Solar photovoltaic (PV) systems on packhouses: the business case for an apple packhouse

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List of acronyms

IRR	internal rate of return
KVA	kilovolt-amps
CO_2e	carbon dioxide equivalent
LCOE	levelised cost of energy
kW_p	kilowatt-peak
MW	megawatt
MW_p	megawatt-peak
NERSA	National Energy Regulator of South Africa
NPV	net present value
NRS	National Regulatory Standards
PV	photovoltaic
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
SANS	South African National Standards
SSEG	Small-scale embedded generation

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Executive summary

This report presents the business case for the installation of solar photovoltaics (PV) systems on packhouses to highlight the opportunity to packhouse owners. This is done in the context of an increased focus on energy security for industries in South Africa.

Although it is currently not possible to connect and feed-in to the grid everywhere, the report lists those municipalities that allow connection and those that are developing rules and regulations. It also shows when Eskom allows feed-in. The establishment of tariffs and regulations for feeding electricity into the grid are fundamental in enabling the uptake and feed-in of renewable energy, such as solar PV.

The value of renewable energy projects (commercially i.e. not at utility scale) is mostly derived from replacing relatively expensive electricity rather than selling excess electricity back to the grid which receives a significantly lower return. This drives the business case for solar PV on packhouses as they require electricity at the same time that solar PV generates electricity. This is due to packhouses' significant cooling needs and the fact that most energy-intensive activities occur during the day.

The financial feasibility for installing solar PV on a packhouse is shown by modelling an apple packhouse based on industry averages. The feasibility is examined under a number of scenarios namely:

- Two size solar PV installations:
  - 500 kW_p solar PV installation
  - less than 10 kW_p
- Two tariff structures:
  - George Municipality tariffs
  - Eskom Ruraflex tariffs
- Two tariff increase scenarios
  - 13% per annum for five years then 8% per annum
  - 10% per annum increase
- Different financing solutions
  - Self-funded (full cost borne in first year)
  - 80% financed by 10 year loan at 10%
  - 80% financed by 10 year loan at 18%

The modelled results provide some key insights:

- **The economies of scale are significant**
  - Large (500kW_p) systems were feasible in all scenarios considered.
    - 8 – 13 years of 'free energy' once the system is paid off based on simple payback
    - Net present value of R0.5 – R4.1 million on R8.1 million system
    - Internal rate of return greater than 18% discount rate in all scenarios
- **Financing is key to unlocking full potential of solar PV:**
  - Even small systems (≤10 kW_p) are financially viable under the right financing conditions.
    - 5 – 10 years of 'free energy' once the system is paid off on simple payback
    - Positive net present value only under favourable (10%) loan terms
    - Internal rate of return range: 11-21% thus profitable when lower discount rate is used

The opportunity for financing solutions is currently being unlocked by innovative performance-based contracting helping to overcome capital cost constraints, with Energy Service Companies (EScos) playing a significant role. For businesses this implies that external financing solutions may provide greater returns than self-finance when implementing solar PV solutions. Solar PV installations on packhouses are thus worth exploring, most clearly shown through the case studies that have already been able to profitably implement them.

1. Introduction

This report is aimed at packhouse owners to help inform them of the financial feasibility of installing solar PV. The report provides a basic business case for the installation of solar photovoltaic (PV) systems on packhouses. An apple packhouse is modelled to illustrate this and is based on established industry energy use.

One of the first aspects to be considered in relation to solar PV installation is who the utility, or seller of electricity is, as the rules and regulations vary according to the seller. The next section (Section 2) highlights where the rules and regulations are in place to allow connection and feed-in to the grid.

The general business case for solar PV on packhouses is discussed in Section 0. This section highlights why packhouses are a logical fit for the application of solar PV systems and discusses how the cost of solar PV has fallen as the technology has become more efficient. Case studies of packhouses that have installed solar PV systems demonstrate that this is an economically feasible opportunity with real uptake.

An apple packhouse is modelled under a range of scenarios in Section 4 to illustrate the financial feasibility of solar PV systems. The packhouse is modelled on established industry energy use benchmarks. The scenarios include different: solar PV installation sizes, tariff structures and financing methods. With the financial feasibility demonstrated in terms of:

- Simple payback
- Net present value
- Internal rate of return

In the final section, the results of the modelled scenarios is considered and the implications for packhouses discussed, highlighting the opportunity for greater uptake of solar PV.

2. Regulations and tariffs

Regulations relate to both installation of solar PV and feeding of electricity back onto the grid. Regulations are important for a number of reasons including, ensuring grid safety and stability. To make this possible, **all connections to the grid must be registered** with the relevant utility (or seller of the electricity) to ensure that they can be isolated from the grid when need be (i.e. have sufficient reverse flow protection). This helps ensures the safety of maintenance staff.

The ability to feed-in (or sell excess electricity) is also important for many PV installations as not all electricity is necessarily generated at the time that it is needed. When excess energy is generated it would have be stored or sold. Alternatively, the installation size can be limited to avoid excess generation. The mismatch between generation and use can also mean insufficient energy is produced at certain times, thus requiring either: (a) stored energy from when excess was generated, or (b) back-up energy from an alternative source, such as the grid.

The specific electricity regulations and tariffs that a packhouse will be subject to will depend on the facility's utility, i.e. whether the facility buys electricity from Eskom or the local municipality. Some packhouses fall within municipal boundaries and purchase their electricity from their local municipality, in which case it is necessary to check the applicable regulations and tariffs. This is fundamental to the business case as the cost of the system is offset by the electricity costs it is replacing. Figure 1 highlights the questions to ask to determine under which regulations a potential solar PV installation would fall. A list of the relevant regulations and policies is provided in the appendix of the report, with more detail available in GreenCape's 2014 Renewable Energy Market Intelligence Report[1].

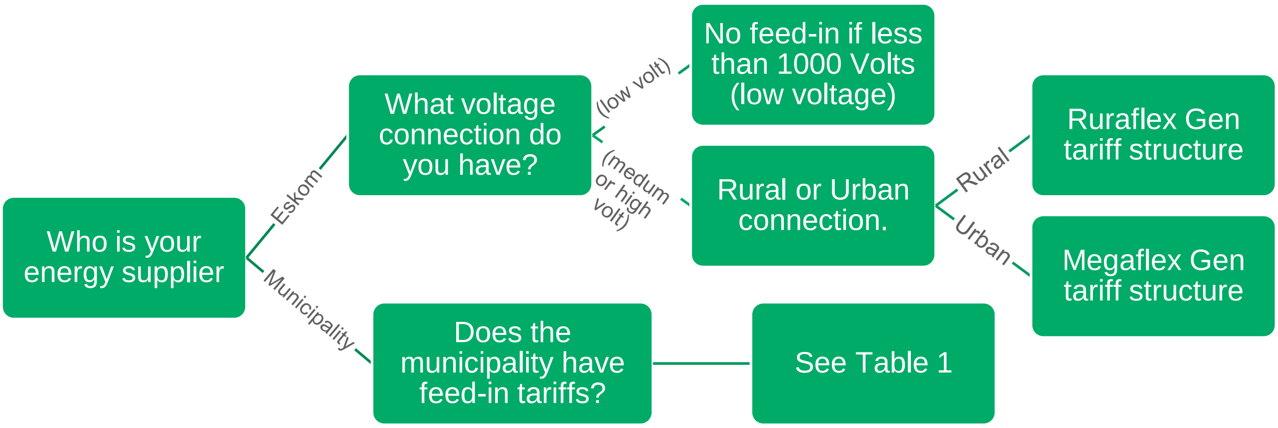


Figure 1: Questions to determine applicable tariffs for solar PV system

Currently, selling excess electricity generated is only possible in a certain municipalities within the Western Cape, as highlighted in Table 1 (see page 4). However, GreenCape's Smart Electricity Project is continuing to work with municipalities to assist in the development of feed-in tariffs[2].

At the time of publication, the municipalities indicated in Table 1 have either set up feed-in tariffs or are working in conjunction with GreenCape's Smart Electricity team to do so. Note that the availability of regulations and tariffs indicates that rules are in place to allow feed in, but the local municipality would still need to be consulted on the required processes and likely timeframes for approval.

[1] Available at: greencape.co.za/what-we-do/sector-development/renewable-energy/
[2] Latest version available at: greencape.co.za/munic-pv

If a Western Cape municipality is not in Table 1, it is currently not permissible to feed electricity onto the grid, although it is envisioned that most municipalities within the Western Cape will adopt enabling regulations within the next two years.

Table 1: Municipalities with, or currently developing, feed-in tariffs

Municipality	Allow feed-in	Feed-in rules & regulations	Approved feed-in tariffs	Further information
City of Cape Town Metropolitan	Yes	Yes	Yes	The detail of these tariffs can be found on the City of Cape Town's website.[3]
Drakenstein Local Municipality	Yes	Yes	Yes	Current net metering tariff information available on the municipality's website[4].
George Local Municipality	Yes	Yes	Yes	Current "imbedded generation" tariffs available in the municipality's tariff book[5].
Stellenbosch Local Municipality	Yes	Yes	Yes	These municipalities have been selected by the Western Cape Government's Energy Security Game Changer as key municipalities for Energy Security and are explore various interventions to reduce load on the national grid.
Mossel Bay Local Municipality	Yes	Yes	Yes	
Theewaterskloof Local Municipality	Yes	In progress	In progress	Further information can be obtained from Theewaterskloof Municipality Technical Services Department[6] or GreenCape's Smart Electricity team.[2]
Swartland Local Municipality	Yes	Yes	Yes	For further information on Swartland's 'net-metering tariffs' contact the Swartland Municipality's Technical Services Department[7]
Beaufort West Local Municipality	Yes	In progress	Yes	The municipality has been working with GreenCape's Smart Electricity team. It is expected that rules, regulations and tariffs will be in place this year. Further information can be obtained from Beaufort West Municipality Technical Services department.[8]
Overstrand Municipality	Yes	In progress	Yes	The municipality's small scale embedded generation guidelines, based on GreenCape's guidelines, are available on Overstrand Municipality's website[9]

[3] Available at: www.capetown.gov.za/en/electricity/Pages/ElectricityTariffs.aspx
[4] Available at: www.drakenstein.gov.za/Administration/Documents/Documents%20For%20Citizen%20Viewing/Finance/Tariffs/2015%20-%202016/Tariffs%202015-2016.pdf
[5] Available at: www.george.org.za/listings/policy as tariff list.
[6] Contact info available at: www.twk.org.za/node/51
[7] Contact info available at: www.swartland.org.za/pages/english/contact-us/general.php
[8] Contact info available at: www.beaufortwestmun.co.za
[9] Available at: https://www.overstrand.gov.za/en/documents/electricity/3347-sseg-guidelines/file

Municipality	Allow feed-in	Feed-in rules & regulations	Approved feed-in tariffs	Further information
Oudtshoorn Local Municipality	Yes	In progress	In progress	The municipality has been working with GreenCape's Smart Electricity team. It is expected that rules, regulations and tariffs will be in place this year. Further information can be obtained from Oudtshoorn Municipality Technical Services department[10] or GreenCape's Smart Electricity team.[2]
Bergrivier Local Municipality	Yes	In progress	No	The municipality have indicated that they have begun to explore the City of Cape Town small scale embedded generation rules and regulations as there has been an increasing interest in SSEG and energy efficacy in the municipality.

[10] Contact info available at: www.oudtmun.gov.za/index.php?option=com_content&view=category&layout=blog&id=131&Itemid=61

3. Solar PV and packhouses

Packhouses are highly appropriate for solar PV installation due to the energy demands of packhouses. Additionally, the cost of PV has fallen significantly and is not prohibitive. This is illustrated with a number of successful installations at the end of this section.

3.1. Suitability of solar PV for packhouses

Solar PV has great potential in South Africa as the country has some of the best solar irradiation in the world[11]. Solar PV is especially appropriate on packhouses because:

- The electricity is generated during the day when demand is highest.
  - Most energy is needed for cooling (80%), which requires 30% more energy during the day.
  - The most energy intensive activity is packing which also occurs during the day.
- Seasonal trends have an impact on packhouse activity and thus energy demand.
  - Packhouses are most active during summer when solar PV generates the most electricity.
  - This is particularly notable in the Western Cape which experiences winter rainfall.

This is clearly demonstrated in Figure 2 and Figure 3. Figure 2 below shows how much energy is typically generated by a solar PV system in summer and winter, showing a peak in the middle of the day. It highlights that energy generation is highest in the middle of the day and higher for summer than winter.

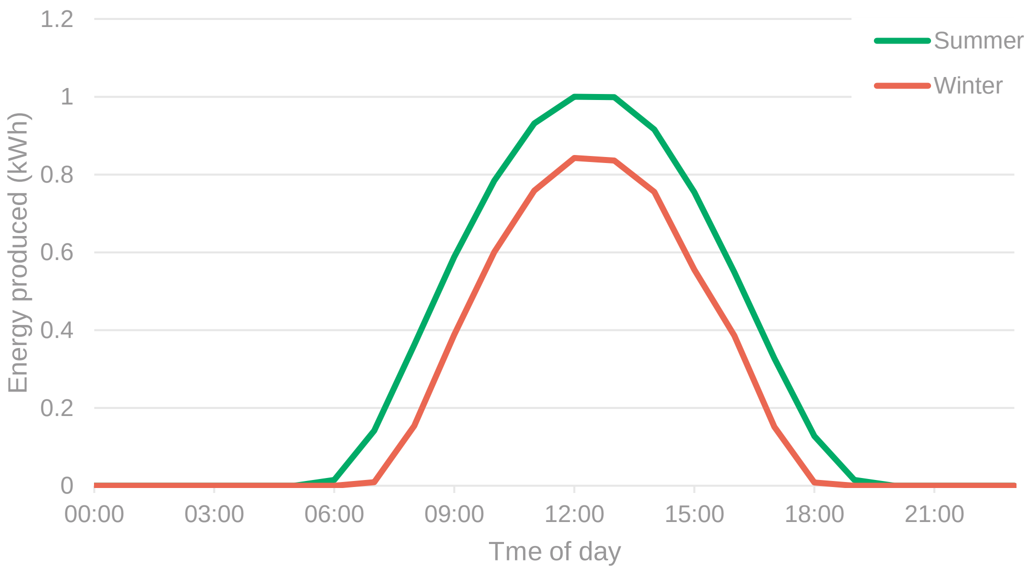
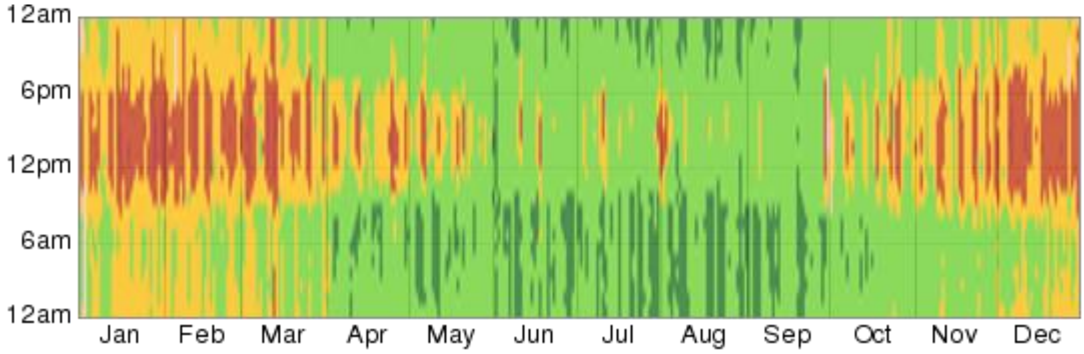


Figure 2: Typical profile of solar energy produced (kWh) in summer and winter for 1 kW_p solar PV system[12]

[11] See Figure 5 in appendix for map of global radiation illustrating this.

[12] Own calculations based on Sustainable Energy Africa (SEA, 2014). For larger scale installations simply multiply size by output as graph e.g. 250 kW_p will produce 250kWh midday in summer.

Figure 3 shows the average temperatures during different parts of the day in Cape Town for a year, with the highest temperatures in the afternoon, highlighting the greater cooling needs during the day especially in summer thus supporting higher electricity requirements during the day.



Legend	
Colour	**Temperature (°C)**
Dark green	0-10
Light green	10-18
Yellow	18-24
Light red	24-29
Medium red	29-38
Dark red	above 38

Figure 3: Full yearly hourly temperature Cape Town 2013[13]

3.2. Solar PV development and costs

Solar PV has experienced significant advances in manufacturing technology and energy efficiency, allowing significant decreases in prices. Internationally, solar PV prices fell 35% a year from 1980 to 1995 per kWh generated (Taggart, 2009), with further decreases thereafter. This is evident at utility scale with solar PV in South Africa falling from an average of R3.35[14] per kWh in 2011 to average of R0.90 per kWh in the fourth round of the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP[15]). This is partly driven by increases in the efficiency with which solar PV can turn sunlight into electricity - the 20% efficiency threshold was first overcome in 1989 and the 40% efficiency milestone was reached in 2014 (The University of New South Wales, 2014).

The downward trend of solar PV costs is also reflected in smaller scale solar PV installations, based on GreenCape interactions with suppliers in South Africa. Figure 4 below shows the capital and installation costs of both small (1-10 kW_p) and large solar PV systems (>100 kW_p).

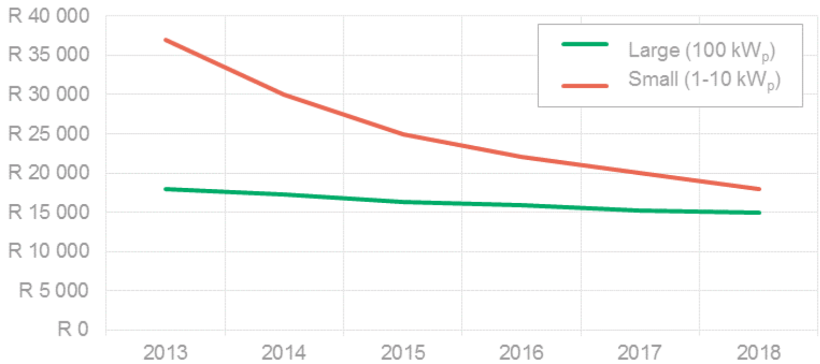


Figure 4: Cost of solar PV installations over time (R/kW_p)[16]

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[13] The full year of hourly temperature reports, with the days of the year on the horizontal axis and the hours of the day on the vertical axis. Source: (WeatherSpark, n.d.).
[14] Expressed in 2015 Rand value.
[15] For broad overview of falling utility scale costs see Table 4 in GreenCape's 2015 Renewable Energy Market Intelligence Report available at: greencape.co.za/what-we-do/sector-development/renewable-energy/
[16] Based on reported cost and estimated costs of solar PV installations from industry players provided to GreenCape energy team.

3.2.1. Energy storage costs

Including batteries in a solar PV system would allow solar PV installations to better match energy supply to energy demand as excess energy can be stored for later use. While the rate at which solar PV prices have been falling is slowing, the cost of battery systems is predicted to fall substantially over the next couple of years and thus a better option could be to delay including battery storage at this stage (Vorrath, 2015)[17].

3.2.2. Grid connection costs

While it is possible to feed-back excess electricity onto the grid for installations on medium or high voltage connections to Eskom, there may be additional costs implications to ensure the grid is able to manage the electricity flows. To assess whether there is a need for any upgrades, a request can be made to Eskom's grid access unit for a technical assessment. This assessment will involve a cost to the company requesting it[18]. This would be completed in a maximum of 90 days. This non-binding cost assessment will provide information on: (a) whether it is possible to feed-in at the connection, as well as (b) what upgrades, if any, are necessary to make it possible. If one chooses to go ahead based on the non-binding cost assessment a full cost assessment would have to be undertaken that would take an additional three to six months.

3.3. Case studies

There have been a number of solar PV projects within the agricultural sector in the last few years with total installed solar PV capacity of 6 075 kW_p (Ballack, 2015). This includes some sizeable installations on packhouses, with some specific examples presented in Table 2 overleaf. These case studies demonstrate that the application of solar PV for packhouses has already proved to be feasible in a number of cases. Given the trends highlighted, the business case is set to improve. To illustrate this, the business case for solar PV on an apple packhouse is considered in the next section based on average industry energy needs.

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[17] Specifically with respect to packhouses, as most energy is used as it is generated i.e. the amount of energy available for storage would be less than that generated for other applications. In recognition of this, and the significant cost of including batteries, the business case in in Section 4 does not include batteries.

[18] More information available at: www.eskom.co.za/Whatweredoing/Pages/Consultation_And_Application_Process.aspx

Table 2: Case studies of packhouses with solar PV installations

	Ceres Fruit Growers	Ceres Koelkamers	ArbeidsVreugd Fruit Packers	Stellenpak Fruit Packers
Town	Ceres	Ceres	Villiersdorp	Paarl
System:	**986 kW_p system** Installed by SolarWorld Africa and African Technical Innovations (ATI) • 4 060 SW250 SolarWorld polycrystalline panels • 58 x 17kW three phase invertors (Sunny Tripower Invertors)	**508 kW_p system** Installed by SolarWorld Africa and African Technical Innovations (ATI) • 2117 SW240 polycrystalline PV panels • 3 800m^2 surface area	**450 kW_p system** Installed by Renewable Energy Design Engineering • 1876 x 240 W_p Trina Solar modules • 26 SMA Tripower 17000 three-phase inverters • Online data of power production[19]	**420 kW_p system** Installed by Energyworx • 1680 SolarWorld SW250 polycrystalline modules • 2 744m^2 surface area • 21 Steca 20,000 TL3 grid tied inverters
Return on investment	• Generating 1 690 MWh per year • 6% reduction in annual electricity consumption • 1 622 tonnes CO_2e avoided per annum	• Generating 848 MWh per year • 11%[20] reduction in annual electricity costs • 839 tonnes of CO_2e avoided per annum	• Generating 743 MWh per year • R38 million savings over 25 year lifetime • 733 tonnes CO_2e avoided per annum • Estimated payback 6 years	• Generating 600MWh per year • 15% reduction in electricity costs • 25 year guaranteed lifespan of the system
Sources:	ESI Africa, 2013	Taylor, 2013	Brandt, 2013 & RED Engineering.	Bizcommunity, 2014

[19] Available at: http://www.redengineering.co.za/RedEngWeb/index.php?id=342
[20] Originally 17% reduction in annual electricity costs but now only 11% due to expansion of facilities.

4. Business case for an apple packhouse

This section examines the financial feasibility of installing solar PV on a modelled apple packhouse. The business case for solar PV on an apple packhouse is examined under a number of different scenarios. The financial feasibility is tested using simple payback, net present value (NPV) and internal rate of return (IRR) [21].

[21] An example of the costs and value generated per year is shown in
Assumptions and parameters for the business case

This section provides the assumptions made regarding the energy demands of the modelled packhouse and the solar PV installed thereon.

1.1.1. Solar PV system

A solar PV system of 500 kWp with characteristics presented in Table 6 is modelled in the business case. This size system was chosen to align with those already installed, shown in Section 3.3 which range from 420 to 1 015 kWp.

Table 6: Summary of modelled solar PV characteristics

Solar PV System	
Size of system	500 kWp
Life span of PV	20 years
Peak energy reduction from solar PV (share of solar PV peak production capacity)	30% (i.e. 500 kWp results in 150 KVA reduction, only applicable when selling to Eskom)
Decrease in yield per year	0.5%
Operating cost	5% of capital cost
Energy storage/batteries	None

1.1.2. Energy demand profile of packhouse

To examine the business case for an apple packhouse, energy demand is based on benchmarks determined by an expert in the industry. An estimated 80-85% of energy needs at a packhouse come from cooling needs, which fluctuate with ambient temperatures. The basic business case presented here is based on the assumptions of a 20 week peak packing period followed by systematic decrease in stock (10 500 tonnes at start of the off-peak period) over the remaining weeks. The full set of assumptions are laid out in Table 7 and Table 8. For simplification, the off-peak period is assumed to have one day of packing per week at a reduced throughput. This is a gross simplification, as in reality packing during off-peak will be in response to higher off-peak prices due to decreased supply. There would thus be short periods of more intense packing. This makes the energy demand estimations for the off-peak period less accurate than that for the peak period.

Table 7: Apple packhouse: assumptions for peak and off-peak periods

	Peak Period	Off-Peak Period
Duration	20 weeks	32 weeks
Work week	5 days a week	1 day a week

Volume	400 tonnes packed per work day and 200 tonnes added to controlled atmosphere storage or 1000 per week.	625 tonnes packed per work day (built up stock of 20 000 tonnes spread over 32 weeks)

The energy demand for the modelled packhouse is laid out in Table 8 overleaf, as well as what share of electricity is assumed to be substitutable by the solar PV system. The cooling (controlled atmosphere, regulated atmosphere and pallet) are assumed to run constantly and thus only partially substitutable. The average storage in the different sections is also shown in the last column. Packing is the most energy intense and most substitutable as it occurs almost exclusively when the solar PV is generating electricity. This helps justify the rationale for applicability of solar PV on packhouses. It is also assumed that there is no changing tariff structure and thus all fixed costs, such as connection costs and administrative charges, related to connecting to the electricity provider remain the same and thus are not part of the business case.

Table 8: Apple packhouse: energy demand components

	Energy demands	Share that can be supplied by PV	Average days in each section
Controlled atmosphere	0.7 kWh/day/tonne stored	42%*	N/A – long term storage
Regulated atmosphere	3.5 kWh/day/tonne stored	42%*	2 days
Pallet Cooling	7 kWh/day/tonne stored	42%*	5 days
Packing	15 kWh/day/tonne packed	90%	1 day
Other energy needs	10% of total energy (constant over the entire year)	30%	Everyday

*For cooling: solar PV is not generating electricity for 14 of 24 hours (58%).

1.1.3. Energy profile for a year

Taking the assumed solar PV system size of 500 kWp, the energy produced could be calculated using the energy produced in summer and winter (shown in Figure 2). Using this energy produced by the solar PV system in conjunction with energy needed for the packhouse (From Table 7 & Table 8) the energy profile for a year could be established, as shown in Figure 6 below.

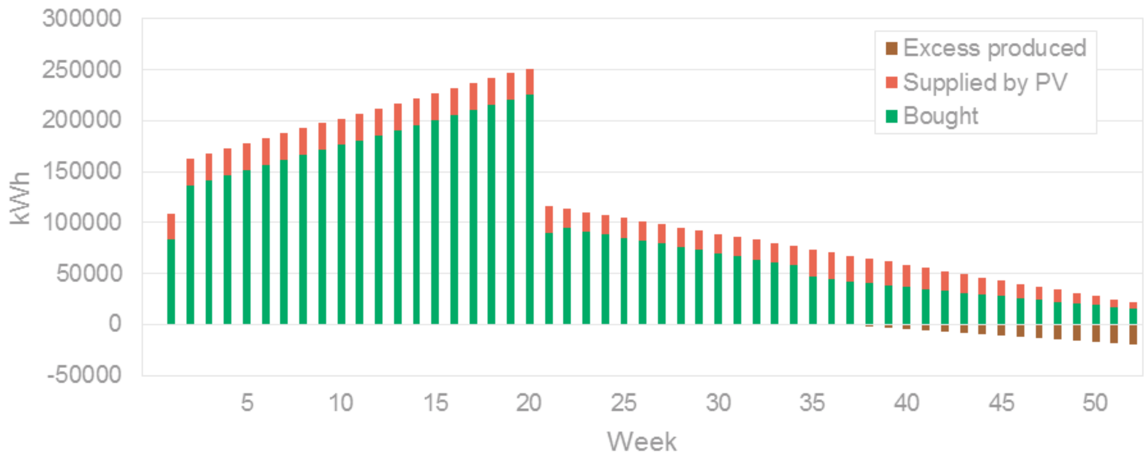

Figure 6: Electricity profile of a packhouse packing 1000 tonnes of apples a week with a 500 kWp solar PV system installed

As shown in Figure 6 above, energy demands rise rapidly from week one to two as stocks build up. The packhouse is working at full capacity by the second week, with additional rises as stocks in controlled atmosphere storage build up. Energy demands are high and rising as stock increases during peak period with a sudden decrease in the off peak as less active packing takes place. Energy demands then continue to fall as the built up stock diminishes. Eventually, as energy demands fall low enough, excess energy is then sold back onto the grid (shown as negative values in Figure 6) with increasing amounts over time as less of the electricity produced is needed for own use.

1.2. Sales and feed-in tariffs

Two different scenarios are considered for the value of electricity generated by the solar PV system:

- Buying from George Municipality on its embedded generation tariff.
- Buying from Eskom on a Ruraflex Gen tariff.

While there are not many packhouses in George, it has a relatively well developed feed-in tariff system. Other municipalities' tariffs are likely to follow a similar structure and thus George's tariff structure is a useful reference point to consider. Eskom's Genflex tariff is also considered as it is assumed to be the most likely Eskom tariff for a packhouse and allows feed-in of excess electricity as it assumed a packhouse of the scale modelled will have at least a medium voltage connection.

However, when considering the financial feasibility of a specific project the tariff and regulations the installation will fall under is fundamental, as highlighted in Section 2, regulations and tariffs for feed-in of excess energy are not available everywhere. Additionally, where tariffs have been established the costs and feed-in rates vary significantly. To highlight the variance in the costs and feed-in rates, Table 9 below presents the 2015-2016 electricity tariffs for the two tariff structures considered.

Table 9: 2015/16 Rand per kWh tariffs for medium voltage connections for George Municipality and Eskom Ruraflex Gen

	George Municipality Embedded Generation				Ruraflex Gen			
	Cost of electricity		Feed-in tariff*		Cost of electricity		Feed-in tariff*	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Peak	R 1.15	R 2.77	R 0.8281	R 2.5388	R 0.9779	R 2.9975	R 0.0924	R 0.2832

4.1. Why an apple packhouse?

An apple packhouse (the assumptions of which are discussed in Section 7.3) was chosen for a number of reasons, namely:

- Controlled atmosphere storage means there is energy demand throughout the year.
  - Solar PV continues to produce electricity throughout the year.
- The peak season is during summer, when the most energy is required.
  - Solar PV generates the most electricity during summer.
- If electricity is sold in the off-peak period it could supplement the seasonal income of packhouses.
  - While income from feed-in may be small it may aid cash flow.
  - Most electricity prices are higher in winter than in summer (including tariffs for feed-in).

4.2. Financial return for modelled packhouse

The apple packhouse was modelled to consider the financial feasibility of solar PV installations under a number of likely scenarios. This was done to examine the robustness of the results with the scenarios that were considered being:

- Two size solar PV installations:
  - 500 kW_p solar PV installation
  - less than 10 kW_p
- Two tariff structures:
  - George Municipality tariffs[22]
  - Eskom Ruraflex tariffs
- Two tariff increase scenarios
  - 13% per annum for five years then 8% per annum[23]
  - 10% per annum increase
- Different financing solutions
  - Self-funded (full cost borne in first year)
  - 80% financed by 10 year loan at 10%
  - 80% financed by 10 year loan at 18%

Additionally, while selling excess power has a lower value to a company, the generation of excess power occurs during a period of relatively low income for a packhouse (i.e. out of season) and thus could have a greater impact on the cash-flow of a business than the relatively small values would indicate. This is not captured by any of the measures used to examine the financial feasibility but may be worth considering.

Breakdown of financials for the most likely scenario

Table 10 below shows a detailed breakdown of the business case for the most likely scenario, namely a large scale (500kWp) solar PV system that is financed with a loan for 80% of the installation costs that is paid off over 10 years. The electricity tariffs are estimated to increase by 13% in the first 5 years and 8% per annum increases thereafter. It is also assumed that the packhouse falls under an Eskom Ruraflex Gen tariff system. Similar details for the other scenarios are available on request.

Table 10 in the appendix for one scenario.

[22] George Municipality tariffs were selected to represent municipal tariffs as they are expected to broadly correspond with other municipal tariffs.

[23] Based on Eskom's historical trends and the current energy crisis the country faces.

The simple payback, net present value (NPV) and internal rate or return (IRR) for these different scenarios are now presented in turn.

4.2.1. Simple payback

The simple payback indicates after how many years the original cost of the project is recovered by the project, i.e. how long before the original cost is paid back. The simple payback also ignores the time value of money, i.e. future incomes are not discounted. The results of the simple payback for the different scenarios are summarised in Table 3 below:

Table 3: Simple payback period of different scenarios for solar PV installation

Tariff increase over time	Payback in years for George Municipality embedded generation		Payback in years for Eskom Ruraflex Gen	
	500 kW_p	≤10 kW_p[24]	500 kW_p	≤10 kW_p[24]
	Cash purchase (no finance costs)			
13% increase to 2019 then 8% thereafter	6.6	9.4	7.4	9.8
10% increase	6.9	9.8	7.8	10.3
	80% financed by a 10 year loan at 10% interest rate			
13% increase to 2019 then 8% thereafter	7.0	11.8	9.0	12.4
10% increase	8.0	12.3	10.0	12.7
	80% financed by a 10 year loan at 18% interest rate			
13% increase to 2019 then 8% thereafter	10.3	13.8	11.4	14.4
10% increase	10.7	14.0	11.7	14.5

Given the expected lifetime of solar panels of 20 years and the longest payback period of 15 years, the model indicates **a payback before the end of the solar panels lifetime in all scenarios**. The simple payback results thus indicate that implementing solar PV on packhouses is worth considering. Once the solar PV system has been paid off it continues to generate value at no cost**. For the large system this means 8 - 13 years of 'free energy' and 5 – 10 years for the small system.**

4.2.2. Net present value and levelised cost of energy

The net present value (NPV)[25] considers the time value of money, with money in the future being less valuable than money today due to inflation and uncertainty of the future. Taking all the costs and incomes of a project to the present day provides an indication of whether an investment would be profitable. This is done by using a discount rate or value with which value is deemed to lose value per annum. The resulting NPV indicates a profitable investment opportunity with a positive value i.e. considering all the costs and revenue at present day the revenue is greater. A negative NPV indicates that the costs over the lifetime are greater than the 'revenue', when considering when the costs and revenue occurs.

[24] All small systems have the same payback as all electricity is utilised at this small scale and costs and values are per kW_p.

[25] NPV = $(income_t – cost_t)(1+i)^t$ where t = time and i = discount rate

The NPV under the different scenarios is shown in Table 4 overleaf, using a discount rate of 18%. To place these returns in perspective, the cost of the 500kW$_p$ system is R8.15 million and a 10 kW$_p$ system R0.25 million. **For all 500 kW$_p$ scenarios, the NPV shows the investment to be profitable,** shown by a positive value. However, **the small (less than 10 kW$_p$) system is only profitable under favourable loan terms** (10% interest) i.e. shows a positive NPV. This shows that while economies of scale make larger systems more viable, **with the correct financing smaller systems can be profitable investments** as well.

Table 4: Net present value of different scenarios for solar PV installation

Tariff Increase over time	NPV for George Municipality embedded generation		NPV for Eskom Ruraflex Gen	
	500 kW$_p$	≤10 kW$_p$[26]	500 kW$_p$	≤10 kW$_p$[26]
	Cash purchase (no finance costs)			
13% increase to 2019 then 8% thereafter	R 2 016 376	-R 48 323	R 654 703	-R 59 855
10% increase	R 1 859 463	-R 51 579	R 517 032	-R 62 948
	80% financed by a 10 year loan at 10% interest rate			
13% increase to 2019 then 8% thereafter	R 4 154 481	R 17 263	R 2 792 808	R 5 732
10% increase	R 2 246 243	R 14 007	R 2 655 137	R 2 638
	80% financed by a 10 year loan at 18% interest rate			
13% increase to 2019 then 8% thereafter	R 2 403 155	-R 36 458	R 1 041 483	-R 47 990
10% increase	R 2 246 243	-R 39 715	R 903 812	-R 51 084

Alternatively the levelised cost of energy[27] (LCOE), the discounted cost of energy produced over the systems lifetime (20 years), could be considered. For small systems (10kW$_p$ and less) the LCOE is R0.65 per kWh with larger systems achieving R0.42 per kWh, again indicating the value of economies of scale[28].

4.2.3. Internal rate of return

The internal rate of return (IRR) indicates the interest rate at which the net present value of all the cash flows (both positive and negative) from a project or investment equal zero. Theoretically, all projects with an IRR higher than the cost of capital (interest rate on loan) would be financially feasible. The IRR results shown in Table 5 overleaf show that **large systems' IRR range from 19 to 64% indicating a profitable investment opportunity**, as it is greater than the most expensive interest rate of 18%.

Smaller systems of less than 10 kW$_p$ have an IRR in the range of 11 - 21%, showing that if a good lending terms (10%) are achieved small-scale solar PV systems make economic sense.

[26] All small systems have the same NPV as all electricity is utilised at this small scale and costs and values are per kW$_p$.
[27] Discounted total costs of installation ÷ electricity produced over lifetime
[28] This seems to be broadly in line with the utility scale solar PV in the Department of Energy's REIPPPP where the solar PV average cost was R0.79 per kWh in the fourth round[28] (GreenCape, 2015).

However, it is important to remember that all electricity is replacing purchased electricity in the model, which may not be the case in smaller packhouses as they have lower electricity demands. Thus the financial feasibility of possible small scale projects would have to be examined in more detail.

Table 5: Internal rate of return of different scenarios for solar PV installation

Tariff Increase over time	IRR for George Municipality embedded generation		IRR for Eskom Ruraflex Gen	
	500 kW_p	≤10 kW_p[29]	500 kW_p	≤10 kW_p[29]
	Cash purchase (no finance costs)			
13% increase to 2019 then 8% thereafter	22.6%	14.3%	19.5%	13.4%
10% increase	22.0%	14.2%	19.1%	13.3%
	80% financed by a 10 year loan at 10% interest rate			
13% increase to 2019 then 8% thereafter	30.3%	13.2%	22.7%	11.8%
10% increase	28.2%	13.2%	21.7%	11.9%
	80% financed by a 10 year loan at 18% interest rate			
13% increase to 2019 then 8% thereafter	64.7%	21.2%	39.6%	19.0%
10% increase	54.4%	20.4%	35.6%	18.4%

4.2.4. Other returns from solar PV

Reducing the carbon footprint of production may add value to producers due to the proposed carbon tax of R120 per tonne CO_2e[30]. Additionally, 45% of deciduous fruit in South Africa is exported and increasing pressure in the global market for low carbon products provides a more immediate motivation for reducing emissions. Comparing the life cycle-based emissions of the South African electricity mix and solar PV, the South African electricity mix contains 1.09kg CO_2e per kWh more than solar PV[31]. Thus the uptake of solar PV will clearly decrease the emissions related with fruit production and packaging. For the modelled packhouse **the installation of 500 kW_p solar PV would result in an approximately 35% reduction of CO_2e per annum**[32].

4.3. Financing options

While financing terms vary from project to project, in part recognised with the two different loan terms in the business case, there are financing opportunities that specifically target green technology projects. These targeted financing opportunities allow the financiers to better understand the risks and returns of projects and thus offer better loan terms than financiers that have to include a larger component of uncertainty in their risk assessment. There are numerous financing opportunities and funds such as:

[29] All systems have same IRR as all electricity is utilised at this small scale and cost and value are per kW_p.
[30] For more information on the carbon tax see: www.treasury.gov.za/public%20comments/CarbonTaxBill2015/
[31] Based on ecoinvent 3.2 database and the ReCiPe Midpoint Global Warming Potential in 100 years: 1.13 CO_2e per kWh for low voltage electricity in SA and 0.04 CO_2e per kWh for low voltage for solar PV.
[32] Own calculation based on average emissions per kg fruit from Confronting Climate Change (CCC, 2014).

- The Green Energy Efficiency Fund of the Industrial Development Corporation[33].
- Innovative funding contracts such as Energy Services Companies (ESCos) who enter into performance-based contracting where income is linked to the amount of savings achieved in a project[34].

GreenCape's Green Finance Desk is able to provide information on the funds available that would be applicable to specific projects[35].

In addition to the funding opportunities, there are tax incentives that could strengthen the business case such as the 12B Income Tax Act No. 58 of 1962. This allows rapid depreciation of renewable energy installations. For the case of solar PV installations less than $1MW_{p,}$ such as the one modelled, the full cost can be depreciated in its first year of installation. This will enable greater returns by reducing the taxable income in the year of installation as the full amount would be seen as an expense.

While economies of scale seem to play a large role in the return of projects, the large capital outlays needed may limit uptake. To some extent this can be overcome through innovative financing and incentives. Alternatively, solar PV is relatively modular as adding an additional panel would not substantially change the solar PV system. Thus, larger installations can be done in phases as capital becomes available, although this is not an established *modus operandi*.

[33] See IDC website for more information: http://www.idc.co.za/home/idc-products/special-schemes/geef.html
[34] For a list of ESCos in Cape Town See: www.escos.co.za/index.php/list-of-escos
[35] For more information contact GreenCape's green finance desk: gf@greencape.co.za

5. Conclusion

The use of energy generated from solar PV is the key driver of the feasibility of solar PV projects, with the returns of replacing electricity purchases significantly larger than selling excess energy produced back onto the grid. As the selling of electricity back onto the grid is not possible everywhere (especially for low voltage connections) this makes the prioritisation of own use even more fundamental. Packhouses are highlighted as a key opportunity for solar PV installation as their energy demand profiles match electricity generation of solar PV well.

The financial feasibility for installing solar PV on a packhouse is shown using an apple packhouse modelled on industry averages under a number of scenarios. The model highlighted that:

- **The economies of scale are significant:**
  - Large (500kW$_p$) systems were feasible in all scenarios considered.
    - 8 – 13 years of 'free energy' once the system is paid off based on simple payback
    - Net present value of R0.5 – R4.1 million on R8.1 million system
    - Internal rate of return greater than 18% discount rate in all scenarios
- **Financing is key to unlocking full potential of solar PV:**
  - Even small systems (≤10 kW$_p$) are financially viable under the right financing conditions.
    - 5 – 10 years of 'free energy' once the system is paid off on simple payback
    - Positive net present value only under favourable (10%) loan terms
    - Internal rate of return range: 11-21% thus profitable when lower discount rate is used
- **Tariffs and regulations are key:**
  - It is not possible to connect to and feed-in to the grid everywhere, most notably for low voltage connections. This is a key limitation on greater uptake of solar PV.

The ability to secure financing is a key enabler as the returns on investment on systems financed by loans are greater than those paid off in their first year. The opportunity is currently being unlocked by innovative performance-based contracting that help overcome these capital cost constraints, with Energy Service Companies (EScos) playing a significant role. For businesses this implies that external financing solutions may provide greater returns than self-finance when implementing solar PV solutions.

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7. Appendix

7.1. List of relevant regulations and policies for embedded generation

7.1.1. Acts

Electricity Regulation Act, Act 4 of 2006 and Electricity Regulation Amendment Act, Act 28 of 2007 as amended. The act states that no person may, without a license issued by the regulator (NERSA), operate any generation facility. The *Electricity Regulation Act, Act 4 of 2006* holds that exemption is held for non-grid-tied projects. Note that NERSA has issued a communication giving license exemption to SSEG installations in municipal areas under 100kW.

Occupational Health and Safety Act 1993 as amended. The Occupational Health and Safety Act provides for the health and safety of the people by ensuring that all undertakings are conducted in such a manner so that those who are, or who may be, directly affected by such an activity are not negatively harmed as far as possible and are not exposed to dangers to their health and safety.

7.1.2. By-laws

Municipal Electricity Supply By-Law. This document provides the general conditions of supply of electricity, outlines the responsibility of the customers, systems of supply, measurement of electricity and the electrical contractors responsibilities.

7.1.3. Codes

South African Distribution Code (all parts). The South African Distribution Code applies to all entities connected to the distribution network, including embedded generators. It sets the basic rules for connecting to the distribution network, ensures non-discrimination to all users connected to the distribution network and specifies the technical requirements to ensure the safety and reliability of the distribution network.

South African Grid Code (all parts). The South African Grid Code contains the connection conditions that are required by all generators, distributors and end-users (customers) connected to the municipal electrical grid, as well as the standards used to plan and develop the transmission system.

South African Renewable Power Plants Grid Code. This document sets out the technical and design grid connection requirements for renewable power plants (0-1MVA LV[36]) to connect to the transmission or distribution network in South Africa.

7.1.4. South African National Standards (SANS)

SANS 10142- Parts 1 to 4: The Wiring of Premises. This document serves as the South African national standard for the wiring of premises in low and medium voltage networks (AC/DC). The aim of the document is to ensure that people, animals and property are protected from dangers that arise during normal as well as fault conditions, due to the operation of an electrical installation. Compliance to the standards and regulations as laid out in SANS 10142-1 is required and proof should be provided via an electrical installation certificate of compliance. The implication is that a registered professional is required to sign the installation.

[36] Voltage levels up to and including 1 kV (1kV= 1000 Volts).

SANS 474/ NRS 057 Code of Practice for Electricity Metering. SANS 474 specifies the metering procedures, standards and other such requirements that must be adhered to by both electricity licensees and their agents.

7.1.5. National Regulatory Standards (NRS)

NRS 048: Electricity Supply – Quality of Supply. The NRS 048 series covers the quality of supply parameters, specifications and practices that must be undertaken to ensure correct and safe operation. The NRS 048-2 and NRS 048-4 have the most relevance to the operation and connection of SSEG's to the municipal electrical grid: NRS 048-2: 'Voltage characteristics, compatibility levels, limits and assessment methods' sets the standards and compatibility levels for the quality of supply for utility connections as well as for stand-alone systems. It is intended that generation licensees ensure compliance with the compatibility levels set in this document under normal operating conditions. NRS 048-4: 'Application guidelines for utilities' sets the technical standards and guidelines for the connection of new customers. It also sets the technical procedures for the evaluation of existing customers with regards to harmonics, voltage unbalance and voltage flicker.

NRS 097-1: Code of Practice for the interconnection of embedded generation to electricity distribution networks. Part 1 MV and HV (Eskom 240-61268576 / DST 34-1765: Standard for the interconnection of embedded generation, is applicable until published)

NRS 097-2: Grid interconnection of embedded generation: Part 2 Small Scale Embedded Generation. NRS 097-2-1 (Part 2: Small Scale Embedded Generation, Section 1) this document serves as the standard for the interconnection of SSEG's to the municipal electrical grid and applies to embedded generators smaller than 1000kVA connected to LV networks of type single, dual or three-phase.

NRS 097-2-3 (Part 2: Small Scale Embedded Generation, Section 3). This document provides simplified utility connection criteria for low-voltage connected generators.

7.2. Potential for solar PV applications

The direct solar irradiation illustrated below shows clearly that South Africa has large potential especially when considering that some European countries have successfully pursued solar energy solutions.

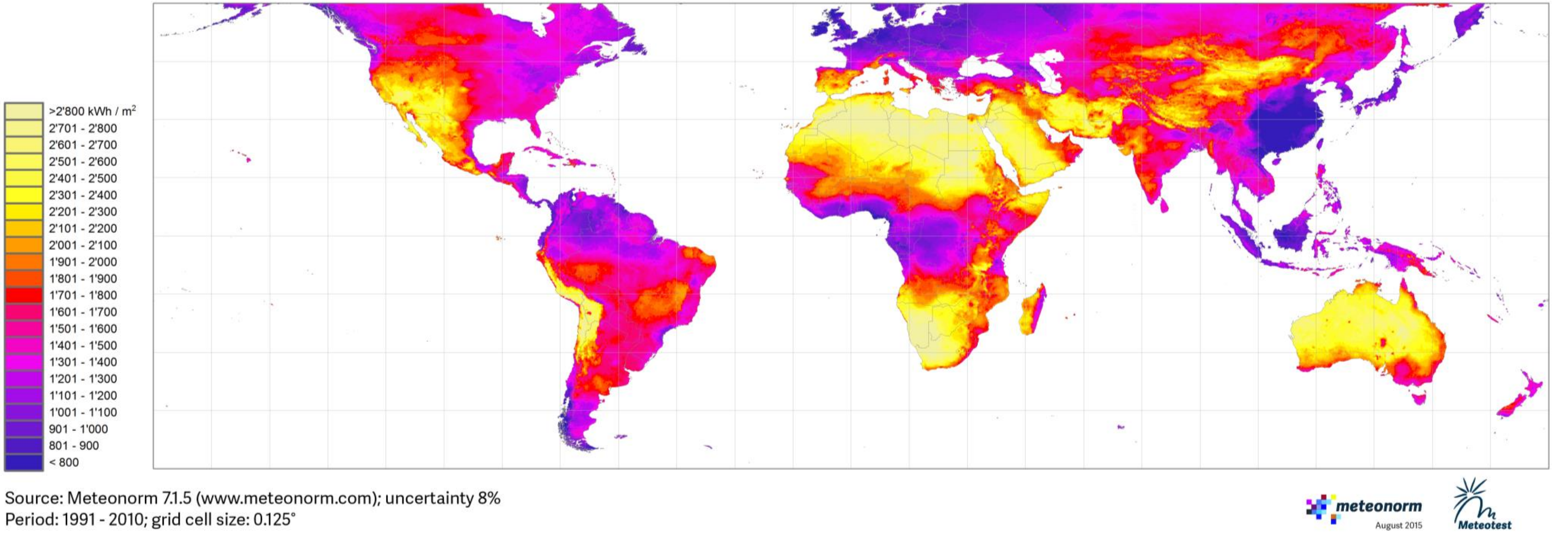

Figure 5: Yearly sum of direct normal irradiation on the earth[37]

[37] Source: Soltrain training course material (AEE Intec, 2009, p. 16)

7.3. Assumptions and parameters for the business case

This section provides the assumptions made regarding the energy demands of the modelled packhouse and the solar PV installed thereon.

7.3.1. Solar PV system

A solar PV system of 500 kW_p with characteristics presented in Table 6 is modelled in the business case. This size system was chosen to align with those already installed, shown in Section 3.3 which range from 420 to 1 015 kW_p.

Table 6: Summary of modelled solar PV characteristics

Solar PV System	
Size of system	500 kW_p
Life span of PV	20 years
Peak energy reduction from solar PV (share of solar PV peak production capacity)	30% (i.e. 500 kW_p results in 150 KVA reduction, only applicable when selling to Eskom[38])
Decrease in yield per year	0.5%
Operating cost	5% of capital cost
Energy storage/batteries	None

7.3.2. Energy demand profile of packhouse

To examine the business case for an apple packhouse, energy demand is based on benchmarks determined by an expert in the industry (Bouwer, 2015). An estimated 80-85% of energy needs at a packhouse come from cooling needs, which fluctuate with ambient temperatures. The basic business case presented here is based on the assumptions of a 20 week peak packing period followed by systematic decrease in stock (10 500 tonnes at start of the off-peak period) over the remaining weeks. The full set of assumptions are laid out in Table 7 and Table 8. For simplification, the off-peak period is assumed to have one day of packing per week at a reduced throughput. This is a gross simplification, as in reality packing during off-peak will be in response to higher off-peak prices due to decreased supply. There would thus be short periods of more intense packing. This makes the energy demand estimations for the off-peak period less accurate than that for the peak period.

Table 7: Apple packhouse: assumptions for peak and off-peak periods

	Peak Period	Off-Peak Period
Duration	20 weeks	32 weeks
Work week	5 days a week	1 day a week
Volume	400 tonnes packed per work day and 200 tonnes added to controlled atmosphere storage or 1000 per week.	625 tonnes packed per work day (built up stock of 20 000 tonnes spread over 32 weeks)

The energy demand for the modelled packhouse is laid out in Table 8 overleaf, as well as what share of electricity is assumed to be substitutable by the solar PV system. The cooling (controlled

[38] Municipalities build KVA charges into their energy tariffs.

atmosphere, regulated atmosphere and pallet) are assumed to run constantly and thus only partially substitutable. The average storage in the different sections is also shown in the last column. Packing is the most energy intense and most substitutable as it occurs almost exclusively when the solar PV is generating electricity. This helps justify the rationale for applicability of solar PV on packhouses. It is also assumed that there is no changing tariff structure and thus all fixed costs, such as connection costs and administrative charges, related to connecting to the electricity provider remain the same and thus are not part of the business case.

Table 8: Apple packhouse: energy demand components

	Energy demands[39]	Share that can be supplied by PV	Average days in each section
Controlled atmosphere	0.7 kWh/day/tonne stored	42%*	N/A – long term storage
Regulated atmosphere	3.5 kWh/day/tonne stored	42%*	2 days
Pallet Cooling	7 kWh/day/tonne stored	42%*	5 days
Packing	15 kWh/day/tonne packed	90%	1 day
Other energy needs	10% of total energy (constant over the entire year)	30%	Everyday

*For cooling: solar PV is not generating electricity for 14 of 24 hours (58%).

7.3.3. Energy profile for a year

Taking the assumed solar PV system size of 500 kW_p, the energy produced could be calculated[40] using the energy produced in summer and winter (shown in Figure 2). Using this energy produced by the solar PV system in conjunction with energy needed for the packhouse (From Table 7 & Table 8) the energy profile for a year could be established, as shown in Figure 6 below.

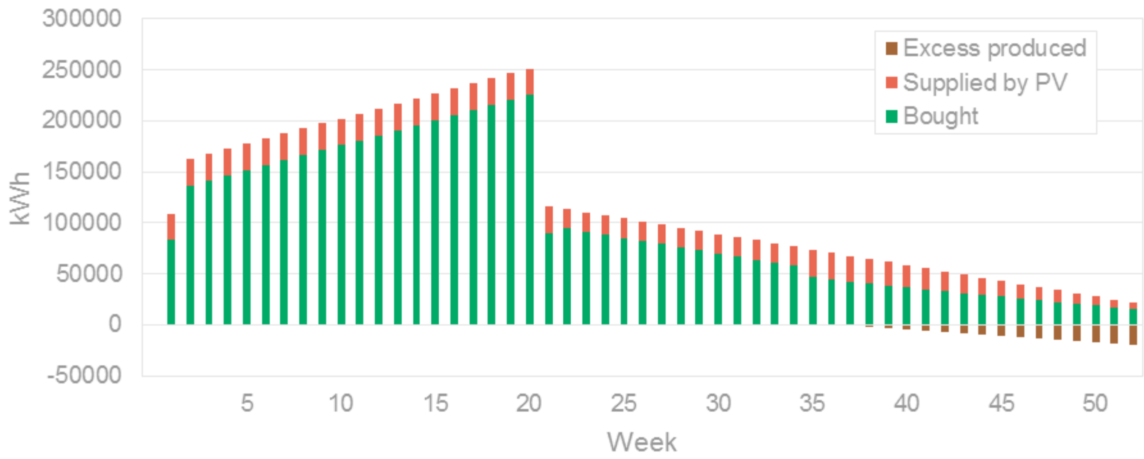

Figure 6: Electricity profile of a packhouse packing 1000 tonnes of apples a week with a 500 kW_p solar PV system installed

[39] Established in an interview with industry expert Koos Bouwer of Koos Bouwer Consulting (kbcindustrial.co.za) in October 2015.

[40] Aggregating the daily output in Figure 2 to a weekly energy production to align with the energy while considering standard, peak and off-peak times of energy production.

As shown in Figure 6 above, energy demands rise rapidly from week one to two as stocks build up. The packhouse is working at full capacity by the second week, with additional rises as stocks in controlled atmosphere storage build up. Energy demands are high and rising as stock increases during peak period with a sudden decrease in the off peak as less active packing takes place. Energy demands then continue to fall as the built up stock diminishes. Eventually, as energy demands fall low enough, excess energy is then sold back onto the grid (shown as negative values in Figure 6) with increasing amounts over time as less of the electricity produced is needed for own use.

7.4. Sales and feed-in tariffs

Two different scenarios are considered for the value of electricity generated by the solar PV system:

- Buying from George Municipality on its embedded generation tariff[41].
- Buying from Eskom on a Ruraflex Gen tariff[42].

While there are not many packhouses in George, it has a relatively well developed feed-in tariff system. Other municipalities' tariffs are likely to follow a similar structure and thus George's tariff structure is a useful reference point to consider. Eskom's Genflex tariff is also considered as it is assumed to be the most likely Eskom tariff for a packhouse and allows feed-in of excess electricity as it assumed a packhouse of the scale modelled will have at least a medium voltage connection.

However, when considering the financial feasibility of a specific project the tariff and regulations the installation will fall under is fundamental, as highlighted in Section 2, regulations and tariffs for feed-in of excess energy are not available everywhere. Additionally, where tariffs have been established the costs and feed-in rates vary significantly. To highlight the variance in the costs and feed-in rates, Table 9 below presents the 2015-2016 electricity tariffs for the two tariff structures considered[43].

Table 9: 2015/16 Rand per kWh tariffs for medium voltage connections for George Municipality and Eskom Ruraflex Gen

	George Municipality Embedded Generation				Ruraflex Gen			
	Cost of electricity		Feed-in tariff*		Cost of electricity		Feed-in tariff*	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
Peak	R 1.15	R 2.77	R 0.8281	R 2.5388	R 0.9779	R 2.9975	R 0.0924	R 0.2832
Standard	R 0.82	R 1.77	R 0.5699	R 0.7690	R 0.6729	R 0.9081	R 0.0636	R 0.0858
Off-Peak	R 0.70	R 0.95	R 0.3615	R 0.4176	R 0.4270	R 0.4931	R 0.0403	R 0.0466

Source: Eskom and George tariffs (Eskom, 2015; George Municipality, 2015).

*Note that the Ruraflex Gen tariff does not have a demand charge worked in, thus feed-in rates are not strictly comparable[44].

The difference in cost (i.e. municipal selling price) of electricity and the feed-in tariff highlights the importance of maximising self-use of energy. In other words, the value to company of avoiding electricity cost is clearly greater than value of feeding into the grid. While the tariffs appear to be

[41] George Municipality tariffs available at george.org.za/file/tariewe_2014_2015_web.pdf
[42] Tariff details for Eskom customers: www.eskom.co.za/CustomerCare/TariffsAndCharges/WhatsNew/Pages/2015-16-Tariff-submission.aspx
[43] Time-of-use billing requires the installation of a smart meter. The cost of installing a smart meter is not explicitly considered in this business case as this is a once off cost written off over its lifetime. Thus the costs are unlikely to impact the business case significantly. Furthermore price decreases are anticipated once a standard is established for smart meters.

significantly larger on the George tariffs, the numbers are not strictly comparable as the Ruraflex Gen feed-in tariffs do not incorporate the KVA charges while the George Municipality tariffs do[44]. This highlights the crux of the business case (as done in Section 3.1): **packhouses require energy when solar PV generates electricity**.

Additionally, while selling excess power has a lower value to a company, the generation of excess power occurs during a period of relatively low income for a packhouse (i.e. out of season) and thus could have a greater impact on the cash-flow of a business than the relatively small values would indicate. This is not captured by any of the measures used to examine the financial feasibility but may be worth considering.

[44] This is a cost related to the peak demand of the system. As a result there is an additional saving modelled for the Eskom scenario from a decrease in peak demand highlighted in Table 6: the share of solar PV installation (kW_p) reducing peak by 30%.

7.5. Breakdown of financials for the most likely scenario

Table 10 below shows a detailed breakdown of the business case for the most likely scenario, namely a large scale (500kW$_p$) solar PV system that is financed with a loan for 80% of the installation costs that is paid off over 10 years. The electricity tariffs are estimated to increase by 13% in the first 5 years and 8% per annum increases thereafter. It is also assumed that the packhouse falls under an Eskom Ruraflex Gen tariff system. Similar details for the other scenarios are available on request.

Table 10: Income and costs of years 1-10 of most likely scenario

Year	1	2	3	4	5	6	7	8	9	10
Income										
Value of electricity	R 1 055 792	R 1 187 080	R 1 334 693	R 1 500 662	R 1 687 270	R 1 813 140	R 1 948 400	R 2 093 751	R 2 249 945	R 2 417 791
Costs										
Capital costs	R 1 630 000[45]	-	-	-	-	-	-	-	-	-
operating costs	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500
Financing										
Interest	R 652 000	R 611 090	R 566 089	R 516 588	R 462 137	R 402 240	R 336 354	R 263 880	R 184 158	R 96 464
Principal	R 409 100	R 450 010	R 495 011	R 544 512	R 598 963	R 658 860	R 724 746	R 797 220	R 876 942	R 964 636
Total Costs	R 3 098 600	R 1 468 600	R 1 468 600	R 1 468 600	R 1 468 600	R 1 468 600	R 1 468 600	R 1 468 600	R 1 468 600	R 1 468 600
Return for year	**-R 2 042 808**	**-R 281 520**	**-R 133 907**	**R 32 062**	**R 218 670**	**R 344 540**	**R 479 800**	**R 625 151**	**R 781 345**	**R 949 191**
Loan outstanding	R 6 520 000	R 6 110 900	R 5 660 890	R 5 165 879	R 4 621 367	R 4 022 404	R 3 363 544	R 2 638 799	R 1 841 578	R 964 636
Electricity generated (kWh)	1273160	1266794	1260460	1254158	1247887	1241648	1235440	1229263	1223116	1217001

[45] 20% Share not funded by external financing.

Table 10 Continued: Income and costs of years 11-20 of most likely scenario

Year	11	12	13	14	15	16	17	18	19	20
Income										
Value of electricity*	R 2 598 158	R 2 791 980	R 3 000 262	R 3 224 082	R 3 464 598	R 3 723 057	R 4 000 797	R 4 299 257	R 4 619 981	R 4 964 632
Costs										
operating costs	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500
Financing	0	0	0	0	0	0	0	0	0	0
Total Costs	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500	R 407 500
Return for year	**R 2 190 658**	**R 2 384 480**	**R 2 592 762**	**R 2 816 582**	**R 3 057 098**	**R 3 315 557**	**R 3 593 297**	**R 3 891 757**	**R 4 212 481**	**R 4 557 132**
Loan outstanding	0	0	0	0	0	0	0	0	0	0
Electricity generated (kWh)	1210916	1204861	1198837	1192843	1186878	1180944	1175039	1169164	1163318	1157502