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Gauteng Department of Economic Development (GDED)

SME Green Support Incentive Program

ENERGY CONSUMPTION ASSESSMENT FOR MEZE FOODS FACTORY

190 Eland Rd, Daleside, Meyerton. GAUTENG

13 June 2022

REPORT

Prepared for: **CSIR** National Cleaner Production Centre South Africa
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NOMENCLATURE

CDD	Cooling Degree Days
CFL	Compact fluorescent lamp/light
CO_{2e}	Carbon dioxide equivalents
CP	Cleaner Production
Deg.C	Degrees Celsius
Hr	Hours
kL	Kilolitres
kVA	Kilovolt Amperes
kW	Kilowatts
kWp	Kilowatt Peak
kWh	Kilowatt-hours
LED	Light-emitting diode
NCPC-SA	National Cleaner Production Centre of South Africa
R	Rands
PV	Photo-voltaic
RECP	Resource Efficient and Cleaner Production
W	Watts

EXECUTIVE SUMMARY

The CSIR Energy Centre has reviewed the Resource Efficiency & Cleaner Production Assessment Report for Meze Foods, based at 190 Eland Rd, Daleside, Meyerton, Gauteng Province.

The scope of the review covered energy consumption assessment for all sources used on site with a focus on solar PV generation options. Recommendations which were made for energy savings were reviewed for their relevance. Data contained in the assessment report has been used to draw conclusions on the state of energy consumption and recommendations made for renewable energy options on site.

A summary of the Solar PV system size made in the assessment report as an alternative energy source is presented in **Error! Reference source not found.**. Based on the estimated 12-month energy consumption of 1 141 721 kWh, an estimated 0.98% reduction in electrical energy usage procured from the municipality and a cost of R 16 930.12 per annum can be achieved through the installation of an 8 kWp solar PV system producing about 11 212 kWh of electricity per annum at a cost of R234 942.52.

Table 1: Alternative energy source opportunities

Alternative Energy source opportunities	Projected Annual Savings			Investment	Saved of total kWh
	Energy	Cost	CO_2 Emissions		
	kWh	R/year	Tons	(R)	%
Install an 8kWp Solar PV System	11 212	R16 930.12	11.69	R234 942.52	0.98

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1. INTRODUCTION

Meze foods is a cheese manufacturing plant located in Daleside, Meyerton. The main operations on site are Milk receiving (which includes pasteurization), Curd production (which includes milk solidification, whey separation and sometimes culture addition), cheese stretching, cooking, incubation, and cheese packaging. The site produces a total of 9 different types of cheeses and produces over 4,000 tonnes of the product per month. The site operates for 5 days a week, 3 days of which are typically used for production and the rest for cleaning. Production hours per day depend on the amount of milk available, and can be for a period of up to 16 hrs. The buckets and packing trays used during the production process are cleaned throughout the day as production proceeds.

This review forms part of the Gauteng Department of Economic Development (GDED)'s SMMEs Green Support Incentive Program whose objectives are to assist SMMEs based in Gauteng to instal alternative sources of energy to mitigate the high cost of energy and green their operations through reduced carbon emissions. This review report presents the relevant findings contained in the RCEP Assessment Report and information obtained from the site visit relating to energy usage and opportunities for energy performance improvements and renewable energy resources that can supplement grid power. The opportunities are evaluated for technical and financial feasibility. High level investment costs, energy and cost savings and simple payback periods are presented.

2. COMPANY INFORMATION

Table 2: Company Information

Assessment Type	Review of Renewable Energy opportunities
Assessment Period	June 2022
Company Name	Meze Foods Factory
Physical Address	190 Eland Rd, Daleside, Meyerton
Phone	
Trading Since (year)	
No. of Full time Employees	
Industrial Processes	Food and Beverages
Company Contact Person:	
Name:	
Designation:	
Telephone: **Mobile:** **E-mail:**	

3. DESCRIPTION OF PROCESS

The cheese manufacturing process starts with the receipt of raw milk, which is transferred from road tankers to milk silos on the site. The silos are jacketed, with chilled water used to maintain milk temperature. The milk passes through an inline chiller, where it is chilled to 2 – 4 ^{0}C using glycol, as it is pumped to the silos.

From the silos, each batch of milk is transferred to the balancing tank at the pasteurization step. Milk pumped from the balancing tank is pre-heated using hot milk leaving the pasteuriser. The pre-heated milk then enters a separator where cream and some whey are separated from the milk according to a desired recipe. The cream goes back to the balancing tank and the whey goes to drain. Separated milk is transferred to the standardizer and then either bypasses the homogenizer or is homogenized before it enters the heating stage of the pasteuriser. In the pasteuriser, hot water is used to heat the milk to pasteurization temperature. The milk is then transferred to a holding/delaying tube, where it spends 20 seconds at elevated temperature. The temperature of the milk is checked, and it is then either diverted back to the balancing tank if its temperature is lower than the target or used to preheat the incoming milk. After pre-heating the incoming milk, the milk has a reduced temperature and is further cooled to a temperature that depends on the recipe selected. This happens in the cooling stage of the pasteuriser. The milk, which is still warm in temperature, is then transferred to storage vats for solidification and cheese production. There are 9 cheese vats, two of which are closed and automated. The other 7 are open and manually operated. The automated vats are jacketed, as are 5 of the manually operated vats. The other two open vats are not equipped with jackets.

Direct steam injection is used for scalding i.e., to heat the milk in the jacketed vats if the temperature after pasteurization is still lower than required. In the open vats, if the temperature is too high after pasteurization, chilled water is used for cooling through the vat jackets, depending on the type of cheese produced. An open sterilant bath containing hot water is used for cleaning of the open vats and for sterilising equipment used during production. To heat the water used for sterilisation, steam is injected directly into the water using a submerged lance. The water is kept hot throughout the production process through the periodic injection of live steam by the operator, at a frequency of approximately every 15 minutes, with steam injected for roughly 3 minutes at a time. All heating and cooling processes for the vats and sterilant baths are operated manually.

After the curd solidifies in the vats, it is cut into smaller blocks. After cutting, some of the whey is transferred to whey receiving vessels for protein and fats recovery. The rest of the whey and cheese will then be transferred to either the AFE machine for filling into trays, where more whey will be separated, or to the CMT for stretching and moulding. When transferring cheese to the CMT machine, almost all of the whey would have been separated. When transferring cheese to the AFE machine, most of the whey would still be remaining in the cheese vats and so will be pumped together with the cheese.

Whey from the AFE machine is transferred to the open vats for recovery of some of the remaining small curd particles to produce a product called ricotta cheese. Curd from the AFE machine is transferred to a turning machine to remove the remaining whey. After the turning process, cheese is either cooked (haloumi) or incubated (feta). When cooking haloumi cheese, whey from ricotta production is first heated in pots on LPG gas stoves before cheese from the turned trays is cut and inserted into the heated whey. After cooking, the haloumi is then spiced and kept in the fridge for cooling. Some of this cheese will then be placed into cold brine before packaging and some will be vacuum-packed without having been in brine. Incubated cheese is kept in the fridge for cooling after incubation and then placed in brine before packaging.

The cheese transferred to the CMT for stretching is kept in chilled water containing blocks of ice before it is transferred to the stretching machine. A bath containing sterile hot water supplies the stretching process to keep the temperature during the stretching phase high enough. The water in the sterile water bath is kept at 81 ^{0}C. and heated using live steam, with an automatic feedback loop used to open or close a solenoid valve on the steam supply based on the water temperature.

After stretching, some of the cheese is moulded and then submerged in chilled water, after which it is stored in the fridge. For mozzarella fingers and balls, when the cheese is moulded, potable water is sprayed onto the balls and used to push the cheese out and into the chilled water bath. Cheese from the chilled water baths is transferred to chilled water buckets first and then to the fridge. After having been stored in the fridge, moulded cheese is transferred to into brine water before packaging.

Depending on the product, sometimes the curd is separated from whey in the vats using cheese cloth, and then kept in the fridge to cool and dry before being transferred to brine water for packaging.

illustrates the process described above:

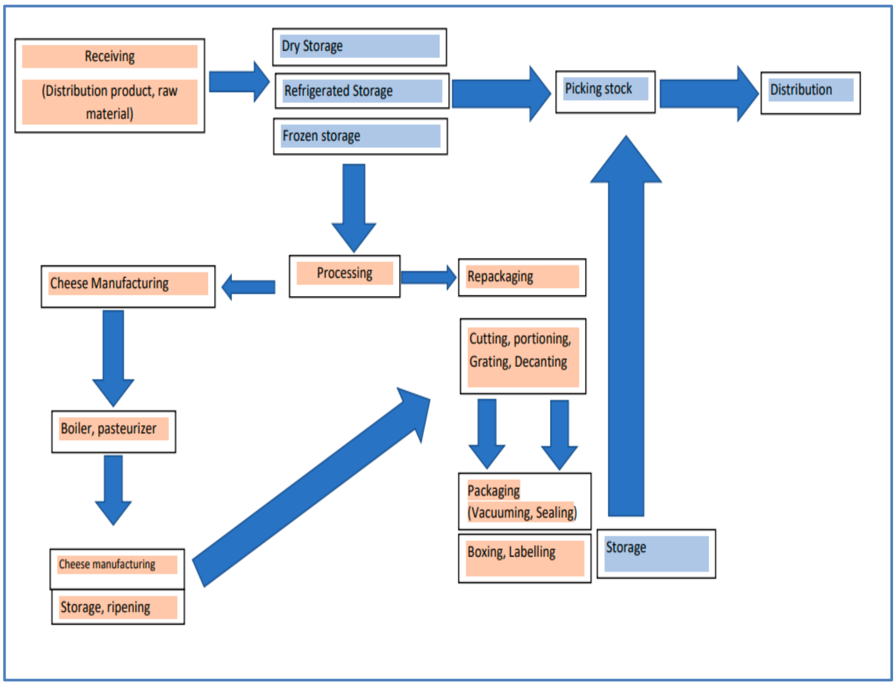

Figure 1: Process Flow Diagram

4. ENERGY CONSUMPTION

4.1 General Findings

In this section, energy consumption data is used to evaluate the operational efficiency of the factory. Data collected about management activities can be used to monitor and control overall efficiency, set targets, and calculate monthly or yearly indicators. Data collected about operational activities can be used to evaluate the performance of a specific section of the business. Collection and evaluation of data will most likely reveal operational deficiencies. For instance, high electricity consumption outside occupation times may indicate equipment in operation when not required.

Electricity consumption data was provided by Meze Foods for the period February 2018 to January 2022. Electricity is not the only energy source used at the factory. The factory uses heavy fuel oil (HFO) to operate the boilers and liquefied petroleum gas (LPG) to operate the gas stove for Haloumi Production. However, this analysis is only focused on electricity consumption. The electrical energy consumption for the period 2018-2022 is depicted in figure 6. The plant's electricity usage remained fairly constant over this period and was not affected by the lockdown. That is likely attributed to the fact that machinery, such as the compressor, was kept on in full capacity throughout the lockdown months.

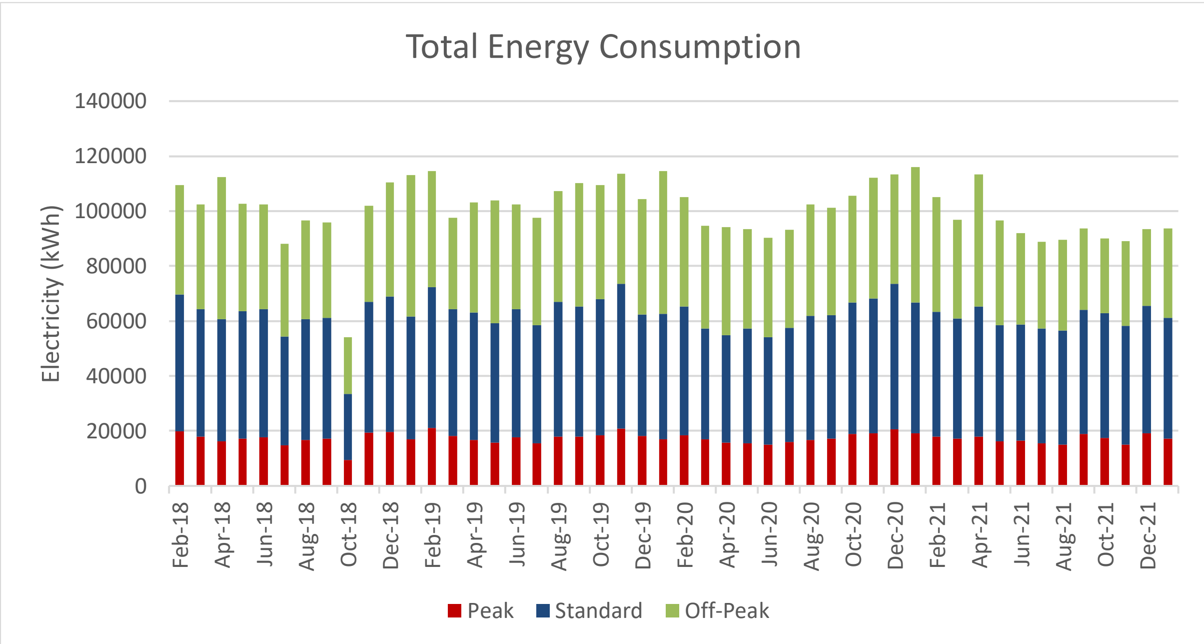

Figure 1 Total Energy Consumption

Most of the electricity is used during standard periods and off-peak periods. Figure 2 depicts that 43% of the site's electricity usage is during standard periods whereas 40% is during off-peak periods and 17% during peak periods.

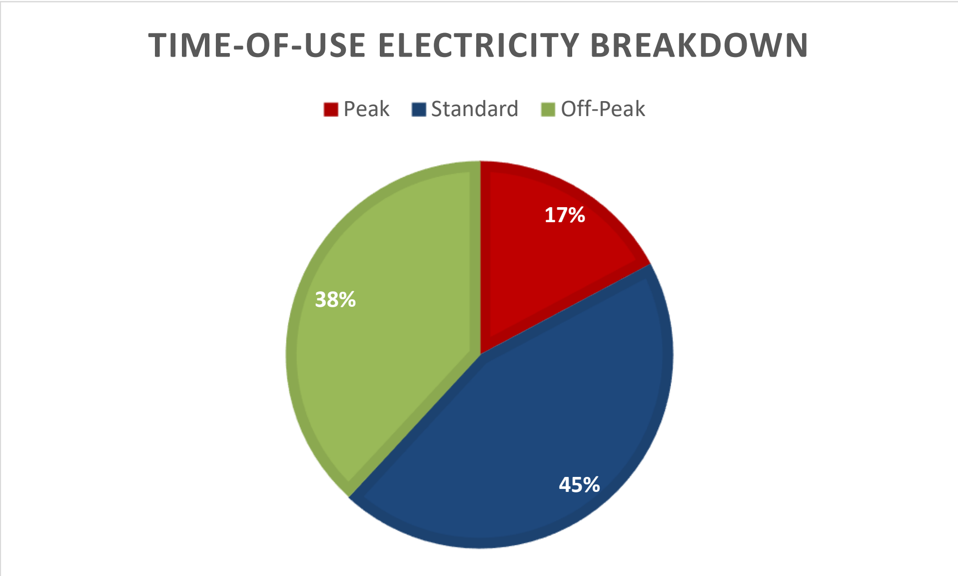

Figure 2 Electrical energy time of usage division

Table 2 below provides a summary of total energy consumption and cost for 48 months for the purpose of Solar PV System sizing. The average monthly electricity consumption is 100 664 kWh and the average monthly cost of electricity is R154 935.50.

Table 2 Summary of the total energy consumption and cost for 48 months

	48 Months		*12 Months*		*Monthly Average*	
Energy Consumption	4831868	kWh	1 141 721	kWh	100 664	kWh
Energy Cost	R7 436 904.01	ZAR	R2 109 006.30	kWh	R154 935.50	ZAR

4.2 Baseline Establishment

This section provides an analysis of the energy consumption data at the factory in order to establish a relationship between consumption and the relevant variables (drivers) that influence this consumption. In an ideal world, the product output volumes would be the primary drivers of energy consumption. However, there is sometimes an added complexity where one or more other factors may influence energy consumption. In this case, the weather was identified as one of the energy drivers. Thus, the relevant variables used in this analysis are the production throughput, Heating Degree Days (HDD 18°C), and Cooling Degree Days (CDD°C) taken from www.degreedays.net, for FAVV: Vereeniging, ZA (27.96E,26.57S). The base-year period used is from January 2020 to December 2020, because of the availability of weather data.

To do a regression analysis, all variables that can drive the monthly electricity consumption were identified. Three variables were identified:

- Production quantities
- Heating Degree Days (HDD)
- Cooling Degree Days (CDD)

Data was collected for the identified variables as displayed in Table 3.

Table 3 Energy consumption variables

Month	Energy [kWh]	Production	HDD	CDD
Jan 20	114674	55930	8.4	111
Feb 20	105032	49200	11.1	102.2
Mar 20	94724	51977	27.7	76.9
Apr 20	94199	52789	67.7	43.1
May 20	93387	46533	126.8	26
Jun 20	90227	51285	219	6.3
Jul 20	93231	43860	203.5	10.1
Aug 20	102450	41532	144.8	23.8
Sep 20	101281	49535	62.8	73.4
Oct 20	105670	51143	31.5	110.9
Nov 20	112193	62380	21.1	89.8
Dec 20	113386	56147	10.4	111.2

A multi-variable regression was done to determine a model to project energy consumption. A 3-variable model (Production values, HDD, CDD) yielded poor results with an adjusted R^2-value of 70% and good P-value ($P<10\%$) for CDD, both production and HDD variables had poor P-values ($P>10\%$) indication that only CDD has sufficient influence in energy consumption, as shown in Table 4. A 2-varible model, using CDD and HDD, was also performed and results indicated that only CDD has a significant influence.

Table 4 Multivariable Regression Analysis Summary of Results

Regression Statistics	
Multiple R	0.835266687
R Square	0.697670438
Adjusted R Square	0.584296852
Standard Error	5566.690504
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	572076153.7	190692051.2	6.153730011	0.017892593
Residual	8	247904345.3	30988043.17		
Total	11	819980499			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	72552.61076	23227.99586	3.123498523	0.014153642	18988.75625
Production (ton)	0.199775006	0.38371563	0.520632964	0.616720981	-0.685074825
HDD	46.06146518	64.75778276	0.711288485	0.497117819	-103.2702497
CDD	235.0452142	119.5487966	1.966102721	0.08485358	-40.63480502

Similarly, the regression model with 1 variable was also performed using the variable with the lowest P-values namely the CDD. The model yielded poor results as shown in Table 5, the R2 value is 82% indicating that the relationship between energy consumption and CDD is fairly accurate. The adjusted R^2-value should be ideally above 75% to indicate an adequate fit.

Table 5 Single variable Regression Analysis Summary of Results

Regression Statistics	
Multiple R	0.81986854
R Square	0.672184423
Adjusted R Square	0.639402865
Standard Error	5184.615516
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	551178118.6	551178118.6	20.50495675	0.001094354
Residual	10	268802380.4	26880238.04		
Total	11	819980499			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	90485.17707	2894.597034	31.26002549	2.63597E-11	84035.61296
CDD	171.571142	37.8891457	4.528239918	0.001094354	87.1488644

Consequently, using the cooling degree days data, the estimated energy consumption values can be calculated through a standard equation employing the regression analysis as depicted in Table 5. The following equation is used for the calculation of estimated energy consumption.

$$E = 90\,485.18 + CDD * 171.57 \ldots\ldots (1)$$

Where:

E = Estimated energy consumption (kWh)

CDD = Cooling Degree Days

4.3 Energy consumption monitoring

Energy performance was evaluated using the CUSUM method. CUSUM represents the difference between the expected consumption and the actual consumption points over the baseline period. The CUSUM technique calculates the energy savings or losses to date and shows when changes in performance occur. The baseline period for this study is the year 2020, as analysed in previously. For the CUSUM analysis, 2021 energy consumption data was considered as shown in

Table 6. The formula, shown in equation 1, was used to calculate the expected energy consumption.

Table 6 CUSUM calculations performed on data

Months	Electrical Energy Consumption in kWh			CUSUM Energy in kWh
	Actual	Expected	Difference	
Jan 21	116022	109135	-6887	-6887
Feb 21	105124	104485	-639	-7526
Mar 21	96732	104194	7462	-64
Apr 21	113238	102512	-10726	-10790
May 21	96483	94243	-2240	-13030
Jun 21	91982	92218	236	-12794
Jul 21	88857	91395	2538	-10257
Aug 21	89472	95323	5851	-4405
Sep 21	93633	104159	10526	6121
Oct 21	90076	102289	12213	18334
Nov 21	89127	108226	19099	37433
Dec 21	93397	103713	10316	47749

The CUSUM chart shown in Figure 3 is based on the CUSUM electricity consumption calculated in

Table 6. The primary purpose of a CUSUM control chart is to detect small shifts from the process target. The changes in direction of the line indicate events that have relevance to the energy consumption pattern. An upward change indicates a positive event, and a downward change indicates a negative event. The analysis found that there are significant changes in the usage pattern. Positive events are observed from February 2021 to March 2019 and from May 2021 to December 2021 indicating events that were not energy efficient. The energy performance only increased from March 2021 to May 2021. This increase could have been due to the implementation of energy efficiency strategies. An analysis of both Table 6 and Figure 3 show that the energy loss in 2021 was 47 749 kWh.

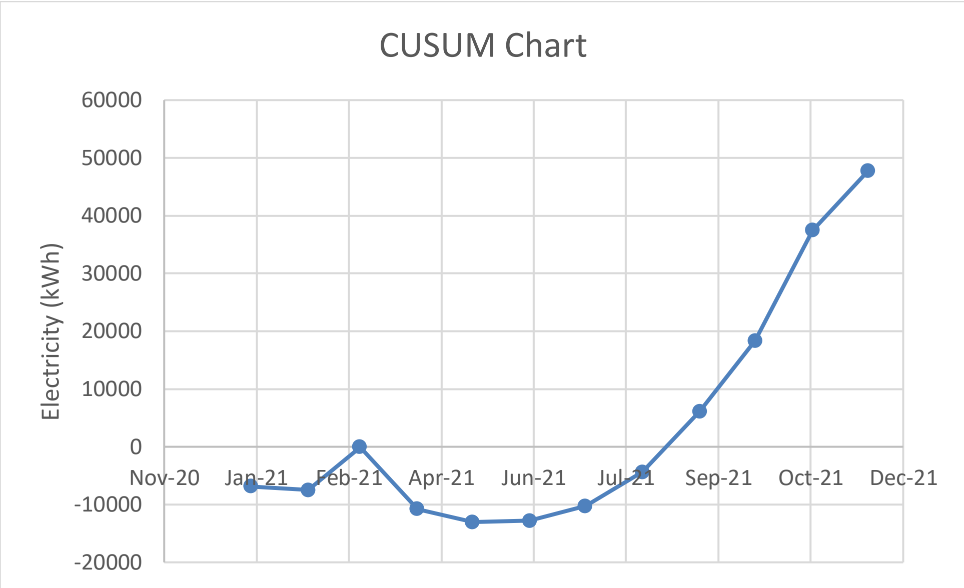

Figure 3 CUSUM Chart

4.4 Identification of Significant Energy Users

Significant energy users installed in the factory with their estimated capacities are presented in Table 7 below. Normally, actual demand and energy use is lower because equipment is not switched on all the time and when running, it is loaded between 50 and 75% of its rated capacity. This information was provided by the client. The load inventory was not conducted due to time constrains of the project. As a result, the load balancing analysis won't form part of this report.

Table 7 Installed capacity & estimated energy usage

ID	Name of SEU	What are the main variables/ drivers?	Is the SEU metered? Auto/ Manual	kWh p.a.	% Of Overall Usage	Who influences the Energy Use?
1	Building Cooling	Weather and occupancy	No	4 000	20%	Facility operator
2	Process Cooling	Production	Auto	6 000	30%	Production supervisor
3	Compressed air	Leaks and waste	Manual	5 000	25%	Facility operator
4	Lighting	Daylight	No	3 000	15%	Everyone
5	Other				10%	

5. DESIGN OF A GRID-TIED SOLAR PV SYSTEM

Since Meze Foods operate mostly during the day, renewable energy can be generated and be used to supply some of the energy required to operate the plant. Based on the 12-month energy consumption of 1 141 721 kWh, it is possible to run a portion of the plant on renewable energy during the day.

Based on the available budget of R235,000 through the GDED Green Incentive Program for SMEs and the available north-facing roof space, a grid-tied solar system with a capacity of 8kWp was sized and presented. **Error! Reference source not found.** below indicates the size of the designed solar PV system, component costs and installation cost.

Table 8: Solar PV System Sizing

DESCRIPTION	NO	UNIT	TOTAL
INVERTER (8kW)	1	R43,800.00	R43,800.00
PV MODULES (*540Wp datasheet attached*)	18	R4,042.92	R72,772.56
MOUNTING STRUCTURE	1	R5,980.65	R5,980.65
DC CABLE	100	R15.22	R 1,522.00
MC4 CONNECTORS	12	R49.84	R598.08
DC ISOLATION (*SANS and NRS compliance*)	1	R10,332.00	R10,332.00
CONSUMABLES	1	R6,320.11	R6,320.11
CABLE TRAYS OUTDOOR	1	R8,843.00	R11,843.00
EARTHING AND LPS	1	R5,761.89	R5,761.89
TRUNKING INDOOR	1	R7,041.21	R7,041.21
AC CABLE AND SWITCHING (C/O, INPUT AND OUTPUT)	1	R19,443.11	R19,443.11
INSTALLATION (PC AMOUNT)	1	R29,446.01	R29,446.01
COMMISSIONING TECHNICIAN (PC AMOUNT)	1	R2,133.00	R2,133.00
GRID PROTECTION ANTI ISLANDING DEVICE (*Ziehl relay*)	1	R14,969.67	R14,969.67
PROFESSIONAL ENGINEER SIGN-OFF	1	R2,979.23	R2,979.23
BI-DIRECTIONAL METER / IF REQUIRED		R3,322.58	R -
GRAND TOTAL (Exclusive VAT)		**R234,942.52**	

The description of the current electricity consumption, tariff and cost are presented in **Error! Reference source not found.**. The estimated energy savings, required investments, and environmental impacts are summarised in Table 10 based on an 8kW PV system.

Table 9 Description of the current energy consumption tariff and cost

SWAGEFAST (PTY) LTD		
ITEM	**REPORT**	**RESULTS**
1	Current Tariff	Time of Use
2	Operating hours	24/7/365
3	Estimated Consumption split Day vs Night	60% Day; 40% Night
4	Average Monthly Consumption (kWh)	100 664
5	Average daytime consumption per Month (kWh)	60 398
6	Blended Tariff (R/kWh)	R1.51
7	Network Capacity Charge (ZAR)	R9 841.03
8	Excess Network Capacity (ZAR)	R14 574.92
9	Network Demand Charge (Peak and Standard) (ZAR)	R9 414.93
10	Time of Maximum Demand	Dependent only on monthly kWh consumed
11	Is Tariff Correct & the Best Option?	YES
12	System Size Comments	Roof mount system

Table 10 The cost-benefit analysis of the PV system

Calculated annual energy consumption	1 141 721	kWh	
Blended Tariff (R/kWh)	R 1.51	/kWh	
Average Monthly Daytime consumption	60 398	kWh	(60% Day & 40% Night)
Average Daily consumption	3020	kWh	(5 Days per week)
System Size (based on average 5.3hrs/day peak sun hours)	**569**	**kWp**	
PV System Size according to the budget	8	kWp	
Estimated Annual production	**11 212**	**kWh**	
Percentage annual savings	0.98%		
Value of annual PV production	R 16 930.12		
The cost of the system	R 234,942.52		
Average annual total bill	R 2 109 006.30		
Percentage Savings on Total Bill	**0.80%**		
Carbon Dioxide Reduction	**11.69**	**Ton/y**	

6. CONCLUSION

Since Meze Foods operate only during the day, renewable energy can play a role in supplementing electricity supplied by the grid and reduce its cost and carbon footprint. This can be generated using solar PV panels which can be installed on the available north-facing roof space to supply a portion of the energy required to operate the plant.

Based on the estimated 12-month energy consumption of 1 141 721 kWh, the company will be able to reduce its electrical energy usage procured from the municipality by about 1% which is equivalent to an estimated 11 212 kWh and cost of R 16 930.12 per annum through the installation of an 8 kWp solar PV system which will be funded through the GDED SME Green Support Incentive Program. The investment required is estimated at around R 234 942.52. This is a good opportunity for the company since electricity is the only energy source consumed on site. Although the PV system will be paid for through a grant from GDED, its impact on the electricity and cost reduction of Meze Foods will not be significant at about 1% and 0.8%, respectively. However, the decision to go ahead with the implementation of the 8 kWp solar PV system will be made by the company in line with its energy and carbon reduction strategy.