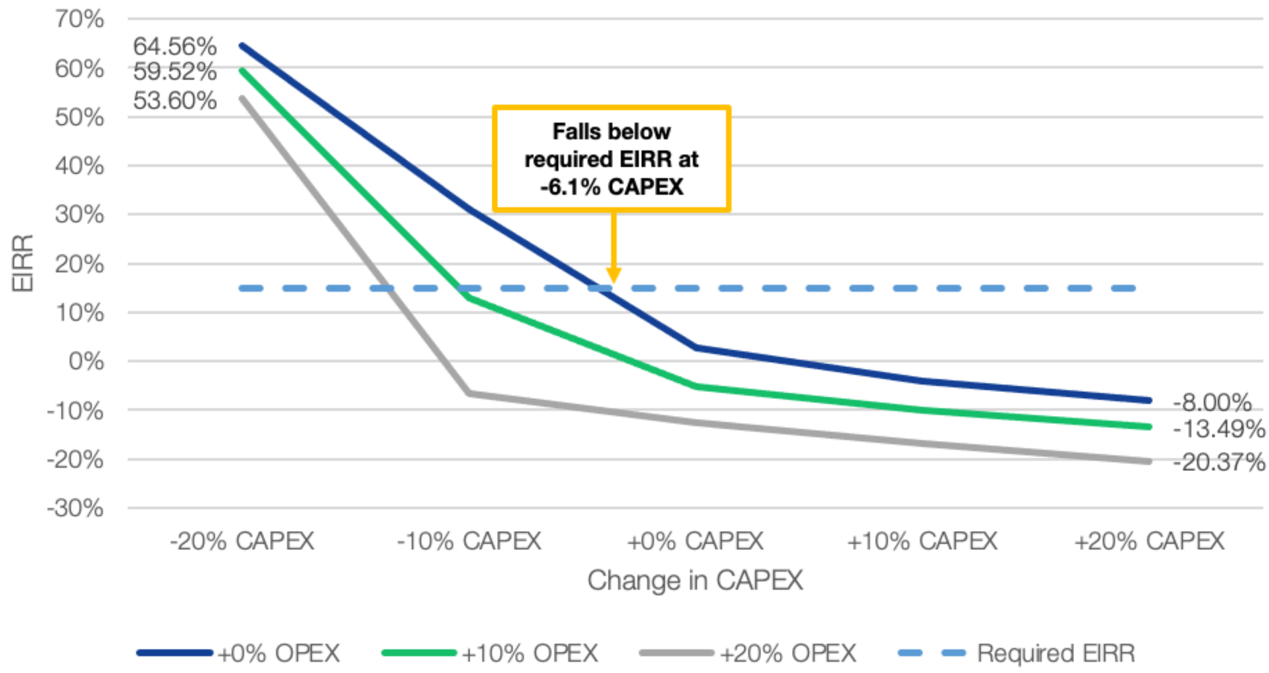


FIGURE 9. Mini-grid CAPEX and OPEX scenarios - Mini-grid only scenario



Local currency depreciation and inflation scenarios

Figure 10 and **Figure 11** present the impact of increases in the local currency annual depreciation rate and inflation rate on equity IRR. The analysis found that under the KMM scenario, even if revenues and costs do not escalate (i.e., 0% inflation rate) throughout the project term, the required equity IRR will still be achieved if the local currency annual depreciation rate does not exceed 5.3% (above the projected average annual depreciation of 2%). However, under the mini-grid only scenario, the results show that even if the local currency does not depreciate, the required equity IRR will only be achieved if revenues escalate annually by at least 6.4% (above the projected escalation rate of 5%). This indicates that the viability of the Project under the mini-grid only scenario will depend on the volatility of the Ugandan Shilling and tariff escalation.

FIGURE 10. Local currency depreciation and inflation scenarios – KMM scenario

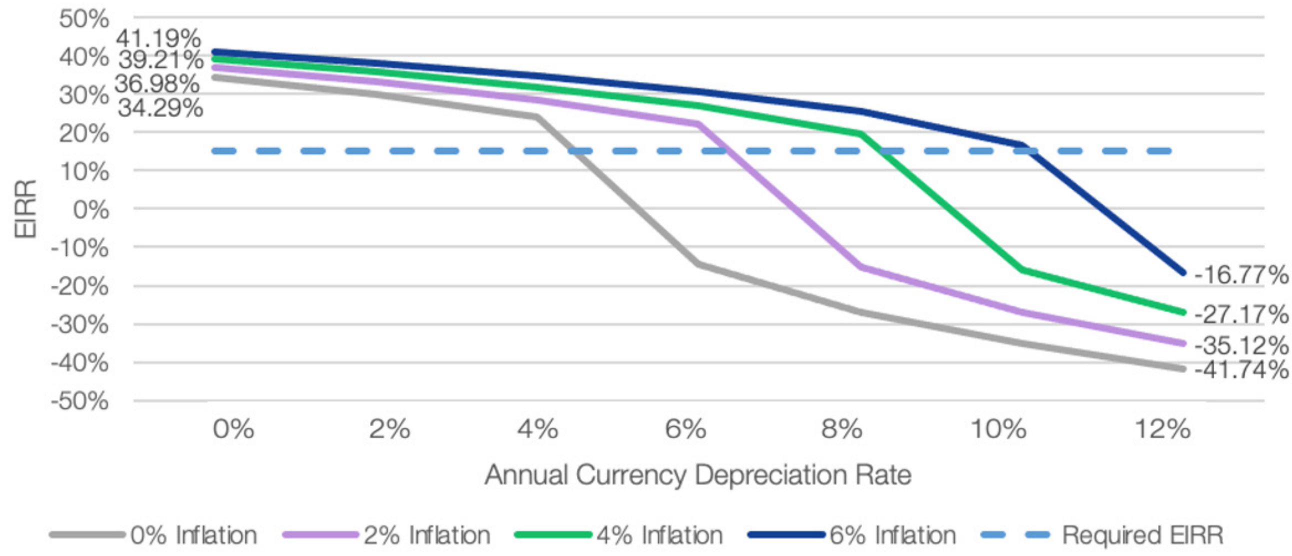
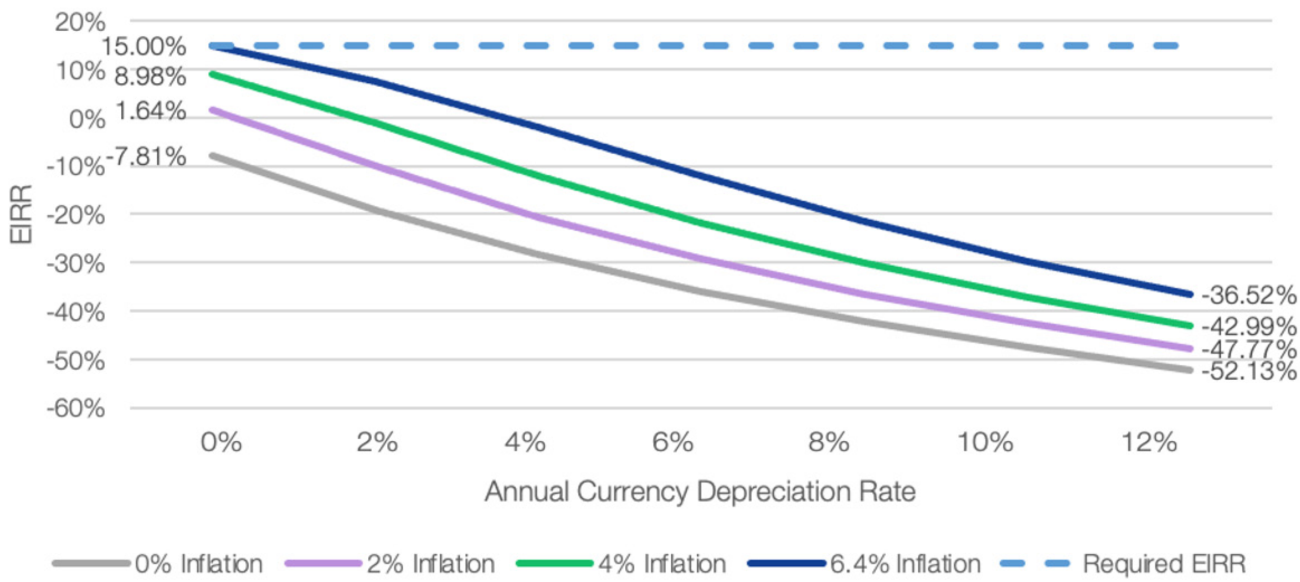


FIGURE 11. Local currency depreciation and inflation scenarios – Mini-grid only scenario



CONCLUSIONS AND KEY TAKEAWAYS

Mini-grids are inherently fragile start-up businesses, as they provide electricity services to rural customers who are often receiving power for the first time, which makes it difficult to predict revenues. Mini-grid developers thus need reliable electricity consumers in order to operate sustainably. Households in rural off-grid communities typically have limited electricity needs. Productive users of electricity make mini-grids more commercially viable by providing developers with more predictable power demand and stable revenues. Under the KeyMaker Model, mini-grid developers can simultaneously become a village's electricity provider and an electricity consumer, while adding value and commercialising a product that is indigenous to the community.[70]

Based on the assumptions presented in this Model Business Case, the Project is estimated to be very attractive under the KeyMaker Model, with an equity IRR of 37.1%. The KMM does, however, require a tariff of EUR 0.5/kWh (without grants) or grant funding of at least EUR 255 per connection (at the assumed EUR 0.25/kWh tariff) in order to be attractive. Furthermore, a minimum of 37 tonnes of fish must be processed annually for the fish cooling operation to be worthwhile.

The analysis highlights the importance of adopting the KeyMaker business model, as the mini-grid will not be attractive under the current cost and financing assumptions without the fish cooling operation due to the low tariff levels chargeable in Uganda. Similarly, the mini-grid project will not be attractive in an alternative scenario where the fish cooling business is operated by a third party, as the additional revenue generated by the mini-grid developer from supplying electricity to the fish freezers is insignificant. It is however worth noting that without the KeyMaker Model, the mini-grid project can still be made attractive if the capital cost reduces by 6.1% to EUR 3,417/kWp, or with a tariff of EUR 0.6/kWh (without grants) or with grant funding of at least EUR 383 per connection (at the assumed EUR 0.25/kWh tariff).

It is important to consider all aspects of the value chain that support implementation of the KeyMaker Model to ensure its success. In this case, the analysis revealed that the viability of the Project relies heavily on the cost of fresh fish purchased from local fisherfolk and on the wholesale price of the frozen fish delivered by the developer.[71]

While this study examined a fish cooling operation, there are several other possible applications of the KeyMaker Model. The model can be used for various agro-processing purposes, such as fruit and vegetable processing, and processing cereal grains and tuber vegetables (milling, threshing, oil pressing etc.), among other applications.

It is recommended that any investment decision be taken only after a detailed assessment is undertaken (combining technical, commercial, social and regulatory analysis) to determine the viability of the Project.

70) It is important to note that many mini-grid developers do not want this additional responsibility, and thus the KeyMaker Model is not appropriate for those developers.

71) Experience has shown that when the mini-grid developer gets involved in the local value chain, the traditional actors in the same value chain use their local presence and credit to guard their territory. Any project developer employing the KeyMaker Model must be prepared for this.

KEY DEFINITIONS

Avg. annual mini-grid revenue is the average annual revenue generated from electricity sales and connection fees over the life of the Project.

Avg. annual KeyMaker revenue is the average annual revenue generated from the sale of frozen fish 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 amortization over the life of the Project.

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

LCOE (Levelized Cost of Energy) is the net present value of the total cost incurred by the mini-grid 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 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.

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The first series of GET.invest Market Insights were 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).

Each Market Insight package includes **a)** a 'how to' Developer Guide, **b)** Model Business Cases and **c)** Case Studies. The Developer Guide enables the reader to navigate the market and its actors, to understand the current regulatory framework and lays down the step-by-step process of starting a new project/business. The Model Business Case analyses project economics and presents hypothetical, yet realistic, investment scenarios. It hence indicates the criteria for a viable project/business to enable the reader to identify the most cost-effective project/business opportunities. The Case Study analyses the viability of operational or high-potential projects/businesses to highlight lessons learnt and industry trends.

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Services include tailored access-to-finance advisory for clean energy developers, a funding database, market information, and financial sector support to increase local currency financing.

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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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