



**Feasibility Study for the Utilization of Solar Energy for Sugarcane
Irrigation Pumping by Emerging Commercial Small Cane Growers
in Eswatini**

**Output 4: Economic Feasibility Study.
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Background

Eswatini, a landlocked, mountainous country in southeastern Africa, is primarily agricultural-based and faces significant climate change impacts, particularly in the agricultural sector. The country's climate change impacts alter rainfall patterns and increase drought frequency, affecting the kingdom's economy.

Agriculture is a major contributor to Eswatini's greenhouse gas (GHG) emissions, with preliminary data indicating that 48% of emissions come from agriculture, forestry, and land use, while the energy sector contributes 40%. Sugarcane, a vital crop, provides livelihoods for many and contributes to the sector, accounting for 35% of private sector employment and significantly boosting the country's GDP.

Sugarcane growers are grappling with rising production costs, primarily due to high electricity costs, as their companies are primarily connected to the national grid.

Given these challenges, economic feasibility aims to evaluate the potential cost savings, possible increase in revenue and environmental benefits associated with the adoption of a Solar Powered Irrigation System (SPIS).

1. Introduction

Renewable energy technologies, specifically SPIS, have gained significant attention due to their potential to reduce greenhouse gas emissions, enhance energy security, and provide sustainable energy solutions. The economic feasibility study for SPIS aims to evaluate the financial viability of adopting SPIS among six selected sugarcane growers in Eswatini. Integrating SPIS can lead to substantial cost savings, increased productivity, and long-term financial benefits for growers.

This report aims to assess the economic feasibility of implementing SPIS for the selected sugarcane growers in Eswatini. This report will offer insights into the financial implications and potential returns on investment for each farmer by conducting a detailed cost analysis, revenue analysis, and cost-benefit assessment. Additionally, the report will recommend a suitable financial model tailored to the growers.

The primary objective is to provide an in-depth evaluation of the economic aspects related to the implementation of SPIS leveraging the System Advisor Model (SAM) for precise and reliable techno-economic analysis.

2. Methodology

This chapter details the systematic approach undertaken to assess the economic feasibility of implementing SPIS. The analysis relies on the SAM to provide a comprehensive techno-economic evaluation, incorporating specific assumptions, data sources, and analytical methods.

2.1 System Advisor Model (SAM)

The SAM is a free desktop application developed by the National Renewable Energy Laboratory (NREL) for the techno-economic analysis of renewable energy projects. SAM allows users to simulate and predict the performance and financial implications of various renewable energy systems, including Solar Photovoltaic (PV) systems. The process will include:

- Inputting farm-specific data from the previous technical assessment report
- Configuring the solar PV system design based on the technical assessment specifications



- Setting up two financing scenarios for each farm:
 - 100% loan financing
 - 50% loan financing with 50% self-funded
- Running simulations to generate performance and financial metrics
- Analysing the feasibility results for each farm and financing option.

To ensure consistency in pricing and financial analysis, all prices and costs in this report are converted using an exchange of 1 USD to 18.18 SWZ.

2.2 Feasibility Indicators

The SAM simulations will provide the following key economic indicators to assess feasibility:

- Net Present Value (NPV)
- Savings
- Payback Period
- Levelized Cost of Energy (LCOE)
- Annual cost flows
- Cost-benefit ratio

2.3 Key Assumptions for Economic Analysis

The following assumptions will be applied consistently across all farm simulations:

1. The solar module selected for this study is the CSI Solar Co. Ltd. CS6U-340P. The inverter chosen is the SMA America: STP24000 TL-US-10(480V).
2. System losses and annual degradation of the system are set to the standard values provided by SAM.
3. The cost of solar modules and inverters has been determined through desk research for the specific module type. Costs related to balance system equipment installation, Labor and installation margin are kept at the standard values provided by SAM.
4. Indirect costs such as permitting, developer overhead, grid interconnection, land purchase, and sales tax are not considered in the total installation cost. A contingency of 5% of the subtotal is included in the cost calculations.
5. The operation and maintenance (O&M) cost of the system is considered a fixed cost by capacity, with values obtained through desk research.
6. The analysis period is set at 20 years, with an inflation rate of 4.25% per year for Eswatini. Net billing is chosen as the metering and billing option for all farmers, as this service is provided in Eswatini for small-scale power producers.
7. Electricity rates for all growers are based on the rates applied by Eswatini Electricity Company (EEC) for the year 2023-24. The electricity bill escalation rate is assumed to be 2% per year. The electricity load for each grower is determined according to the data provided in the technical assessment report.

2.4 Assumptions for Installation Cost

The cost components for implementing SPIS are consistent across all six selected sugarcane farmers. Each system involves the same type of solar modules, inverters, balance of system equipment, installation and installer margin. Specifically:

- Cost of Module per unit: 114.93 USD (2,090.48 SWZ)
- Cost of Inverter per Unit: 1,044.50 USD (18,998.57 SWZ)
- Balance of System Equipment: 0.36 USD per watt-hour (6.55 SWZ per watt-hour)



- Installation Labor: 0.16 USD per watt-hour (2.91 SWZ per watt-hour)
- Installer Margin: 0.31 USD per watt-hour (5.64 SWZ per watt-hour)
- Contingency: 5% of the subtotal installation cost.
- Operation and Maintenance Costs: 15 USD per year per kW (272.84 SWZ per year per kW)

This uniformity in component and maintenance costs allows for a standardised approach to the economic analysis, facilitating a clear comparison of financial metrics across all six farms.

2.5 Key Parameters for Revenue Analysis

1. The analysis focuses on two distinct financing scenarios: a 50% loan and a 100% loan, each evaluated with specific loan terms and interest rates.

Loan Structures:

- 50% loan: Under this scenario, 50% of the total project cost is financed through a loan, while the remaining amount is covered by equity or other sources of funding.
- 100% loan: In this scenario, the entire project cost, including installation and operational expenses, is financed through a loan.

Loan parameters:

- Term: Both loan scenarios are evaluated over a fixed term of 10 years.
 - Interest Rate: A fixed interest rate of 14% is applied uniformly across both loan scenarios.
2. Energy yield in year: The amount of electricity generated per kilowatt (kW) of installed solar capacity in the first year, measured in kWh/kW.
 3. Performance Ratio in Year 1: A measure of the overall efficiency of the PV system, calculated as the ratio of actual energy output to the theoretically possible energy output.
 4. LCOE levelized Cost of Energy Nominal (¢/kWh): The average USD cents per kilowatt-hour (¢/kWh) of electricity generated by the PV system over its lifetime, calculated without adjusting for inflation.
 5. LCOE levelized Cost of Energy Real (¢/kWh): The average USD cents per kilowatt-hour (¢/kWh) of electricity generated by the PV system over its lifetime, adjusted for inflation.
 6. Electricity Bill Without System (Year 1): The total cost of electricity that the grower would pay in the first year if they did not have a PV system, measured in USD.
 7. Electricity Bill with System (Year 1): The total cost of electricity that the grower will pay in the first year with the PV system in place, measured in USD.
 8. Net Savings with System (Year 1): The difference between the electricity bill without the PV system and the electricity bill with the system in the first year, measured in USD. This value represents the financial savings achieved by using a PV system.
 9. Net Present Value (NPV): The difference between the present value of cash inflows (savings and revenues) and the present value of cash outflows (costs) over the 20-year analysis period. A positive NPV indicates that the investment is profitable.
 10. Simple Payback period: The amount of time it takes for the initial investment in the PV system to be recovered through the savings generated by the system, measured in years.
 11. Electricity Rates and charges: Analysing electricity rates for each grower according to the Eswatini Electricity Company (EEC) Time of Use (TOU) tariffs.

A TOU tariff is a pricing scheme for electricity where the cost per unit of energy varies depending on the time of day the day of the week or the season. The tariffs are divided based on the size of



power requirements: T4 for power requirements <100 kVA, T3 for power requirements >100 kVA, and T2 and T1 for large-scale growers. There are four charges in the EEC monthly bill:

- Facility Charge: A fixed charge based on transformer size.
- Demand Charge: Based on the amount of energy demanded (in kVA) in a particular month.
- Access Charge: Based on the highest demand and billed for the next 12 months until a new demand figure is recorded.

12. Energy Charges: Based on the actual energy consumed in kWh, taking into account whether the energy was consumed during peak time (6 am-9 am), standard time (9 am-5 pm), or off-peak time (10 pm-6 am).

The Table 1 below are the Energy charges the according to the consumption time, for each grower.

Table 1 - Energy Demand charges for each grower

Growers	Energy Demand (USD/kVA)		
	Peak	Standard	Off-Peak
Singeni Investments	0.32	0.098	0.064
Mnyangombili Farmer Limited	0.32	0.098	0.064
Asibebahle Mbabala Limited	0.27	0.083	0.056
Lomdashi Investment	0.32	0.098	0.064
Umbane	0.32	0.098	0.064
Dalcrue	0.32	0.098	0.064

The Table 2 below outlines the TOU tariff classification and associated fixed, demand and access charges for each grower.

Table 2 - Electricity charges for each grower

Growers	Time of Use – Tariff	Fixed Charge (USD)	Demand Charge (USD/kVA)	Facility Charge (USD/kva)
Singeni Investments	T3	109.5	11.6	3.52
Mnyangombili Farmer Limited	T3	109.5	11.6	3.52
Asibebahle Mbabala Limited	T4	93.29	9.87	3.28
Lomdashi Investment	T3	109.5	11.6	3.52
Umbane	T3	109.5	11.6	3.52
Dalcrue	T3	109.5	11.6	3.52

13. Possible Feed-in Revenue: For each grower a Possible feed-in revenue is also analysed. These values are a simulation of the potential amount of electricity generated by the PV system and fed into the grid, as well as the electricity that might need to be drawn from the grid. Positive values indicate the expected amount of electricity supplied to the grid, while negative values indicate the expected amount of electricity consumed from the grid. It is important to note that these figures are projections, reflecting possible outcomes before the actual implementation of the PV system.

Although Eswatini currently does not have a monetary Feed-in system, an example from Namibia, which has a monetary feed-in system, is used. The Feed-in Tariff levels in USD are as follows:

- 500 - 750 kW: 0.288 USD/kW
- 750kW – 1MW: 0.284 USD/kW
- 1 MW – 2 MW: 0.281 USD/kW

The calculation is conducted by taking into account the amount of electricity supplied to the grid, thus providing a possible feed-in revenue.



14. Cost-Benefit ratio: The cost-benefit ratio analysis is crucial to the economic feasibility study. The Cost-benefit ratio will be carried out in the following manner.

Identification of Cost and Benefits:

- Cost: Total Installation Cost, OPEX over the lifetime of the system, Overall interest rate payment, Fixed monthly charges with the system over the lifetime
- Benefits: Cost of electricity savings over the system lifetime.
- Cost-Benefit Ratio: Present value of Benefit/ Present value of cost
- Cost-Benefit ratio > 1: This suggests the project will likely be economically viable and profitable.
- Cost-Benefit ratio = 1: The project will recover its costs but not generate additional profit.
- Cost-Benefit ratio < 1: This suggests the project is likely to result in a net loss and may not be economically viable

2.6 Sensitivity Analysis

A sensitivity analysis will be conducted using SAM's built-in tools to account for potential variations in key parameters and their impact on feasibility. This analysis will focus on:

- Fluctuations in loan structure.

2.7 CO₂ Emission Avoidance

The avoidance of CO₂ is measured for the contribution to climate protection, lowering the greenhouse effect. CO₂ is emitted when fossil fuels (such as coal) are burned to generate electricity. Renewable energy-generated electricity (solar, wind, water, biomass) does not produce (additional) CO₂.

The higher a country's portion of renewable energy sources in the fuel mix, the lower the CO₂ emissions. If for example, the grower feeds power into the public grid viz PV system, the grower is making contributions to reducing the CO₂ emission of the country.

The CO₂ factor (kg/kWh) indicates how much CO₂ is produced for every one kilowatt hour of electricity generated in the country. Depending on the technology used and the efficiency, the CO₂ factor can vary between the different energy supply companies in the region. According to data published by the International Energy Agency (IEA) in the year 2023, Eswatini's CO₂ emission factor is 0.0316 kg/kWh.

The formula for calculating CO₂ avoidance:

Generated Electricity (kWh) × CO₂ emission factor (kg/kWh) = Avoided CO₂ (kg)



3. Singeni Investment’s Economic Analysis

The SPIS system for singeni grower consists of 216 solar modules and three inverters, with a total system size of 73.5 kW for the modules and 72 kW for the inverters. This configuration is projected to generate 120,766 kWh of energy in the first year, achieving a DC capacity factor of 18.8.%

- **Installation Cost (CAPEX)**

The estimated costs for installing the SPIS are detailed below:

Table 3 - Installation cost for Singeni Farm

Cost Component	Amount (USD)
Solar Modules	24,824.88
Inverters	3,133.5
Balance of System Equipment	26,460.17
Installation Labor	11,760.08
Install Margin and Overhead	22,785.15
Contingency	3,558.55

The total installation cost for the SPIS system is 92,522.33 USD (1,698,978.29 SWZ). The total installed cost per capacity is 1.26 USD/kWh

- **Operating Cost (OPEX)**

The projected minimum operating costs for the first five years are as follows:

Table 4 - Operational cost for Singeni Farm

Years	Amount (USD)
1	1,103
2	1,149
3	1,198
4	1,249
5	1,302

- **Revenue Analysis**

The financial analysis for the SPIS system is conducted under two loan structures: a 50% loan and a 100% loan. The key financial metrics are projected as follows:

Table 5 - Financial metrics for Singeni Farm

Financial Metric	Value (50% Loan)	Value (100% loan)
LCOE Levelized cost of energy nominal	9.10 ¢/kWh	10.71 ¢/kWh
LCOE Levelized cost of energy real	6.09 ¢/kWh	7.17 ¢/kWh
Net present value	104,209 USD	79,422 USD
Simple payback period	7.8 Years	7.8 Years
Equity	46,261 USD	0 USD
Debt	46,261 USD	92,522 USD
Cost-Benefit Ratio	1.83	1.52

The Table 6 below depicts the savings generated by the SPIS for the Singeni farm in the first five years.



Table 6 - electricity saving for Singeni Farm

Singeni Investments			
Year	Electricity bill W/O System (USD)	Electricity bill with system (USD)	Value of electricity savings (USD)
1	16,133	26,783	10,650
2	17,157	28,457	11,300
3	18,245	30,235	11,990
4	19,403	32,125	12,722
5	20,635	34,133	13,498

• Possibility of Feed-in Revenue

The Figure 1 indicates that in January, February, May, June, July, August, and September, there is an expected surplus of electricity being fed into the grid, suggesting higher solar generation during these months. Conversely, in March, April, October, November, and December, there is a significant consumption of electricity from the grid, indicating higher energy needs or lower solar generation during these periods. The values are provided in the Annex1 below.

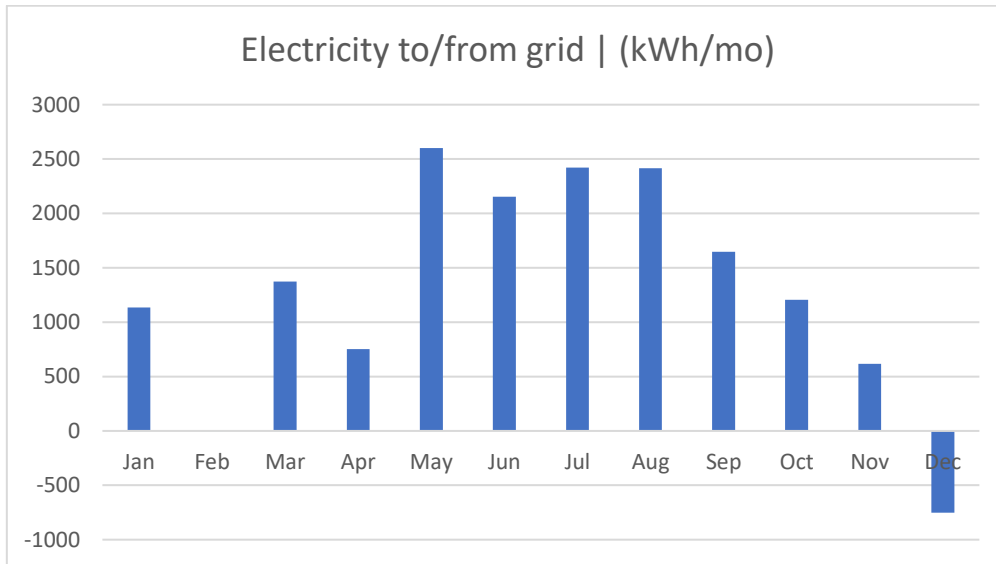


Figure 1 - Electricity to/from the grid for Singeni Farm

The highest export of electricity occurs in May (2602.06 kWh), whereas the highest import is in April (-751.51 kWh). Over the year, a total of 16,321.65 kWh is transferred to the grid. The total possible feed-in revenue for the year is 4700.63 USD (85,457.6 SWZ)

• After-Tax Cash Flow

The Figure 2 below is the after-tax cash flow analysis over 21 years for the SPIS under both loans. The cash flow improves steadily over time for both loan scenarios, demonstrating the increasing financial benefits of the SPIS as loan repayments decrease and energy savings accumulate. The 50% loan scenario shows an earlier transition to positive cash flow, highlighting the advantage of lower initial debt burden and faster financial recovery. The values are provided in the Annex 2 below.

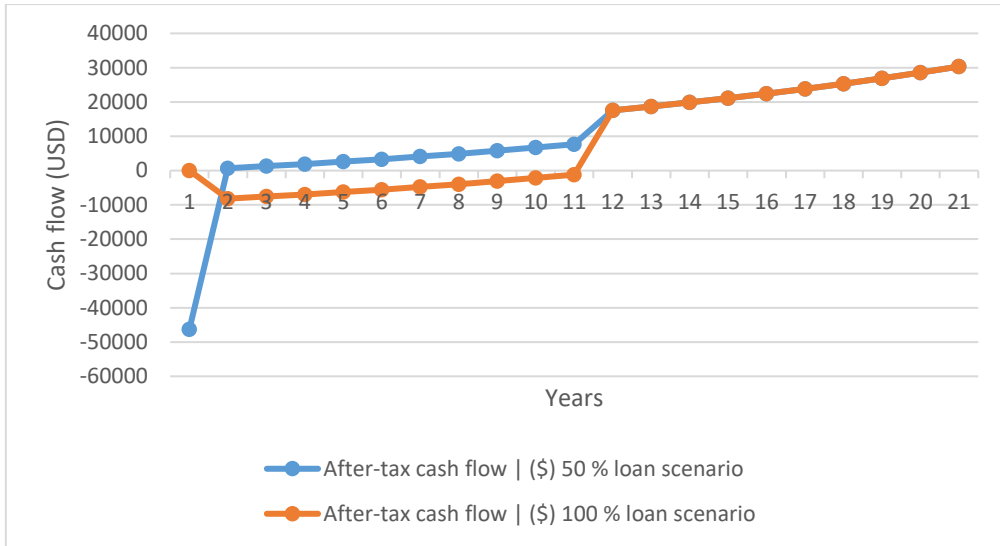


Figure 2 - After-tax cash flow for Singeni Farm

- **CO₂ Emission Avoidance Analysis.**

The expected power generation over the system lifetime is 2,300,756 kWh, leading to a CO₂ emission avoidance of 72,703.8896 kg



4. Mnyangombili Farmer’s Limited Economic Analysis

The SPIS system for Mnyangombili has 6,324 modules and 73 inverters, with respective capacities of 2,152 kW and 1,752 kW. Having a generation capacity of 3,370,018 kWh of electricity in the first year, achieving a DC capacity factor of 17.9%.

- **Installation Cost (CAPEX)**

The following Table 7 provides the cost breakdown for installation and components.

Table 7 - Installation cost for Mnyangombili farm

Cost Component	Amount (USD)
Solar Modules	726,817.32
Inverters	76,613.5
Balance of System Equipment	774,695.06
Installation Labor	344,308.92
Install Margin and Overhead	667,098.52
Contingency	129,476.67

The total installation cost amounts to 2,719,009.98 USD (49,928,908.36 SWZ). The total installed cost per capacity is 1.26 USD/kWh.

- **Operational Cost (OPEX)**

The following Table 8 is a summary of the minimum anticipated operating costs for the first five years:

Table 8 - Operation cost for Mnyangombili farm

Years	Amount (USD)
1	32,279
2	33,650.8
3	35,081
4	36,571.9
5	38,126.2

- **Revenue Analysis**

The financial viability of the SPIS under two loan scenarios is evaluated below Table 9:

Table 9 - Financial metrics for Mnyangombili farm

Financial Metric	Value (50% Loan)	Value (100% loan)
LCOE Levelized cost of energy nominal	9.51 ¢/kWh	11.20 ¢/kWh
LCOE Levelized cost of energy real	6.37 ¢/kWh	7.50 ¢/kWh
Net present value	2,320,574 USD	1,592,157 USD
Simple payback period	8.6 years	8.6 years
Equity	1,359,505 USD	0 USD
Debt	1,359,505 USD	2,719,010 USD
Cost-Benefit Ratio	2.08	1.66

The following Table 10 illustrates the savings produced by the SPIS at the Mnyangombili farm.



Table 10 - Electricity savings for Mnyangombili farm

Mnyangombili Farmer Limited			
Year	Electricity bill W/O System (USD)	Electricity bill with system (USD)	Value of electricity savings (USD)
1	290,116	570,312	280,196
2	308,637	605,956	297,320
3	328,342	643,828	315,487
4	349,309	684,068	334,759
5	371,620	726,822	355,202

• Possible Feed-in Revenue

The Figure 3 below show the monthly electricity exchange with the grid. March, February and April are the highest production months when the system generates and sends the most electricity to the grid. January is the highest consumption month, where the system draws the most electricity from the grid. The total electricity exchanged with the grid over the year is 303,429.1 kWh. Have a possible feed-in revenue of 85,263.57 USD (1,550,092 SWZ). The values will be provided in the Annex1 below.

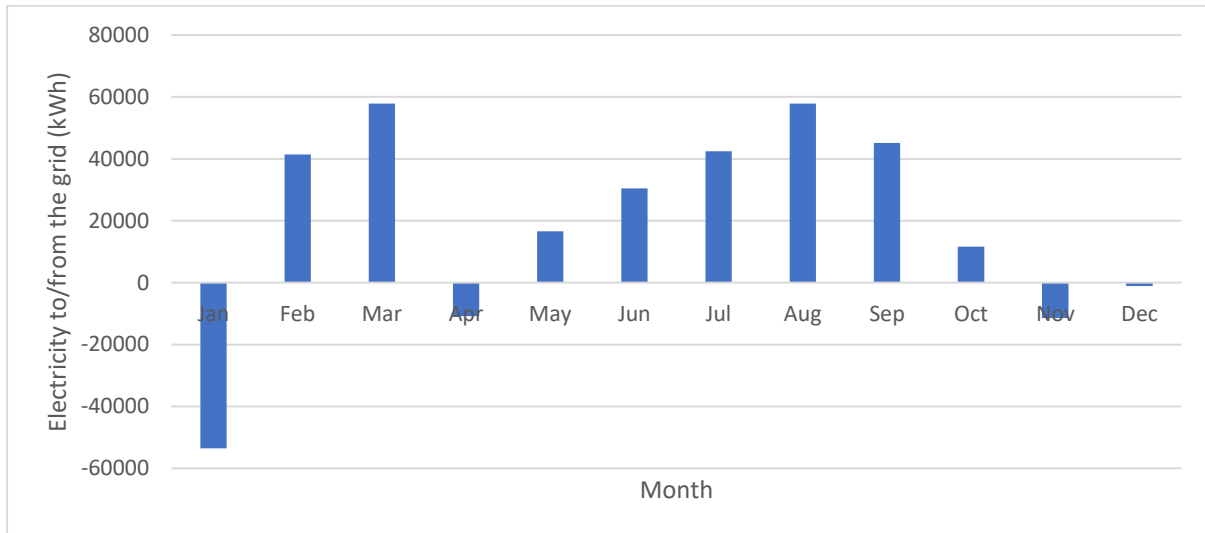


Figure 3 - Electricity to/from the grid Mnyangombili farm

• After-tax cash flow

The Figure 4 below are the projected after-tax cash flows for Mnyangombili’s SPIS over 21 years under both loan structures. In the 50% loan scenario, the initial outflow in Year 1 is -1,360,000 USD, followed by negative cash flows in Year 2 (-12,718.7 USD). Steadily increase each subsequent year, reaching 791,539 USD by Year 21. In the 100% loan scenario, the cash flow starts at 0 USD in Year 1, but then it becomes negative in Years 2 through 11, starting at -273,354 USD in Year 2 and gradually reducing the negative balance each year. Both scenarios transition from negative to positive cash flows, with the 50% loan scenario starting to see positive cash flows earlier (Year 3) compared to the 100% loan scenario (Year 12). The values are provided in the Annex 2 below.

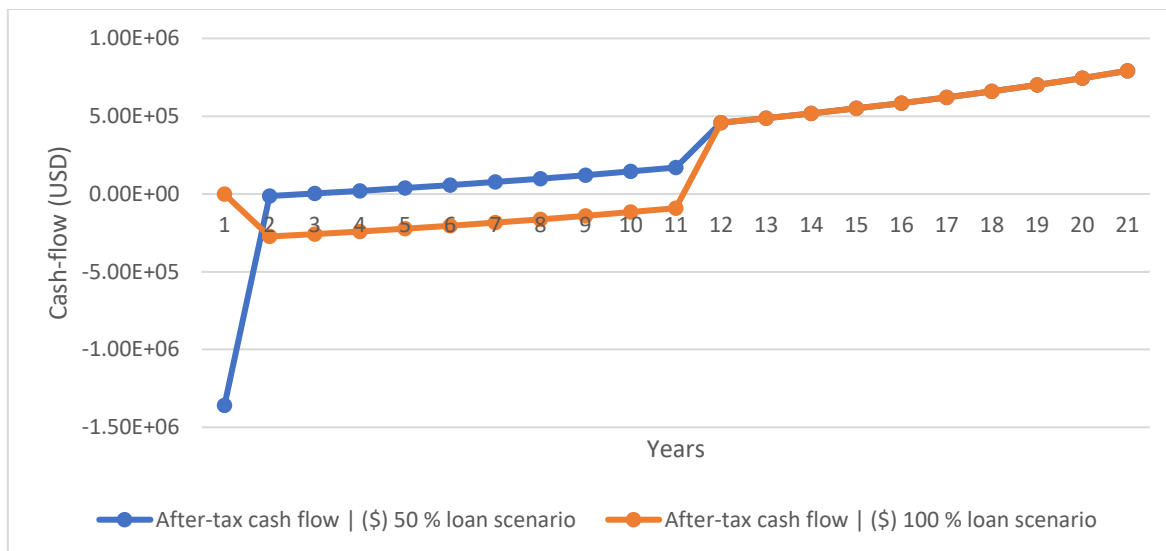


Figure 4 - After-tax cash flow Mnyangombili farm

- **CO₂ Emission Avoidance**

Over the lifetime of the SPIS, it is estimated that 2,029,999.01 kg of CO₂ emissions will be avoided, contributing positively to environmental sustainability efforts.



5. Asibebahle Mbabala Limited Economic Analysis

The Asibebahle Mbabala SPIS system has capacities of 43.56 kW and 48 kW, respectively, with 128 modules and two inverters. Producing 19 % DC capacity factor in the first year with 72,493 kWh of electricity generated.

- **Installation Cost (CAPEX)**

The accompanying Table 11 displays the component and installation cost breakdown.

Table 11 - Installation cost for Asibebahle Mbabala

Cost Component	Amount (USD)
Solar Modules	14,711.04
Inverters	2,099.00
Balance of System Equipment	15,680.10
Installation Labor	6,968.93
Install Margin and Overhead	13,502.31
Contingency	2,648

The total cost of the installation will be 55,609.46 USD (1,021,142.51 SWZ). The total installed cost per capacity is 1.28 USD/kWh.

- **Operational Cost (OPEX)**

The following Table 12 provides a summary of the minimum anticipated operating costs for the first five years.

Table 12 - Operational Cost for Asibebahle Mbabala

Years	Amount (USD)
1	653
2	681
3	710
4	740
5	772

- **Revenue Analysis**

The financial metrics of SPIS are evaluated in the following Table 13 for both loan scenarios.

Table 13 - Financial Metrics for Asibebahle Mbabala

Financial Metric	Value (50% Loan)	Value (100% loan)
LCOE Levelized cost of energy nominal	9.10 ¢/kWh	10.71 ¢/kWh
LCOE Levelized cost of energy real	6.09 ¢/kWh	7.17 ¢/kWh
Net present value	40,340 USD	25,442 USD
Simple payback period	9.0 years	9.0 years
Equity	27,805 USD	0 USD
Debt	27,805 USD (510,580.43 SWZ)	55,609 USD (1,021,142.51 SWZ)
Cost-Benefit Ratio	1.41	1.19



Detailed in the Table 14 below are the savings generated by the SPIS implemented at the Asibebahle Mbabala farm.

Table 14 - Electricity savings for Asibebahle Mbabala

Asibebahle Mbabala Limited			
Year	Electricity bill W/O System (USD)	Electricity bill with system (USD)	Value of electricity savings (USD)
1	8,979	14,386	5,407
2	9,547	15,285	5,738
3	10,151	16,240	6,089
4	10,794	17,255	6,461
5	11,477	18,333	6,857

• **Possible Feed-in Revenue**

The monthly electricity exchanged with the grid over one year is shown in the Figure 5. The electricity supplied shows significant variation throughout the year. For instance, August has the highest export at 1,396.35 kWh. April, November and October show substantially less export, implying higher electricity consumption compared to generation during these months. The total electricity supplied to the grid is 10,966.71 kWh thus providing a potential feed-in revenue of 3,158.42 USD (57,419.95). The values of all the months are provided in the Annex1.

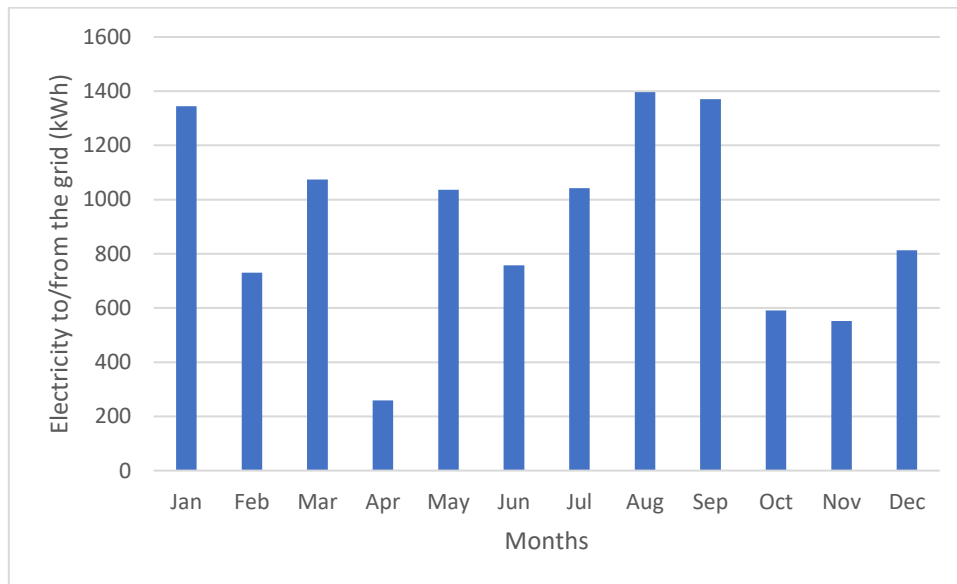


Figure 5 - Electricity to/from the grid for Asibebahle Mbabala

• **After-tax cash flow**

The Figure 6 compares the after-tax cash flows for two loan scenarios: 100% and 50% financing. Both scenarios start with negative cash flows, with the 50% loan scenario beginning with an outflow of -27,800 USD in Year 0. The 50% loan scenario continues with negative cash flows through Year 2 and then transitions to positive cash flows from Year 3 onwards. In contrast, the 100% loan scenario has negative cash flows from Years 1 through 11, starting at -5,907.38 USD in Year 1 and gradually reducing the negative balance each year. All the values are provided in the Annex 2.

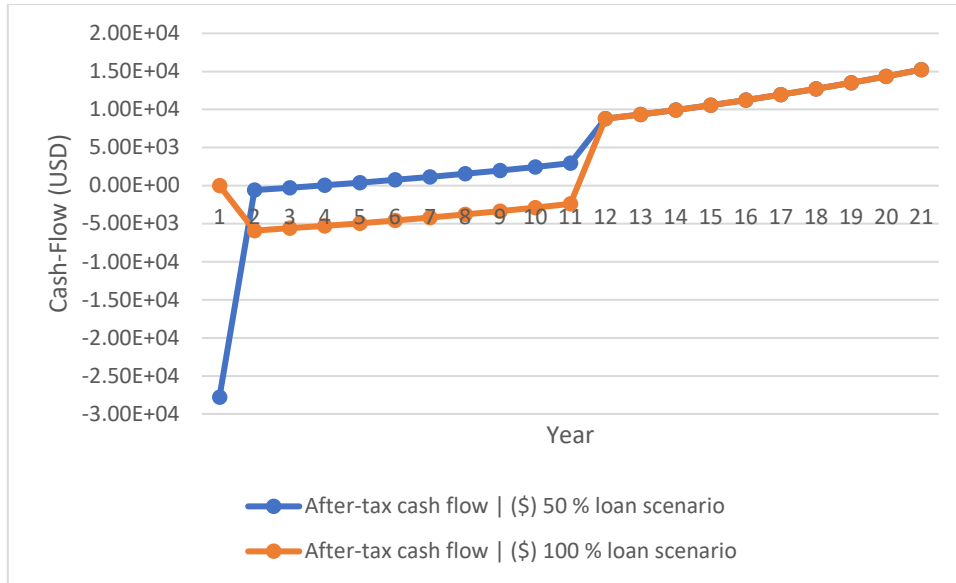


Figure 6 - After-tax cash flow for Asibebahle Mbabala

- **CO₂ Emission Avoidance**

Throughout the SPIS, it is anticipated that 43,640.57 kg of CO₂ emissions will be avoided, positively impacting programmes that promote environmental sustainability.



6. Lomdashi Investment’s Economic Analysis

The Lomdashi investment SPIS consists of 5,287 modules and 61 inverters, with capacities of 1,799 kWh and 1,464 kW, respectively. It produced 2,912,614 kWh of electricity in its first year, achieving an 18.5% DC capacity utilization rate.

- **Installation Cost (CAPEX)**

The breakdown of costs for components and installation is presented in the accompanying Table 15.

Table 15 - Installation cost for Lomdashi

Cost Component	Amount (USD)
Solar Modules	607,634.91
Inverters	64,019.50
Balance of System Equipment	647,661.73
Installation Labor	287,849.66
Install Margin and Overhead	557,708.71
Contingency	108,244

The overall installation cost amounts to 2,273,118.23 USD (41,643,071.35 SWZ), with an installed cost of 1.26 USD per kWh.

- **Operational Cost (OPEX)**

This Table 16 presents a summary of the least anticipated operating costs over the first five years.

Table 16 - Operational cost for Lomdashi

Years	Amount (USD)
1	26,986
2	28,133
3	29,329
4	30,575
5	31,874

- **Revenue Analysis**

This Table 17 examines the financial metrics of SPIS for the two different loan scenarios.

Table 17 - Financial Metrics for Lomdashi

Financial Metric	Value (50% Loan)	Value (100% loan)
LCOE Levelized cost of energy nominal	9.20 ¢/kWh	10.84 ¢/kWh
LCOE Levelized cost of energy real	6.16 ¢/kWh	7.26 ¢/kWh
Net present value	1,868,054 USD	1,259,091 USD
Simple payback period	8.7 years	8.7 years
Equity	1,136,559 USD	0 USD
Debt	1,136,559 USD (20,870,519.26 SWZ)	2,273,118 USD (41,741,038.52 SWZ)
Cost-Benefit Ratio	2.05	1.64

In the Table 18 provided below, you can see the savings resulting from the SPIS at Lomdashi farm.



Table 18 - Electricity savings for Lomdashi

Lomdashi Investments			
Year	Electricity bill W/O System (USD)	Electricity bill with system (USD)	Value of electricity savings (USD)
1	242,449	473,360	230,912
2	257,904	502,945	245,042
3	274,344	534,380	260,036
4	291,834	567,778	275,944
5	310,448	603,264	292,816

• Possible Feed-in Revenue

The Figure 7 displays the monthly electricity interactions with the grid throughout the year. May has the highest electricity sent to the grid at 59,307.3 kWh, while November exhibits the largest intake from the grid at -5,136.88 kWh, indicating potential energy consumption peaks. The total electricity sent to the grid over the year amounts to 328,728.91 kWh, resulting in a possible feed-in revenue of 92,372.82 USD (1,679,338 SWZ).

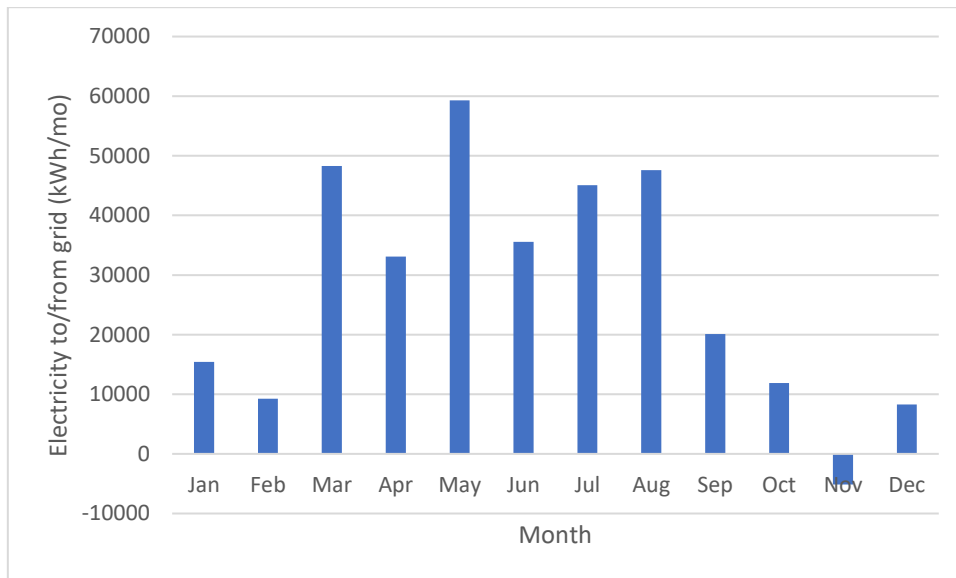


Figure 7 - Electricity to/from the grid for Lomdashi

• After-tax cash flow

The Figure 8 presents after-tax cash flows over 21 years for both financing scenarios. The 50% loan scenario continues with negative cash flows through Year 3 and transitions to positive cash flows starting in Year 4. In contrast, the 100% loan scenario starts with a cash flow of 0 USD in Year 1 but has negative cash flows from Years 2 through 11. Both scenarios exhibit positive and growing cash flows starting in Year 4 for the 50% loan scenario and Year 12 for the 100% loan scenario, with both reaching 652,611 USD by Year 21.

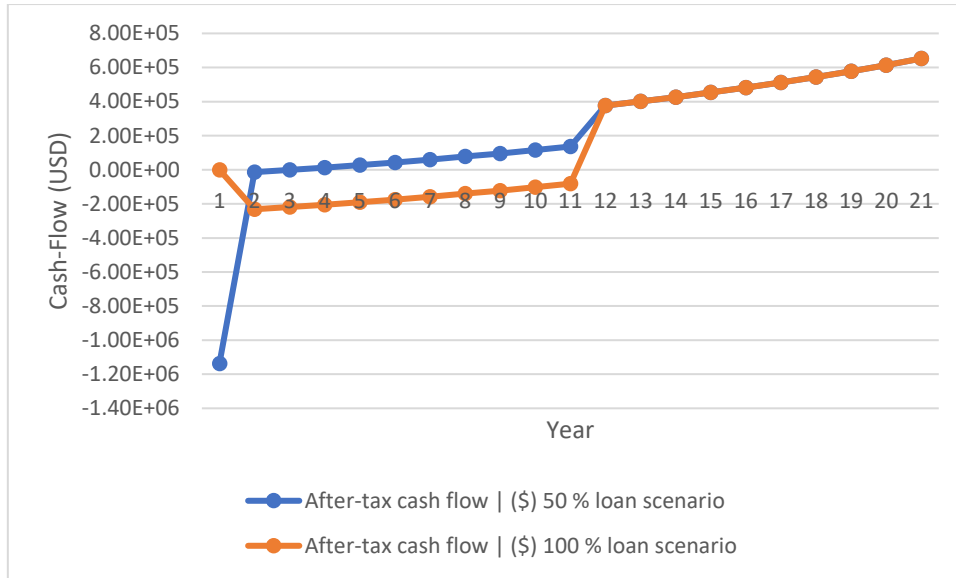


Figure 8 After-tax cash flow for Lomdashi

- **CO₂ Emission Avoidance**

Anticipated throughout the SPIS, the avoidance of 1,754,562.887 kg of CO₂ emissions is expected to bolster efforts promoting environmental sustainability.



7. Umbane Pty Ltd Economic Analysis

There are three inverters and 255 modules in the Umbane SPIS system, each with a capacity of 86.77 kW and 72 kW. In its first year of operation, it generated 137,120 kWh of power or an 18% DC capacity utilisation rate.

- **Installation Cost (CAPEX)**

Each component and installation's specific costs are listed in the Table 19 that goes with it.

Table 19 - Installation cost for Umbane

Cost Component	Amount (USD)
Solar Modules	29,307.15
Inverters	3,148.00
Balance of System Equipment	31,237.00
Installation Labor	13,883.42
Install Margin and Overhead	26,899.13
Contingency	5,224

The total installation cost for the SPIS system is 109,699.71 USD (2,009,676.75 SWZ). The total installed cost per capacity is 1.26 USD/kWh

- **Operational Cost (OPEX)**

The projected minimum operating costs for the first five years are as follows:

Table 20 - Operational Cost for Umbane

Years	Amount (USD)
1	1,302
2	1,357
3	1,415
4	1,475
5	1,537

- **Revenue Analysis**

The financial analysis for the SPIS system is conducted under two loan structures: a 50% loan and a 100% loan. The key financial metrics are projected as follows:

Table 21 - Financial metrics for Umbane

Financial Metric	Value (50% Loan)	Value (100% loan)
LCOE Levelized cost of energy nominal	9.47 ¢/kWh	11.15 ¢/kWh
LCOE Levelized cost of energy real	6.34 ¢/kWh	7.47 ¢/kWh
Net present value	96,009 USD	66,621 USD
Simple payback period	8.5Years	8.5 Years
Equity	54,850 USD	0 USD
Debt	54,850 USD (1,007,205.06SWZ)	109,700 USD (2914410.13 SWZ)
Cost-Benefit Ratio	1.71	1.41

The Table 22 below depicts the savings generated by the SPIS for the Umbane farm



Table 22 - Electricity savings for Umbane

Umbane Pvt. Ltd.			
Year	Electricity bill W/O System (USD)	Electricity bill with system (USD)	Value of electricity savings (USD)
1	18,215	29,618	11,403
2	19,369	31,469	12,100
3	20,596	33,436	12,840
4	21,901	35,526	13,625
5	23,289	37,746	14,457

• **Possible Feed-in Revenue**

The Figure 9 reveals fluctuating patterns of electricity exchange throughout the year. Over the year, the total electricity sent to the grid amounts to 19,983.69 kWh, The potential feed-in revenue generated from selling surplus electricity totals 5755.31 USD (104,631.4 SWZ).

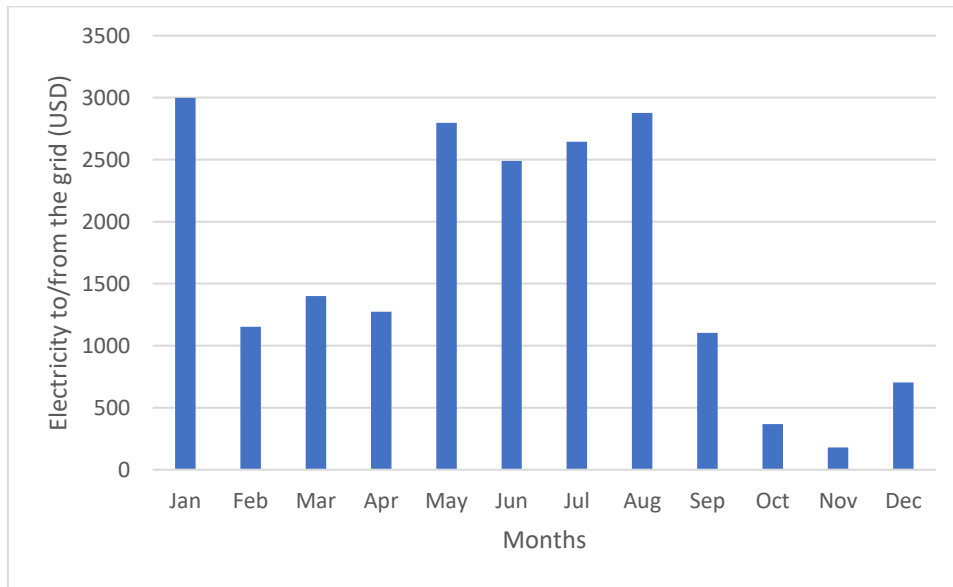


Figure 9 - Electricity to/from the grid for Umbane

• **After-tax cash flow**

The Figure 10 outlines the after-tax cash flows over a 21-year. The 50% loan scenario displays smaller negative cash flows compared to the 100% loan scenario, implying lower debt servicing costs initially. Both scenarios exhibit positive and growing cash flows starting in Year 3 for the 50% loan scenario and Year 12 for the 100% loan scenario, with both reaching 32,282.8 USD by Year 21.

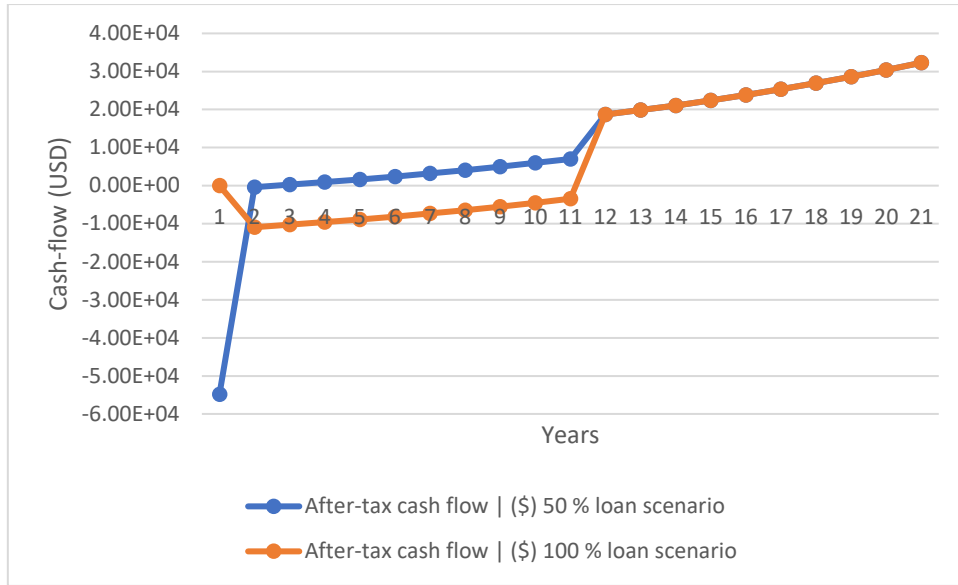


Figure 10 - After-tax cash flow for Umbane

- **CO₂ Emission Avoidance**

For the SPIS implementation, an estimated 169,790.66 kg of CO₂ emissions are expected to be prevented, benefiting initiatives supporting environmental sustainability.



8. Results and Summary

The Table 23 below are the total installation and Operational and Maintenance costs of all growers for both system sizing scenarios.

The CAPEX includes all the components, labour, and installation costs and the OPEX is an average of the operating expenses for the first five years.

Table 23 - Total CAPEX and OPEX for all the growers

	Singeni	Mnyangombili	Asibebahle Mbabala	Lomdashi investment	Umbane
CAPEX (USD)	92,522	2,719,010	55,609	2,273,118	109,700
OPEX (USD)	1,200	35,142	711	29,379	1,417

The Table 24 below are the savings and potential revenue of all growers in both system scenarios

Table 24 - Net savings and Feed-in Revenue for all the growers

	Singeni	Mnyangombili	Asibebahle Mbabala	Lomdashi investment	Umbane
Net savings in 1 Year (USD)	10,650	280,196	5,407	230,912	11,403
Potential feed-in revenue (USD) in 1 year	4,700	85,263	3,158	92,372	5,755
Avoided CO2 Emission (kg)	85,457	2,029,999	43,640	1,754,563	82,579
Simple Payback period (years)	7.8	8.6	9	8.7	8.5

The Table 25 below are the financial metrics for both system scenarios and the different loan parameters scenarios (50 % loan and 100% loan).

Table 25 - Important KPI for all the growers

	Singeni		Mnyangombili		Asibebahle Mbabala		Lomdashi investment		Umbane	
	50%	100%	50%	100%	50%	100%	50%	100%	50%	100%
Return on investment (Years)	2	12	3	12	4	12	4	12	3	12
Cost Benefit Ratio	1.83	1.52	2.08	1.66	1.41	1.19	2.05	1.64	1.71	1.41
LCOE (¢ /kWh)	6.09	7.17	6.37	7.50	6.09	7.17	6.16	7.26	6.34	7.47



9. Conclusion

Return on Investment (ROI):

- Both 50% and 100% loan scenarios project positive long-term economic outcomes. For 50% loan scenarios, the ROI takes place within a 2-4-year loan period, and for 100% loan scenarios the ROI takes place within 12 years, primarily through electricity bill savings. This suggests that growers opting for 50% loans will recoup their investments much faster, enhancing their cash flow and financial stability.
- The simple payback period ranges from 7.8 to 9 years.

Cost-benefit Ratio (CBR):

- The CBR values further clarify the economic implications of these loans. The ratios for 50% loans range from 1.41 to 2.08, while for 100% loans, they decrease to between 1.19 and 1.66. This trend indicates that while both loan types provide positive returns, the higher loan amounts (100% loans) yield lower relative economic benefits compared to their costs.

Levelized Cost of Energy (LCOE):

- The LCOE values show a similar pattern, with cents per kilowatt-hour (¢/kWh) being higher for 100% loans (ranging from 7.17 to 7.50) compared to 50% loans (ranging from 6.09 to 6.37). This indicates that the cost of energy generated through SPIS is more economical when financed through a 50% loan, aligning with the findings from the ROI and CBR analyses.
- The lower LCOE in the 50% loan scenarios suggests that growers can expect to pay less for energy over time, further enhancing their overall economic benefits.

Environmental Impact:

- The estimated CO² avoided by five cane growers in Eswatini, after the implementation of SPIS over 20 years, amounts to approximately 3,996,237.8000 kg (3,994.24 tons).

Overall Conclusion:

- Both 50% and 100% loan scenarios for SPIS in Eswatini for cane growers show positive long-term economic outcomes.
- The analysis highlights that financing SPIS through a 50% loan is more advantageous for cane growers in Eswatini, providing quicker ROI, higher CBR, and lower LCOE compared to 100% loans.
- These factors collectively point to a more sustainable and economically viable investment strategy for growers, encouraging the adoption of SPIS in their agricultural purposes.
- As per the Embedded Generation Policy, the implementation of SPIS is recommended for self-consumption purposes only.

Future considerations:

Once the Feed-in Tariff (like Namibia) has been defined, revenue and important KPIs will be even more positive and accurate, further enhancing the economic attractiveness of SPIS.

Limitations of Study:

- Projection Uncertainty: The study relies on projections and simulations, which may not perfectly reflect real-world conditions after implementation. Actual energy generation and consumption patterns could differ from projections.



- **Loan Parameters:** Different loan structures, interest rates, and repayment terms could significantly affect the financial outcomes. The analysis assumes specific loan conditions which may vary in reality, impacting the overall financial feasibility.
- **Exclusion of Indirect Costs:** The study focuses on direct costs and does not include indirect expenses such as permitting, developer overhead, and grid interconnection fees, which could impact overall project economics.
- **Uniform Component Cost:** The analysis assumes standardised cost components across all farms, which may not account for potential variations in pricing or technological advancements over time.
- **Data Inaccuracy:** Inaccuracies in the data used for projections may exist as a result of inaccurate or ineffective information, compromising the economic feasibility assessment's credibility.



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11. Annexes

11.1 Annex1: Amount of electricity generation and distribution for each grower

Singeni Investments

Month	Electricity to/from the grid (kWh/mo)
January	1135.65
February	2.05543
March	1,374.33
April	752.505
May	2,602.06
June	2,152.35
July	2,420.08
August	2,414.02
September	1,646.59
October	1,204.76
November	617.256
December	-751.477

Mnyangombili Investments

Month	Electricity to/from the grid (kWh/mo)
January	-53,585.5
February	41,458.5
March	57,885.3
April	-10,810.2
May	16,591.8
June	30,433.1
July	42,444
August	57,823.5
September	45,144.7
October	11,648.2
November	-11,419.9
December	-1,100

Asibebahle Mbabala

Month	Electricity to/from the grid (kWh/mo)
January	1,344.93
February	730.412
March	1,073.61
April	259.204
May	1,035.99
June	757.889
July	1,041.89
August	1,396.35
September	1,370.53
October	590.718



Month	Electricity to/from the grid (kWh/mo)
November	551.736
December	813.451

Lomdashi Investments

Months	Electricity to/from the grid (kWh/mo)
January	15,407
February	9,242.43
March	48,263.2
April	33,097.5
May	59,307.3
June	35,553.2
July	45,053.5
August	47,611.5
September	20,108.9
October	11,906.1
November	-5,136.88
December	8,315.16

Umbane Pvt. Ltd.

Months	Electricity to/from the grid (kWh/mo)
January	2,997.12
February	1,151.42
March	1,400.89
April	1,274.04
May	2,796.24
June	2,488.84
July	2,645.5
August	2,876.25
September	1,102.74
October	367.869
November	180.178
December	702.608



11.2 Annex 2: After-tax cash flow for each grower

All values are in USD

Singeni Investments

Year	After-tax cash flow (100% Loan)	After-tax cash flow (50% Loan)
0	-46,261.2	0
1	678.583	-8,190.31
2	1,281.9	-7,586.99
3	1,922.76	-6,946.13
4	2,603.54	-6,265.36
5	3,326.71	-5,542.18
6	4,094.89	-4,774
7	4,910.87	-3,958.02
8	5,777.29	-3,091.6
9	6,697.45	-2,171.44
10	7,674.65	-1,194.25
11	17,581.3	17,581.3
12	18,683.4	18,683.4
13	19,853.6	19,853.6
14	21,096.3	21,096.3
15	22,415.9	22,415.9
16	23,816.8	23,816.8
17	25,304.1	25,304.1
18	26,883.1	26,883.1
19	28,559.5	28,559.5
20	30,339.1	30,339.1

Mnyangombili Investments

Year	After-tax cash flow (100% Loan)	After-tax cash flow (50% Loan)
0	-1.36E+06	0
1	-12,718.7	-273,354
2	3,033.27	-257,602
3	19,770	-240,865
4	37,551.6	-223,084
5	56,440.2	-204,195
6	76,506.9	-184,129
7	97,825.4	-162,810
8	120,472	-140,163
9	144,526	-116,109
10	170,077	-90,558.7
11	457,849	457,849
12	486,666	486,666
13	517,267	517,267
14	549,760	549,760
15	584,263	584,263



16	620,903	620,903
17	659,808	659,808
18	701,117	701,117
19	744,973	744,973
20	791,539	791,539

Asibebahle Mbabala

Year	After-tax cash flow (100%)	After-tax cash flow (50%)
0	-2.78E+04	0
1	-576.837	-5,907.38
2	-273.764	-5,604.31
3	48.3259	-5,282.22
4	390.597	-4,939.95
5	754.328	-4,576.22
6	1,140.85	-4,189.7
7	1,551.54	-3,779.01
8	1,987.91	-3,342.64
9	2,451.51	-2,879.04
10	2,944.05	-2,386.49
11	8,797.83	8,797.83
12	9,353.68	9,353.68
13	9,944.15	9,944.15
14	10,571.4	10,571.4
15	11,237.8	11,237.8
16	11,945.5	11,945.5
17	12,697.1	12,697.1
18	13,495.4	13,495.4
19	14,343.2	14,343.2
20	15,243.5	15,243.5

Lomdashi Investments

Year	After-tax cash flow (100%)	After-tax cash flow (50% loan)
0	-1.14E+06	0
1	-13,968.2	-231,862
2	-984.868	-218,879
3	12,813.3	-205,080
4	27,475.6	-190,418
5	43,047.9	-174,846
6	59,591.6	-158,302
7	77,166.6	-140,727
8	95,839.7	-122,054
9	115,678	-102,216
10	136,749	-81,144.6
11	377,025	377,025
12	400,799	400,799



13	426,052	426,052
14	452,872	452,872
15	481,359	481,359
16	511,617	511,617
17	543,751	543,751
18	577,881	577,881
19	614,125	614,125
20	652,611	652,611

Umbane Pvt. Ltd.

Year	After-tax cash flow (100%)	After-tax cash flow (50%)
0	-5.48E+04	0
1	-413.841	-10,929.3
2	228.028	-10,287.4
3	910.035	-9,605.42
4	1,634.65	-8,880.81
5	2,404.52	-8,110.94
6	3,222.46	-7,293
7	4,091.44	-6,424.02
8	5,014.62	-5,500.84
9	5,995.27	-4,520.19
10	7,036.96	-3,478.5
11	18,658.8	18,658.8
12	19,834.1	19,834.1
13	21,082.5	21,082.5
14	22,408.5	22,408.5
15	23,816.8	23,816.8
16	25,312.6	25,312.6
17	26,901.3	26,901.3
18	28,588.5	28,588.5
19	30,380.1	30,380.1
20	32,282.8	32,282.8