FEASIBILITY REPORT

90 kVA/100 kWp Solar PV system at Warehouse Southern Queensland

Abstract

This report shows the affect that the installation of a 90 kVA/100kWp solar PV installation will have on the energy usage of a warehouse facility in southern Queensland

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Contents

Introduction

The intention of this report is to make predictions about the impact that the proposed installation is going to have on the energy usage profile of a given load or site and therefore on the cost of energy usage to the owner after the system has been installed.

This allows the user to consider the impact of different options before making a decision on a proposal, or to form new strategies how they should approach reducing their energy costs.

Conducting these sorts of studies is important because, generally, the amount of benefit a solar installation will provide to a customer depends highly on the factors that are driving the main costs on their power bill. This means that the effect that a given solar installation has on these factors is going to determine the return on investment.

Some examples of how this works on real world sites are as follows,

- If the main cost to the owner of a site is the volume of their overall energy usage (kWh) and the load type is refrigeration, the load will likely peak in the middle of the day and reduce overnight. The peak load will be bigger on hot days in summer and load peaks will be slightly lower in winter. The load profile of this site is very well suited to the generation profile of a solar PV installation and the result of installing a properly sized, grid connected solar farm would be a dramatic reduction on power flow from the grid, due to the fact that the solar installation is varying it's output power at the same time as the load. The reduction in power flow from the grid will result in a proportionate reduction in the cost to the owner.

- If a manufacturing process uses machinery that runs at a constant base load, then uses large amounts of power in short bursts and the main charge on the energy bill is a combination of maximum demand and energy usage, it may make sense to install a solar array which will produce an equivalent amount of energy that the load would draw over a given period, but also install a battery system capable of charging from the excess solar energy and supplying the maximum demand of the "bursts" in load. The battery system should be capable of storing enough energy such that the demand from the grid remains at zero during times of high demand. Power factor correction could also be a consideration in this case if the power factor of the load is low.

The energy production of a solar installation varies seasonally with temperature, light level and daylight hours. Loads are also often weather or temperature dependant or change greatly at different times of the year due to seasonal changes to weather conditions and industry trends at different times of the year. This report is therefore broken into 1 section for each season, this shows the affect that the solar installation has on the load profile and the driving factors behind energy costs at different times of the year.

It should also be mentioned that the report makes certain assumptions that will be either proven to be correct or incorrect during the network approval process. This includes (but is not limited to),

- The network allowing full export of the inverter system AC capacity
- Network conditions that allow the inverters to produce full power at any given point in time and that the way the network charges the client for energy drawn from the grid after the solar is installed, will be similar to the situation without solar.
- Past weather patters are a good indicator of future weather patterns.
- Past load profiles are a good indicator of future load profiles.

Report structure and Method

The site used in this study is a warehouse located in southern Queesnland. The load mainly consists of high bay lighting, which is largely constant during daylight hours, producing a load profile similar to that shown in figure 1.

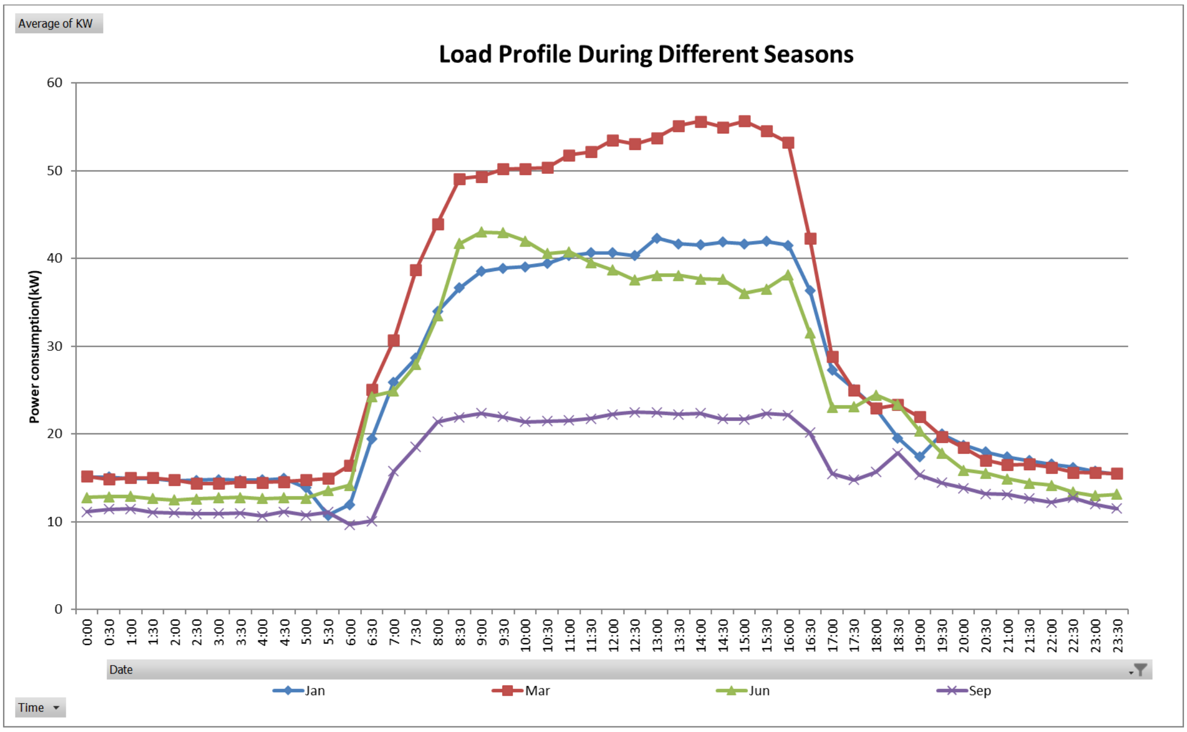

Figure 1 Indicative Load profile

Figure 1 shows that the majority of energy consumption occurs during the day (working hours) and it can also be seen from the bill that the major cost is from the volume of energy consumption (kWh). These 2 factors indicate that a grid connected solar installation that produces a “wide” generation curve with some panels facing east and some facing west would be a good starting point for this installation. The geographic location in southern Queensland also provides relatively long daylight hours and high sun elevation, which will also help an east/west facing system to perform well and produce a generation curve that is similar to the load profile in figure 1.

In addition to this, the ridgeline of the building running approximately North/south and the ~10° slope allows panels to be laid flat against the roof as shown in Figure 2. Mounting roof mounted solar in this way is advisable in Queensland coastal areas due to the extra structural requirements for tilt frames in areas in which cyclones can occur.

Figure 1 shows that the load profile is similar in summer and winter, indicating that the load does not change with the difference in weather and temperature between these 2 seasons, however there is a large increase in load during autumn due to more lighting being used in the warehouse at this time of year and a reduction in load during spring, due to business shutting down during this time of year.

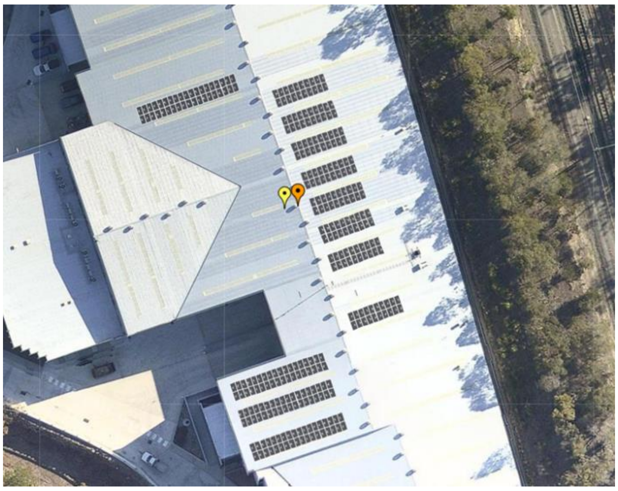

Figure 2 Panels laid Flat Against Roof

The report will show the predicted effect on the sites energy consumption after installing system sizes as shown below,

- 60 kWp
- 80 kWp
- 100 kWp

The results in each season can be broken down in terms of the following factors,

- Energy produced by solar and consumed on site.
- Energy produced by solar and fed into the grid.
- Energy purchased from the grid.
- Self-consumption ratio – the fraction of solar energy generated that is consumed on site (as opposed to being fed into the grid).

Summer Results

Figure 4 through Figure 6 show average figures for the month January. Figure 4 shows the average generation curve for each system size and compares this to the average load profile. If installing a 60 kWp system, almost all of the energy generated is consumed on site, or a high self-consumption ratio as shown in table 1.

Table 1 Factors for measuring success of system sizes in summer

PV System Size (kWp)	Solar Consumed (kWh)	Solar Exported (kWh)	Purchased Energy (kWh)	Self-consumption ratio
60 kWp	251	97	348	0.72
80 kWp	307	158	292	0.66
100 kWp	343	238	256	0.59

The self-consumption ratio of the system decreases as the system size increases due to the increased amount of solar energy being generated that is being fed into the grid, however the amount of energy purchased from the grid is also less at larger system sizes. Whether or not a larger system would be appropriate in this case depends on whether it is more important to the customer to eliminate the cost of power purchased as far as possible by minimising power flow from the grid, or to create the best return on investment for the solar installation itself by ensuring that all the solar generated is consumed on site.

Figure 1 shows that the load profile for this site is very similar in both winter and summer and because a solar installation varies it's output greatly between summer and winter. For load profiles that do not vary greatly between summer and winter, designing a system big enough to provide a reasonable level of benefit in winter will always result in a significant amount of energy fed into the grid in summer.

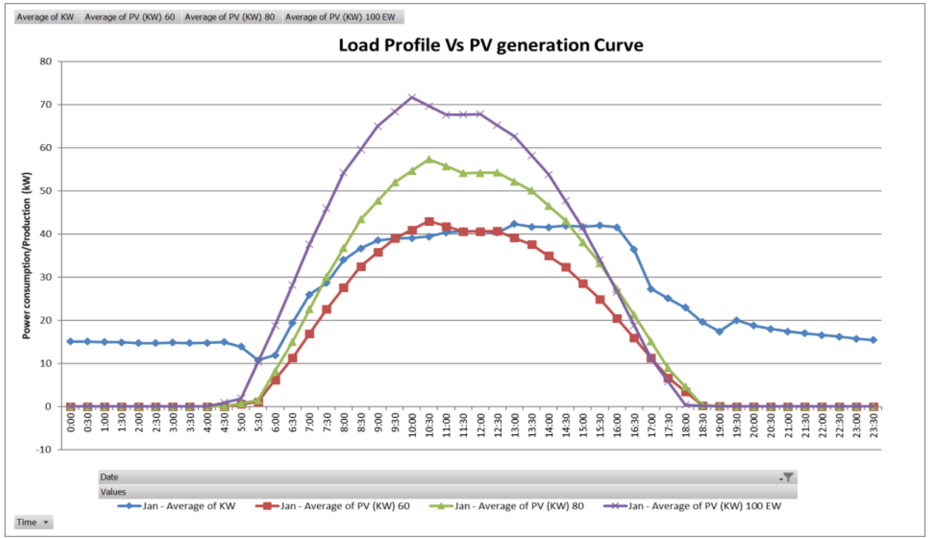

Figure 4 Load Profile Vs Generation Curve for 60kWp, 80 kWp and 100 kWp systems

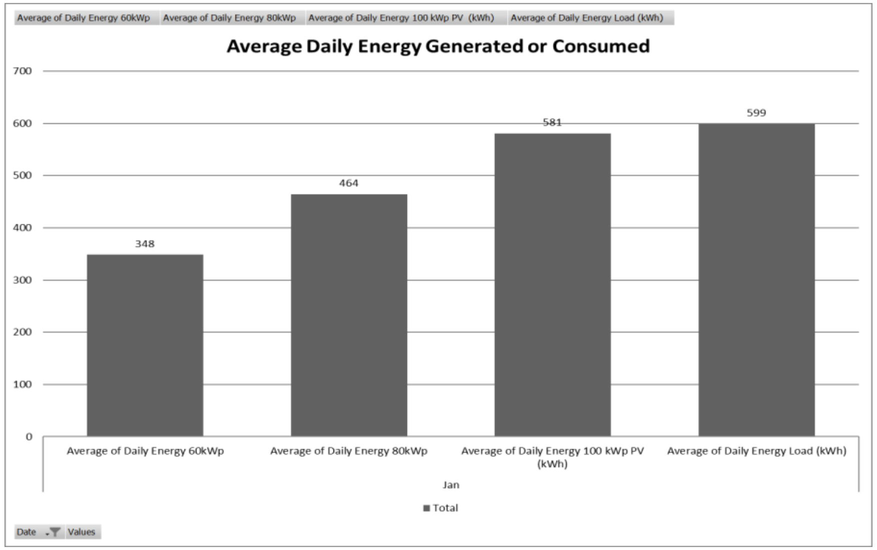

Figure 3 Average Energy Consumed in January and generated from 60kWp, 80 kWp and 100 kWp systems

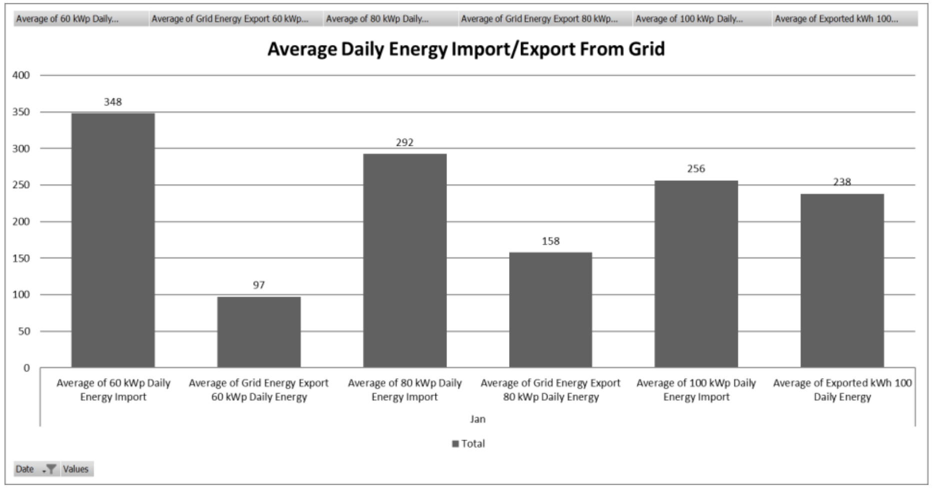

Figure 5 Energy Imported/ exported to grid for 60 kWp, 80 kWp and 100 kWp systems

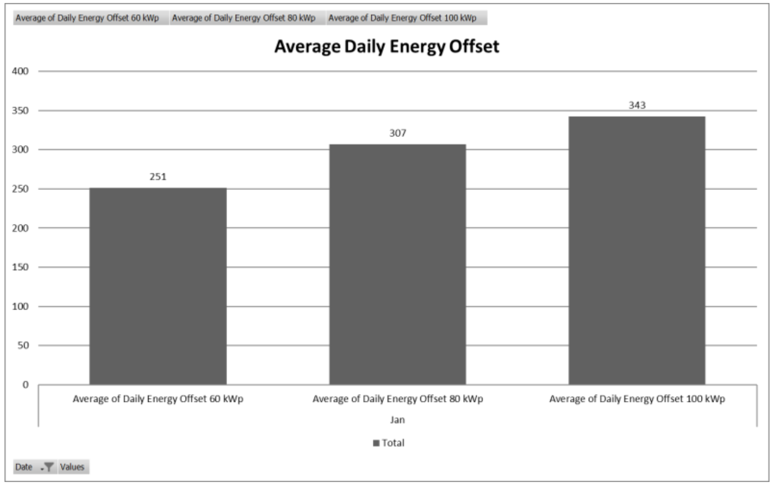

Figure 6 Energy Consumed on Site for 60kWp, 80 kWp and 100 kWp systems

Autumn Results

March shows a higher self consumption ratio than summer for all system sizes, this is partially due to the solar output decreasing but also due to the increase in load but provides a better justification for a larger system than in Summer.

Table 2 Factors for measuring success of system sizes in Autumn

PV System Size (kWp)	Solar Consumed (kWh)	Solar Exported (kWh)	Purchased Energy (kWh)	Self-consumption ratio
60 kWp	251	58	493	0.81
80 kWp	323	89	421	0.78
100 kWp	387	128	358	0.75

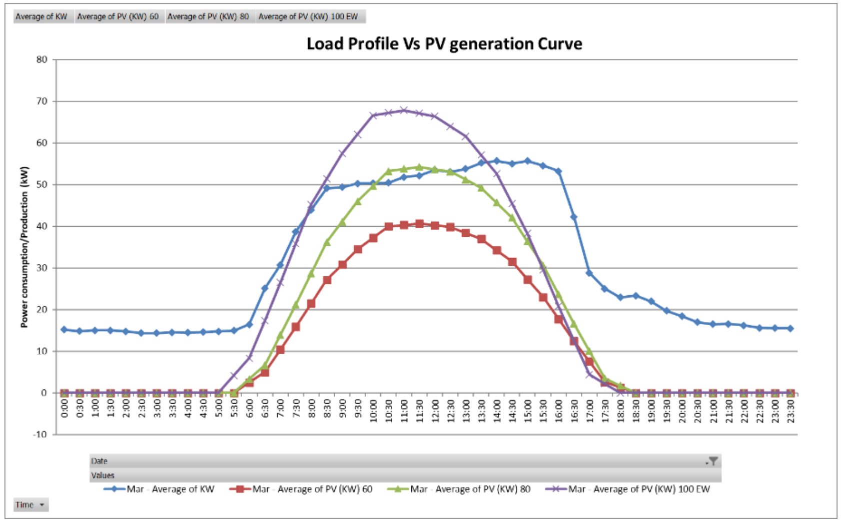

Figure 7 Load Profile Vs Generation Curve for 60kWp, 80 kWp and 100 kWp systems

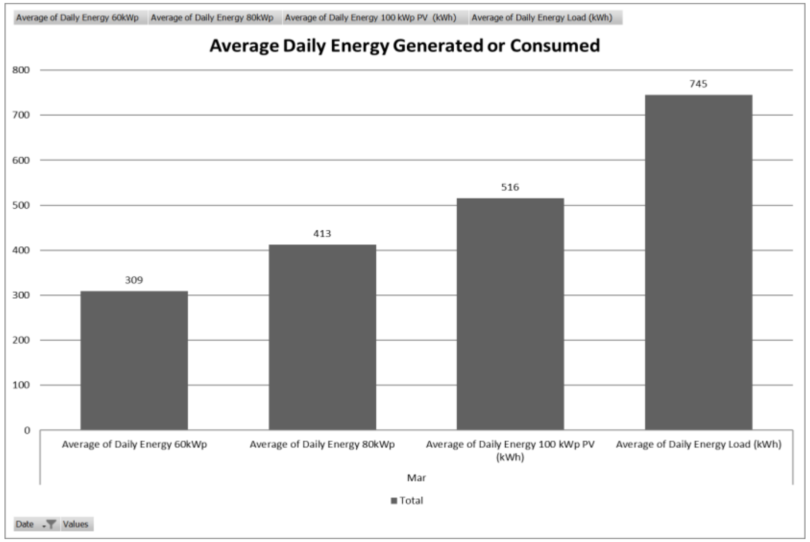

Figure 8 Average Energy Consumed and generated from 60kWp, 80 kWp and 100 kWp systems

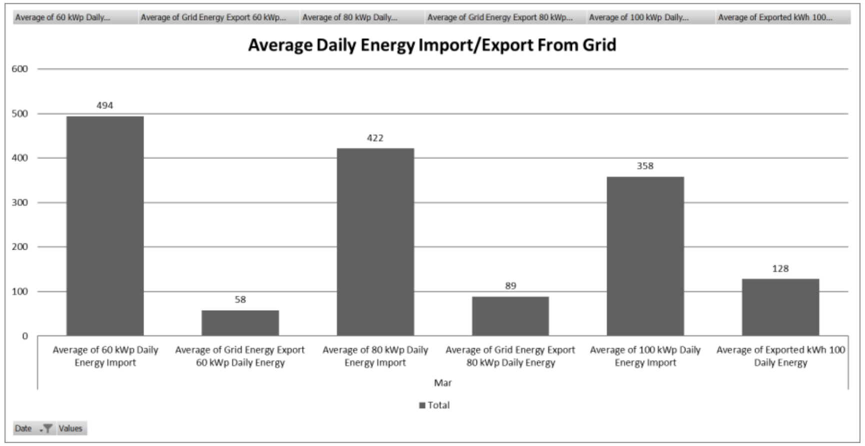

Figure 10 Energy Imported/ exported to grid for 60 kWp, 80 kWp and 100 kWp systems

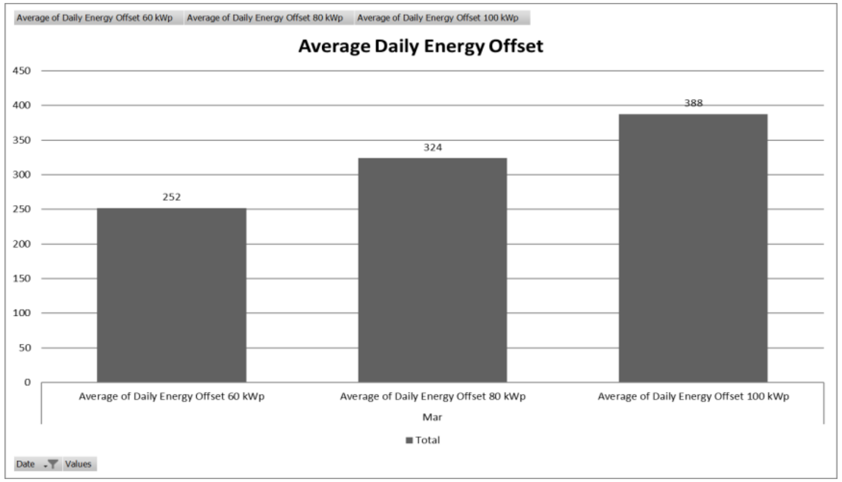

Figure 9 Energy Consumed on Site for 60kWp, 80 kWp and 100 kWp systems

Winter Results

Table 3 Factors for measuring success of system sizes in Winter

PV System Size (kWp)	Solar Consumed (kWh)	Solar Exported (kWh)	Purchased Energy (kWh)	Self consumption ratio
60 kWp	166	24	426	0.87
80 kWp	213	41	380	0.83
100 kWp	251	67	341	0.79

Table 3 shows that during winter, the self consumption ratio for all 3 systems are more similar than in summer ((table 1), this is due to the small amount of solar energy being exported from all 3 systems during this time of year in comparison to the total amount of energy generated and provides justification for the 100 kWp option due to the larger amount of solar energy that will be consumed on site in the 100 kWp scenario in comparison to the scenario with smaller systems, which this energy would need to be purchased from the grid.

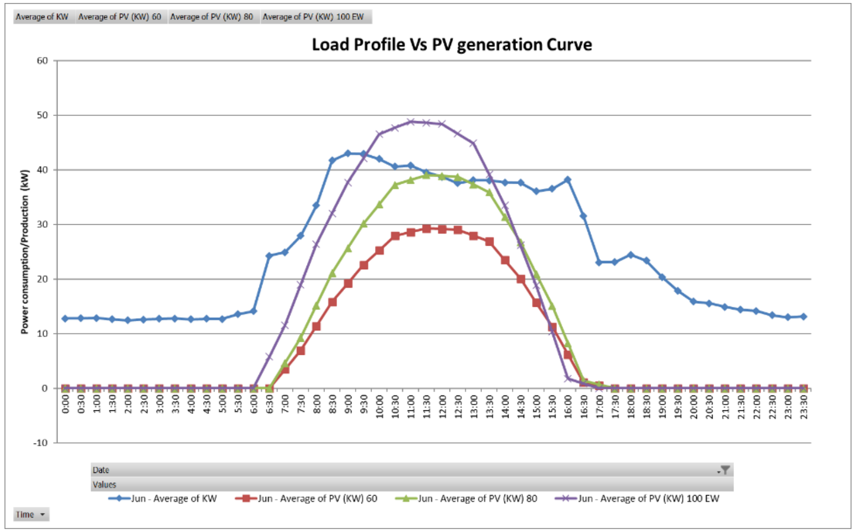

Figure 12 Load Profile Vs Generation Curve for 60kWp, 80 kWp and 100 kWp systems

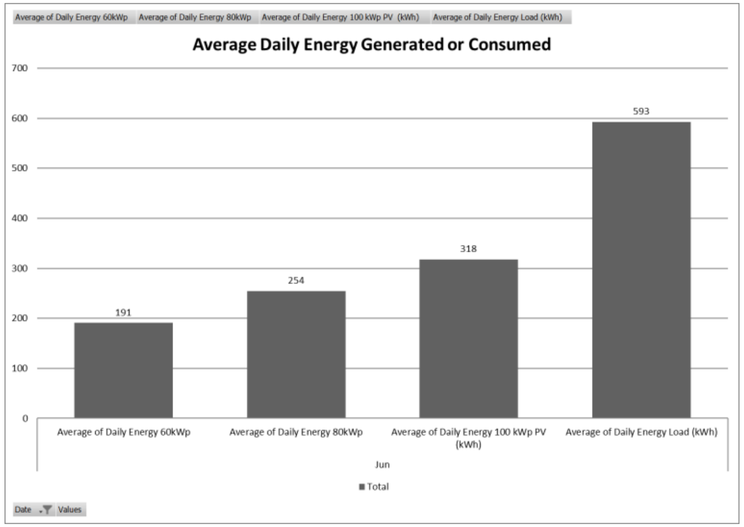

Figure 11 Average Energy Consumed and generated from 60kWp, 80 kWp and 100 kWp systems

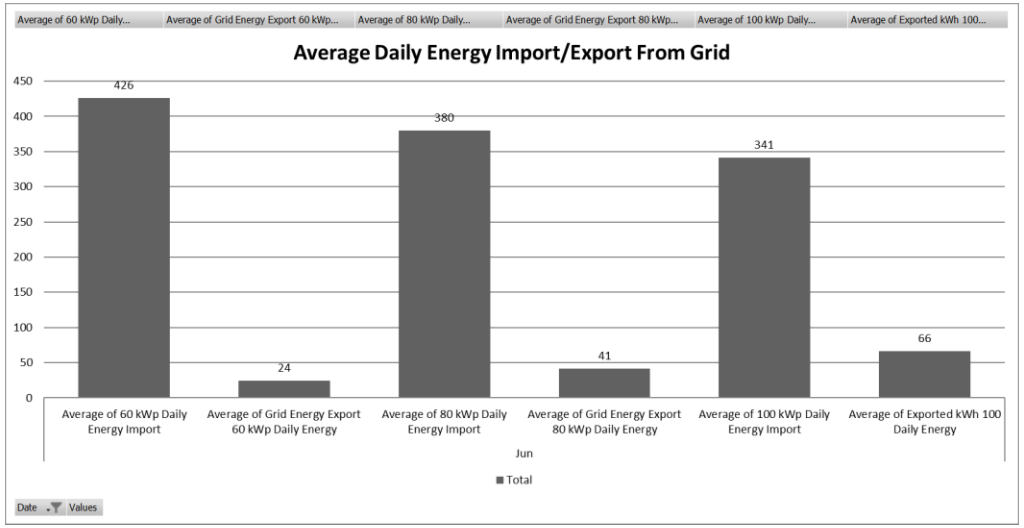

Figure 14 Energy Imported/ exported to grid for 60 kWp, 80 kWp and 100 kWp systems

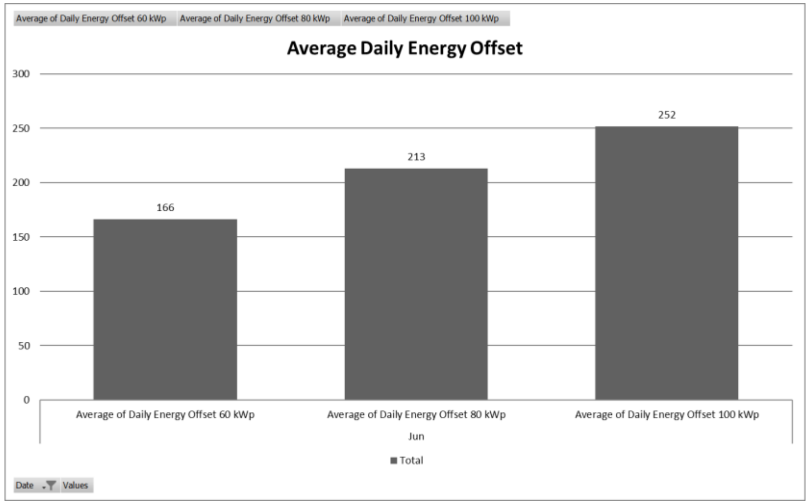

Figure 13 Energy Consumed on Site for 60kWp, 80 kWp and 100 kWp systems

Spring Results

Table 4 Factors for measuring success of system sizes in Spring

PV System Size (kWp)	Solar Consumed (kWh)	Solar Exported (kWh)	Purchased Energy (kWh)	Self consumption ratio
60 kWp	187	107	200	0.63
80 kWp	204	189	183	0.51
100 kWp	212	279	279	0.43

Figure 17 shows that the daytime load of the warehouse has approximately halved at this time of year, which is due to the warehouse reducing business activity. This accounts for a large amount of solar being fed into the grid from all 3 system sizes and corresponding low self consumption ratios. This would normally indicate that the system has been oversized, however, future springtime loads are likely to be similar to other times of the year, meaning that the results in table 4 are not a reliable indicator of future results and should be given less weight than other times of the year when making a decision.

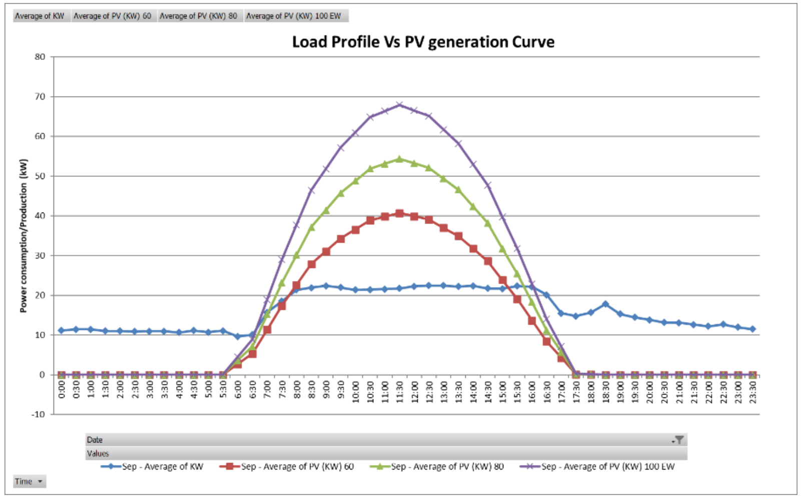

Figure 17 Load Profile Vs Generation Curve for 60kWp, 80 kWp and 100 kWp systems

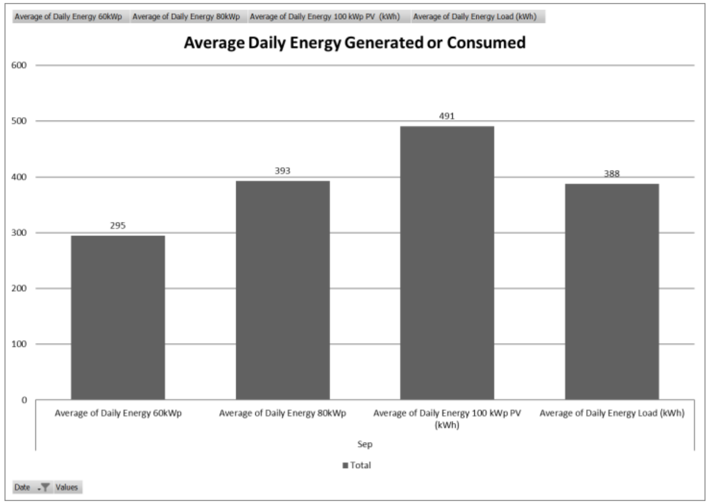

Figure 18 Average Energy Consumed and generated from 60kWp, 80 kWp and 100 kWp systems

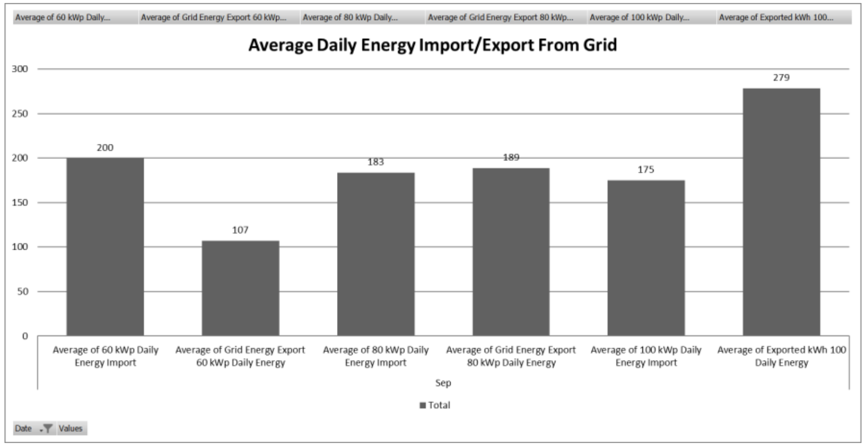

Figure 16 Energy Imported/ exported to grid for 60 kWp, 80 kWp and 100 kWp systems

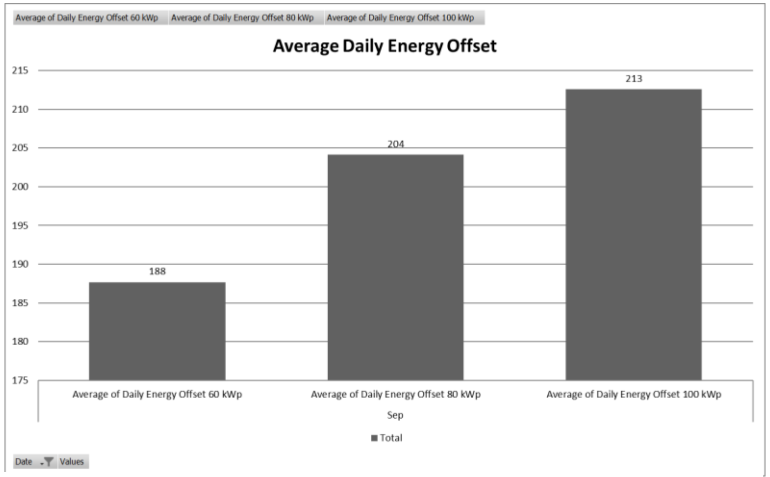

Figure 15 Energy Consumed on Site for 60kWp, 80 kWp and 100 kWp systems

Conclusion and recommendations

The overall results taken from the entire years meter data analysed are shown in Table 5. The self-consumption ratio for the 100 kWp system is low in comparison to the 60 kWp system, however the energy imported from the grid and the ongoing cost of electricity to the owner is lower for the 100 kWp system.

Assuming;

- A cost per kWh of 25c for energy purchased from the grid
- Feed in tarrif of 8c per kWh
- An installation cost of $1.60 per watt
- 0.5% loss in generation each year due to panels degrading over time

The data in table 5 has been used to generate the projected return on investment shown in figure 19. All systems have a payback period of between 6-7 years, however at the 12-year mark, the 100 kWp system starts to become a better long term investment.

The energy exported into the grid from the 100 kWp system during summer also creates an opportunity in the future for the client to improve the return on investment for a faster payback and better ongoing returns, this could be done by,

- Installing a battery system which could be used to store the excess energy for use at night.

- Installing Electric Vehicle charging stations in the car park and selling this energy at market rates of 0.25c/kWh, rather than exporting it into the network at the feed in tarrif rate of 0.8c/kWh.

- Increasing the production of the business during summer and spring, increasing the load and improving the self consumption.

Table 5 Overall results

System Size	**100 kWp**	**80 kWp**	**60 kWp**
total energy consumed	208299.6	208299.6	208299.6
Total PV Generated	172199.7954	137759.8363	103319.8773
Imported Energy	98824.44692	110932.3123	127685.8981
Export	-63420.64234	-41088.54866	-23402.17538
Solar Consumed	108779.1531	96671.28768	79917.70188
Self-Consumption ratio	0.631703149	0.701737823	0.77349784

For clarity, figures 20 and 21 provide a comparison of for each of the seasons for energy imported/exported to the grid for each system size and energy that will be offset by solar for each of the scenarios. These graphs show that generally speaking, the load is large enough such that each step in system size results in a proportionate increase in energy offset, which provides justification for the 100kWp system. If the increase in energy offset was not proportionate to the increase in system size, this would indicate that the 100 kWp system was oversized as the extra energy being produced would not be offsetting the site load.

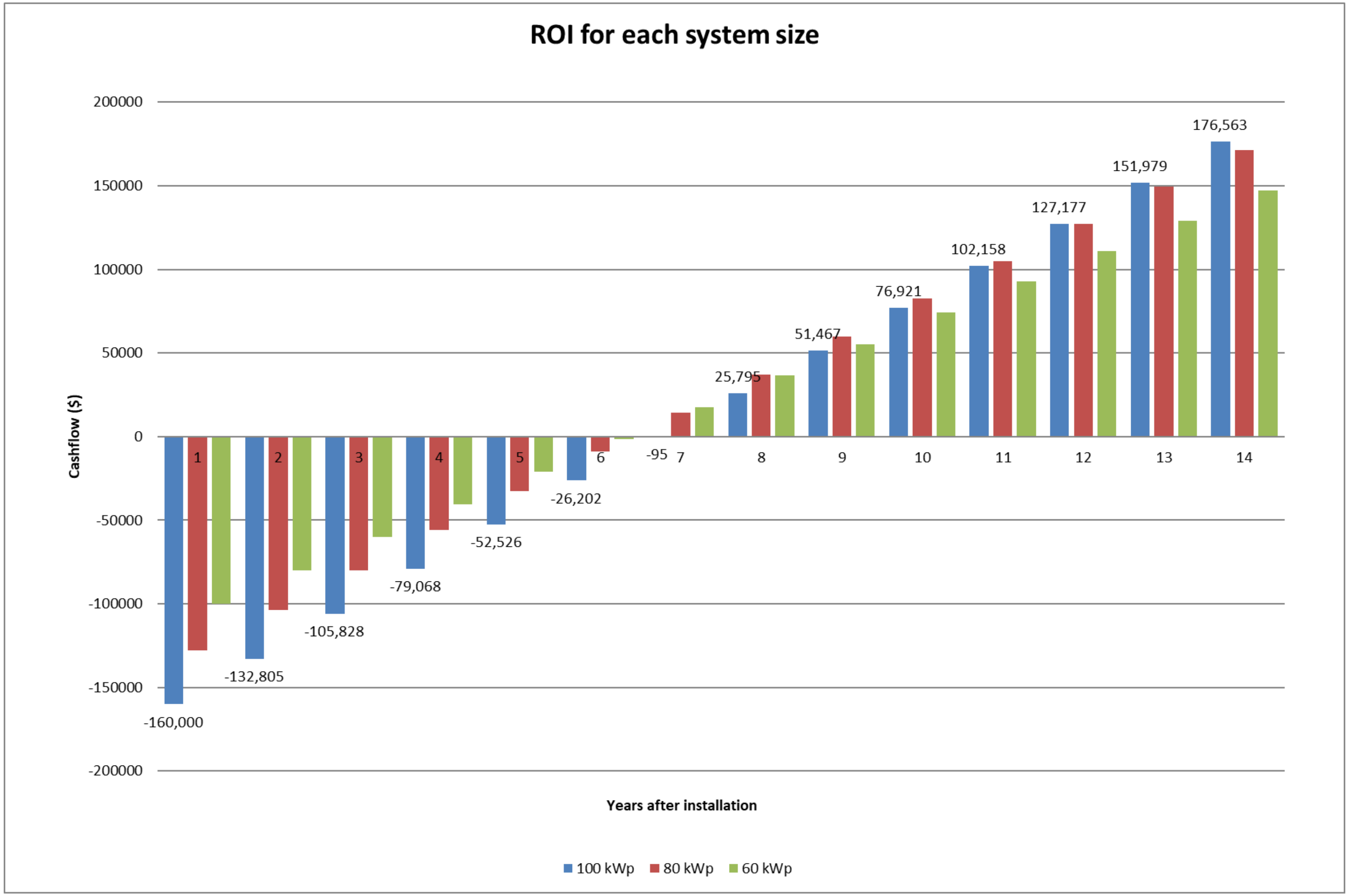

Figure 19 Assumed return on investment for each system size

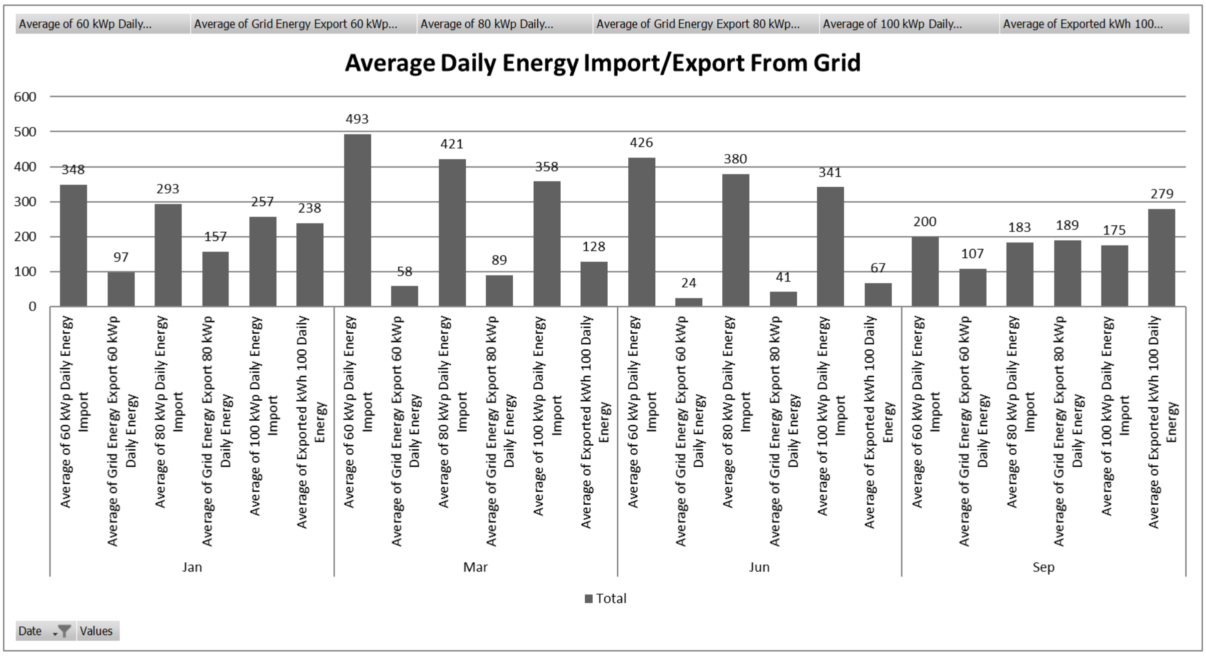

Figure 20 Comparison of seasons imported and exported energy

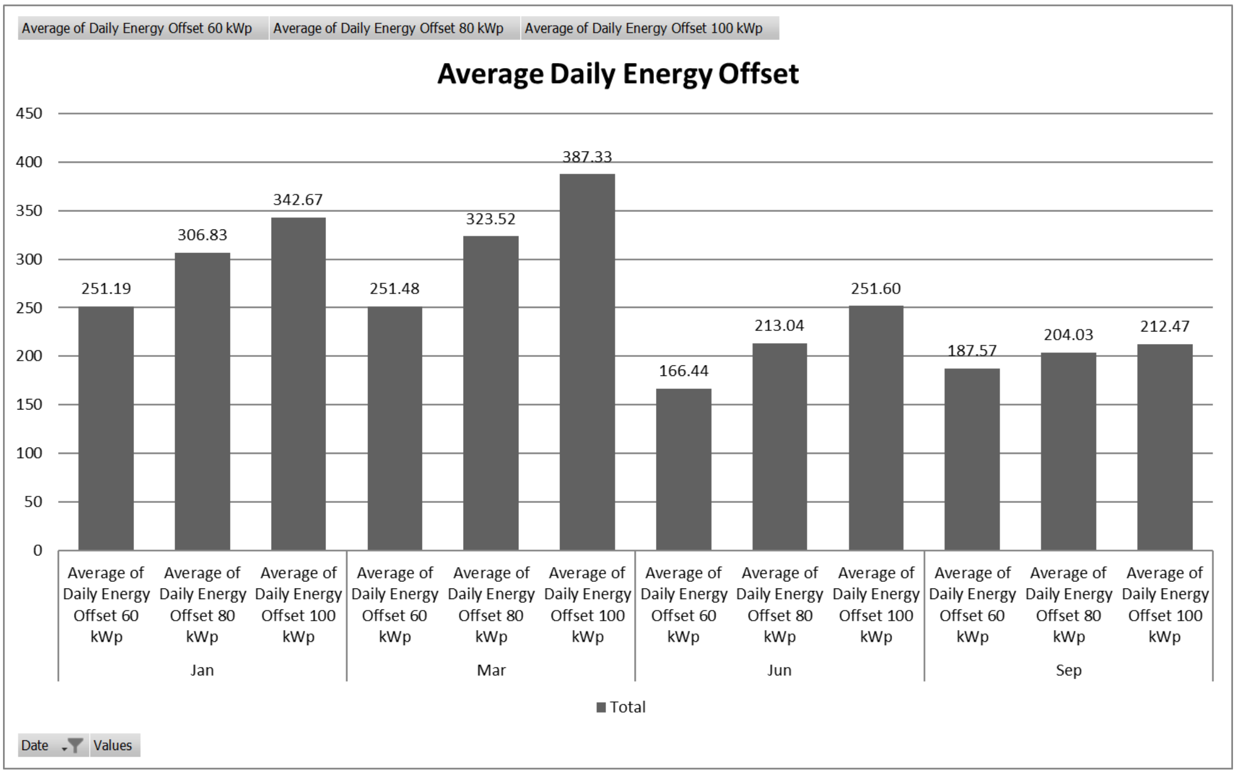

Figure 21 Comparison of seasons energy offset by solar