final report

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Development of funding and finance models for an integrated solar battery solution

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Executive summary

This report assists red meat processing businesses to assess solar-storage solutions. The report includes case study investigations, desktop simulations and in-depth consultation with solar experts.

It was found that in most cases solar energy can deliver a 20% to 40% reduction in power bills with four to six-year payback at red meat processing facilities. Furthermore, due to innovative business models within the solar energy market, it is possible to establish a solar asset with no upfront capital cost.

It was also found that solar battery storage solutions are not economically viable in most cases investigated. This is due to the high cost of batteries relative to their utility. Although the cost of batteries is decreasing, it is still not at a point where it is practical for the applications investigated within this project.

The following recommendations have been put forward:

1. In most cases, solar energy is an economically viable option for red meat processing businesses.
2. For those without capital to invest in a solar asset, power purchase agreements (PPAs) present a viable solution. PPAs provide clean, affordable power with no upfront cost.
3. While solar battery assets are not viable currently, they may become viable in years to come and close attention should be paid to market pricing and the energy storage market develops.

Table of contents

1 Milestone description

This milestone report is the third and final report for the current project "Development of funding and finance models for an integrated solar battery solution". The milestone report is divided into two main sections:

1. Desktop investigation
2. Commercialization and further R&D

1.1 Desktop Investigation

The goals of this desktop analysis are:

1. Develop data
2. Perform an ex-ante cost benefit analysis

Data will be developed by using data from example facilities to discuss aspects of a solar facility a potential client should be aware of. Following this, the section will give rule-of-thumb indications of payback periods and Internal Rate of Returns (IRR) for solar facilities in each of the states and territories.

The key aspects discussed in this section are as follows:

1. Location – solar incidence (kWh/m^2/day)
2. Current price of power purchase from the grid ($/kWh)
3. The rate at which the client can sell power to the grid (feed in tariff)
4. The power consumption pattern of the client facility across a day
5. The size of the solar battery asset installed
6. The cost of solar and battery per kW and kWh, including remoteness considerations and ground mount vs roof mount

Each of these aspects will be discussed, with data from real world facilities providing examples.

1.2 Commercialisation and further R&D

The commercialisation and further R&D section will investigate the following:

1. Establishment of recommended business models & commercial arrangements
2. Potential transaction counterparties

The goal of this section of the report is to empower members of the red meat industry to engage with members of the solar industry. It is hoped that this introduction will assist members of the red meat industry understand where to start and what to expect from the solar industry.

2 Project objectives

2.1 Scoping of technology

The project will scope technology solutions and perform due diligence with technology providers to determine ideal solutions for the red meat sector and tailoring the solution to industry needs (demand profile, geographic location etc).

2.2 Business model and approvals investigation

The project will investigate business models and funding solutions. Included in this investigation will be interactions and negotiations with financial institutions, government agencies, policy makers and incentive programs.

2.3 Costs of solution investigation

Costs of solution specific project logistics to determine project size and viability (e.g. site survey, geotechnical assessments, interactions with the regulator and grid providers).

2.4 Preparation of a strategy/learnings report

Preparation of a strategy/learnings report for MLA regarding the state of industrial solar and the business model options that will enable a path forward for the red meat sector.

3 Success in meeting the milestone

3.1 Desktop investigation

The desktop investigation is divided into two sections, the development of data and the ex-ante cost benefit analysis. The development of data section uses real world examples to help members of the industry understand the key aspects to consider when exploring their own solar battery assets. Development of data includes a sensitivity analysis, precisely illustrating the key variables of a solar asset. The ex-ante cost benefit analysis simulates two solar assets for each of the example client facilities to provide precise insight into the cost benefit equation of a solar battery asset.

3.1.1 Data collection procedures

The data for the current investigation was collected from real world industry members. Wiley believes the four industry members represent a good cross-section of Australian Red meat. A summary of the project partners for this investigation is provided in the following table:

	Product produced	Head per day	Location
Client 1	Lamb	3500 - 4500	NSW
Client 2	Beef	<500	Victoria
Client 3	Mixed	1500-2500	NSW
Client 4	Mixed	1000+	NSW

Table 1 Case study facilities

Each client provided power consumption interval data and power bill information. The data used in this analysis has been kept anonymous. These sites represent a good cross section of the meat processing facilities in Australia as they represent a range of states, products and facility sizes.

The solar energy data for each location was sourced from the Bureau of Meteorology site using the weather station closest to the site. It is assumed that the cloud cover and solar conditions do not vary substantially over the distance between the sites and the weather stations.

3.1.2 Modelling approach

3.1.2.1 Ex-ante Cost Benefit Analyses

Wiley's hourly energy balance simulation model was used to perform the modelling for the ex-ante cost benefit analyses. The hourly simulation delivers the best insight regarding the performance of a solar battery asset possible.

This approach has the following inputs:

1. Hourly interval data from each facility
2. Hourly solar incidence data from the nearest BOM weather station
3. Size of solar array
4. Size of battery asset

The model takes the data and performs an energy balance every hour for at least a year. This model determines how much energy is available from the solar array, how much energy the facility is consuming and how much energy is available in the batteries. With this information, the model will route energy to the batteries, facility or the grid, tracing every kWh for the duration of the simulation.

This allows the model to precisely determine the value of the solar battery asset over the representative year. This simulation is repeated 20 times to take into account diminishing performance of the battery and the solar panels. This process generates the 20-year cashflows used in the ex-ante cash benefit analyses.

The precise logic upon which the model is based is as follows:

If a given hour sees energy consumption of the facility as less than solar production, then the full demand of the facility will be provided by the solar asset. The remaining solar energy will then be routed to the battery for charging. If the battery is full, the energy will be sold to the grid at feed-in tariff rates

If the energy required by the facility is greater than that generated by the solar asset, the power generated by the solar asset will be routed to the facility to reduce grid demand. If there is energy in the battery, this will be subtracted from the grid demand as well. Finally, if there is leftover demand which cannot be addressed by either solar of battery, the facility will draw from the grid.

The advantage of this approach is that instead of using rule-of-thumb figures for the returns of a solar asset, it performs very precise modelling to find the exact returns of such an asset.

Assumptions:

1. Solar panel energy production increases linearly with solar incidence
2. The degradation of solar panels is 0.5% per annum
3. The round-trip efficiency of the battery is 80%
4. The future energy consumption of the client follows the same patterns of the current energy consumption
5. LGCs are not taken into account due to inconsistency of price
6. The feed in tariff a client can achieve is 5c/kWh
7. Any energy loss for being held in the battery for long periods of time is negligible
8. The battery is used for load shifting, not peak shaving
9. The battery lasts 10 years and needs to be replaced after this duration

Note: It was not possible to precisely determine the possible feed-in tariffs for the case study facilities without first constructing the solar facility. For this reason, assumptions have been made based on the recommendations of the Australian PV institute (Australian PV Institute , 2019)

3.1.2.2 Sensitivity Analysis

The modelling approach for the sensitivity model is much more broadly applicable than that used in the ex-ante cost benefit analysis. As the sensitivity analysis is designed to be useful to a wide range of red meat industry members, it does not make assumptions around energy consumption profile or battery utilization. Instead, this approach assumes the solar asset is undersized and that a very large portion of the asset is being used to offset energy consumption. Additionally, the sensitivity analysis does not address battery storage solutions, as the utility of these assets is highly case specific.

In this way, it is possible to produce useful outcomes for a large proportion of the red meat industry without making unreliable assumptions regarding asset utilization.

The sensitivity analysis uses a relatively simple formula to determine the income generated by a solar asset through a year:

$$I = 365(CQUOE + (1 - U)CQFE) + 12(RCD)$$

Where:

- I = Annual income generated by solar asset
- C = Capacity of the solar asset (kW)
- Q = Daily solar incidence (kWh/m^2/day)
- U = Utilization rate (%)
- E = Array Efficiency (%)
- O = Value of power when offsetting purchase from the grid ($/kWh)
- F = Value of power when sold to the grid for feed-in tariff rates ($/kWh)
- D = Demand charge ($/kVA)
- R = Demand charge reduction rate (%)

The demand charge section of the formula is multiplied by 12 as demand charges are computed monthly in many cases.

The following table presents an example calculation to demonstrate how to approximate the value of a solar asset.

Variable	**Value in example calculation**
C = Capacity of solar asset (kW)	600kW
Q = Daily solar incidence (kWh/m^2/day)	4.4kWh/m^2/day
U = Utilization rate (%)	90%
E = Array Efficiency (%)	90%
O = Value of power when offsetting purchase from the grid ($/kWh)	0.16$/kWh
F = Value of power when sold to the grid for feed-in tariff rates ($/kWh)	0.05$/kWh
D = Demand charge ($/kVA)	$8.5/kVA
R = Demand charge reduction rate (%)	30%

Table 2 Example sensitivity analysis calculation

$$I = 365\ days\left(600kW \times \frac{\frac{4.4\text{kWh}}{\text{m2}}}{\text{day}} \times 0.9 \times 0.9 \times \frac{0.16\$}{\text{kWh}} + 600kW \times \frac{\frac{4.4\text{kWh}}{\text{m2}}}{\text{day}} \times (1-0.9) \times 0.9 \times 0.05\$/\text{kWh}\right) + 12(0.3 \times 600kW \times 8.5\$/kVA)$$

Formula 1

For the sensitivity analysis, utilization rate is assumed to be 0.9, based on recommendation from solar industry experts and the fact that all assets are assumed to be undersized. Similarly, array efficiency is assumed to be 0.9 based on the methodology of the PB institute (Australian PV Institute , 2019)

This calculation is performed for each of the 20 years of the cashflow analysis performed in the sensitivity analysis. The cashflow analyses take into account the degradation of solar panels by multiplying the outcome of formula 1 by the degradation rate at the relevant year.

Assumptions:

1. The solar incidence and efficiency factor approach is a close approximation of the performance of a solar asset
2. The degradation of solar panels is 0.5% per annum based on (Solar Choice, 2019)
3. The future energy consumption of the client follows the same patterns of the current energy consumption
4. LGCs are not taken into account due to inconsistency of price
5. The feed in tariff a client can achieve is 0.05$/kWh based on (Jacobs, 2018)
6. Utilization rate is 90% - based on recommendation from solar industry experts
7. Array efficiency is 90% - based on (Australian PV Institute , 2019)
8. The demand charge reduction rate is 30%

3.1.3 Modelling Outcomes

3.1.3.1 Sensitivity analysis

To illustrate the impact which key variables have on the economics of a solar asset, a sensitivity analysis was performed.

The key aspects considered in this sensitivity analysis are:

1. Price of power purchase from the grid ($/kWh)
2. Solar energy available on site (kWh/m^2/day)
3. Demand charge ($/kVA)
4. The price of solar panels ($/Watt)
5. Feed in tariff (c/kWh)

The sensitivity analysis applies to the following boundaries of the four variables mentioned above:

Variable	**Lower bound**	**Average**	**Upper bound**
Power Price	10c/kWh	15 c/kWh	20 c/kWh
Demand Charge	$8/kVA	$13/kVA	$18/kVA
Price of Solar	$1.30/Watt	$1.70/Watt	2.10/Watt
kWh/m^2/day	4.2	4.4	4.6
Feed in Tariff	0.00 $/kWh	0.05 $/kWh	0.10 $/kWh

Table 3 Variables and Bounds of Sensitivity Analysis

Setting all variables to the average delivers an IRR of **15.9%.** Altering the variables will cause a percentage change to the IRR according to the normalized sensitivity plot figure 1. The boundaries for this sensitivity analysis were selected based on the bounds within the 4 case study facilities.

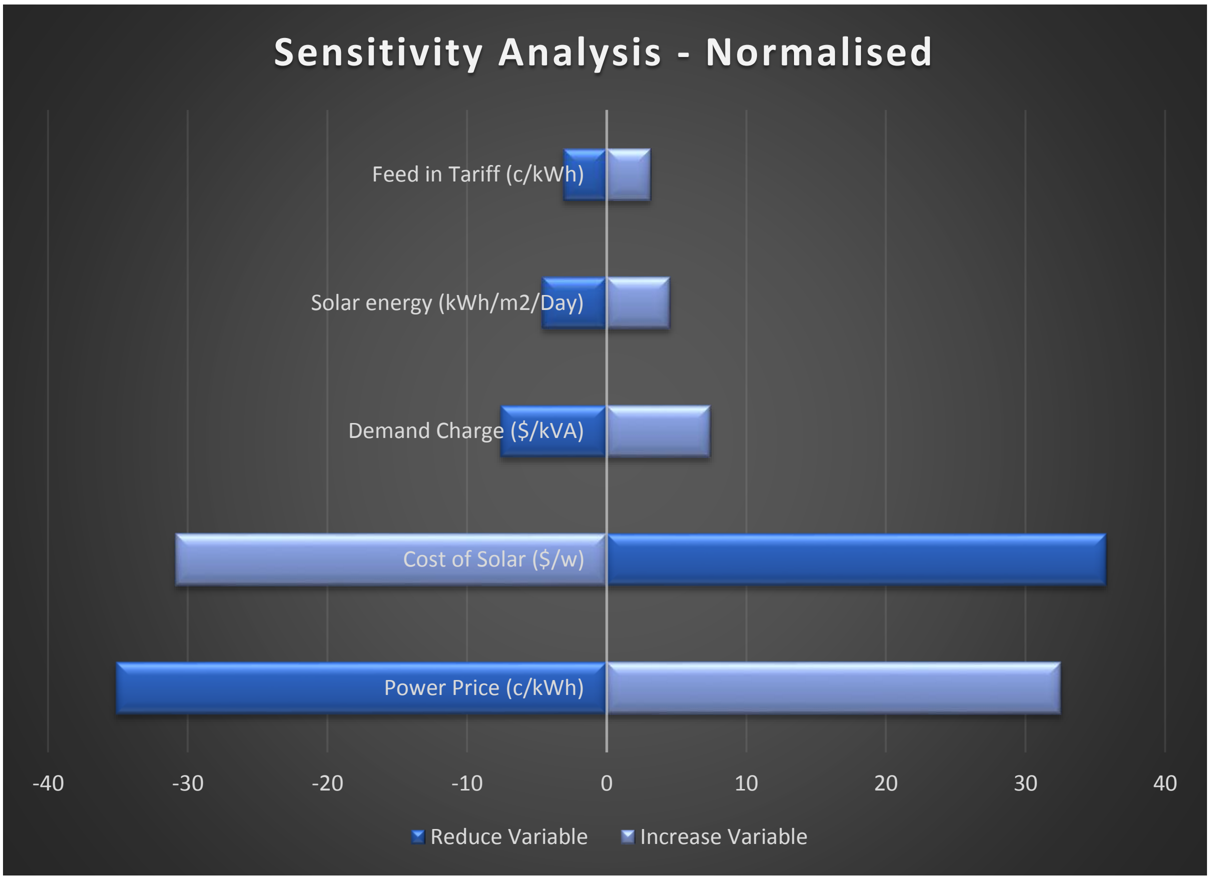

Figure 1 Normalized Sensitivity Analysis

This normalized sensitivity analysis shows the impact each of the 4 variables has a solar facility's IRR. It is very important to note the bounds shown in table 3. These bounds illustrate the variance in the controlling variable which caused the outcome in the sensitivity analysis.

The following table illustrates the outcomes of the sensitivity analysis, next to the variation in key parameters which caused said outcomes:

Variable	Lower bound	Average	Upper bound
Power Price	10c/kWh	15 c/kWh	20 c/kWh
Impact on IRR	-35%	0%	+32%
IRR value	10.3%	15.9%	21%
Demand Charge	$8/kVA	$13/kVA	$18/kVA
Impact on IRR	-7%	0%	+8%
IRR value	14.69%	15.9%	17%
Price of Solar	$1.30/Watt	$1.70/Watt	2.10/Watt
Impact on IRR	+35%	0%	-31%

IRR value	21.5%	15.9%	12%
kWh/m²/day	4.2	4.4	4.6
Impact on IRR	-5%	0%	+5%
IRR value	15.16%	15.9%	16.6%
Feed in Tariff	0 c/kWh	5 c/kWh	10 c/kWh
Impact on IRR	-3.1%	0%	+3.1%
IRR value	15.4%	15.9%	16.4%

Table 4 Outcomes of sensitivity analysis

If the reader finds their price of power is outside these bounds, it is possible to extrapolate findings outside of the bounds however accuracy will diminish.

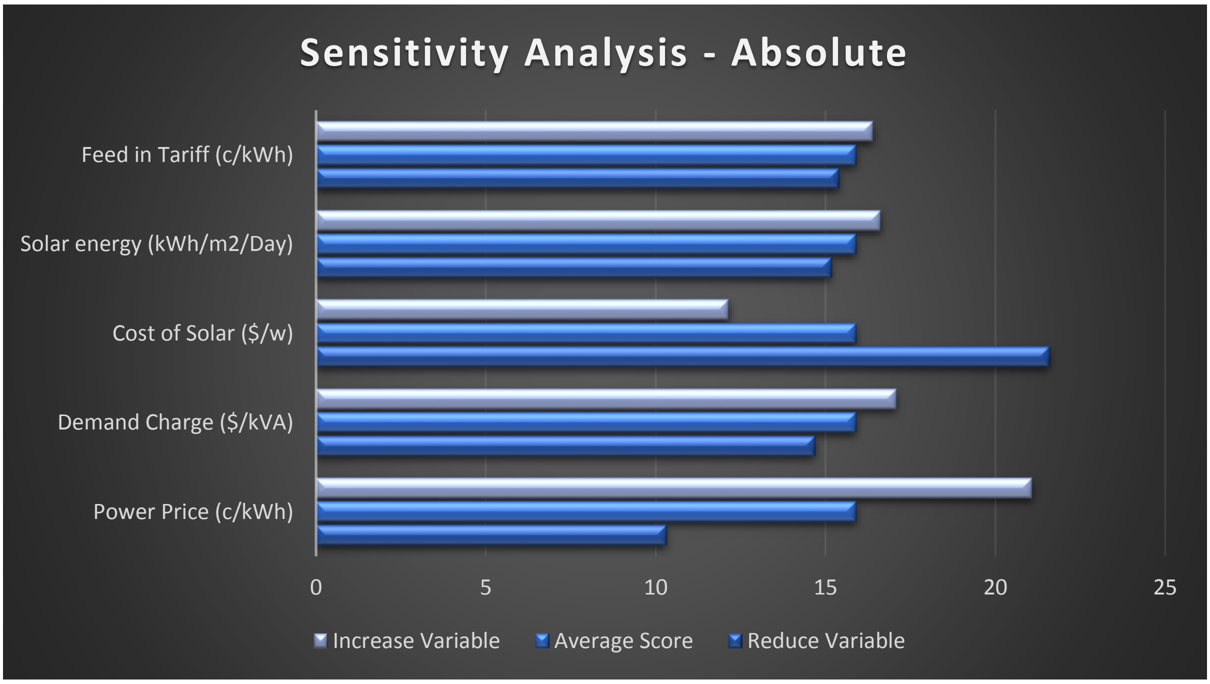

Figure 2 Absolute sensitivity analysis

To further illustrate the sensitivity analysis, the data is presented as absolute values of IRR. One can see the difference an increase or decrease in a variable makes to the business case. Note that the average score IRR of 15.9% has a conservative assumption around the cost of a solar asset. It is likely that a solar asset can be procured at a lower cost than this and the reader should keep this in mind.

Note - The feed-in tariff has a relatively small impact on the over-all IRR because the feed in tariff affects only 10% of the energy produced by the solar asset. This is a result of the 90% utilization rate assumption.

3.1.3.2 Solar asset sizing & feed-in tariff

The sensitivity analysis detailed in section 3.1.3.1 assumes that the solar facility is undersized such that a maximal portion (90%) of the energy produced is offsetting energy consumption from the grid as opposed to being sold to the grid at feed in tariff rates. This is the most IRR effective approach to solar asset sizing. In order to achieve this 90% utilization rate, the solar asset should be sized such that the power output in the middle of the day is 50-70% of the average daytime energy consumption. This figure was determined through consultation with solar industry experts and acknowledges that it is a very high- level assumption which will have varying use to different clients.

The reason it is wise to undersize a solar facility is the fact that greater value is achieved by offsetting consumption from the grid as opposed to selling energy to the grid. Typically, a member of the red meat industry will be paying 12-18 c/kWh depending on the state. The rate at which one can sell to the grid is 6.5 – 7.9c/kWh. Thus, a solar asset is retrieving roughly half to a third its maximum value when selling to the grid. Energy which is sold to the grid is referred to as “spilled” or “leaked”.

The following figures demonstrate facility oversizing – showing energy wasted when the solar asset is too large for demand; and a correctly sized facility delivering energy without wasting capacity.

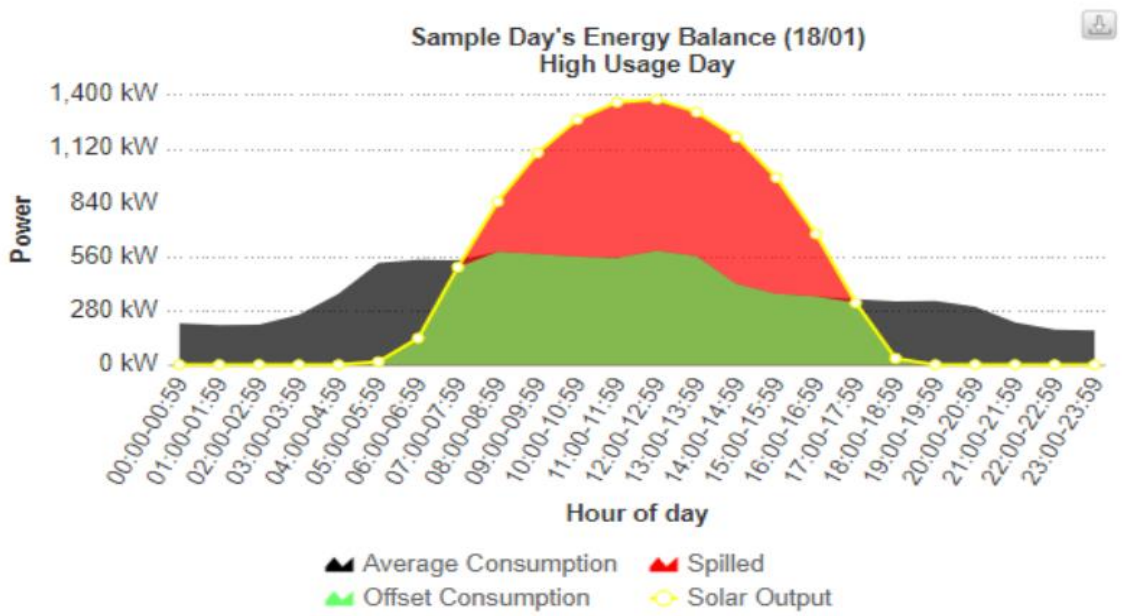

Figure 3 Solar asset sizing 1

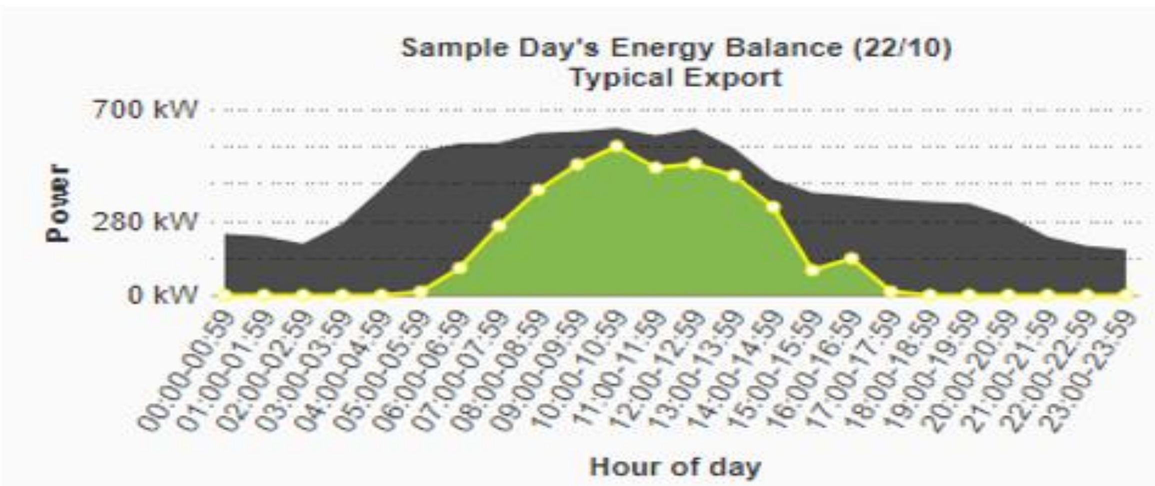

Figure 4 Solar asset sizing 2

Wiley found through developing data that when considered against a typical red meat facility that one can expect 10%-30% of energy requirements to be addressed by a solar asset before the asset becomes oversized with excessive energy spillage.

3.1.3.3 Weekend energy consumption

In addition to the oversizing challenges confronted on week days, it is important to consider the energy leaked on the weekend. This analysis found that not operating on the weekend could make the difference between viable and non-viable solar assets. It is possible to address this challenge by sizing the asset with weekend energy consumption in mind, however this may reduce the capacity of the asset substantially, rendering the asset insignificant relative to the energy consumption on weekdays. Figures 5 and 6 illustrate difference between weekday and weekend energy consumption for a typical facility, respectively. A solar asset sized for effective battery storage is substantially oversized for weekend consumption.

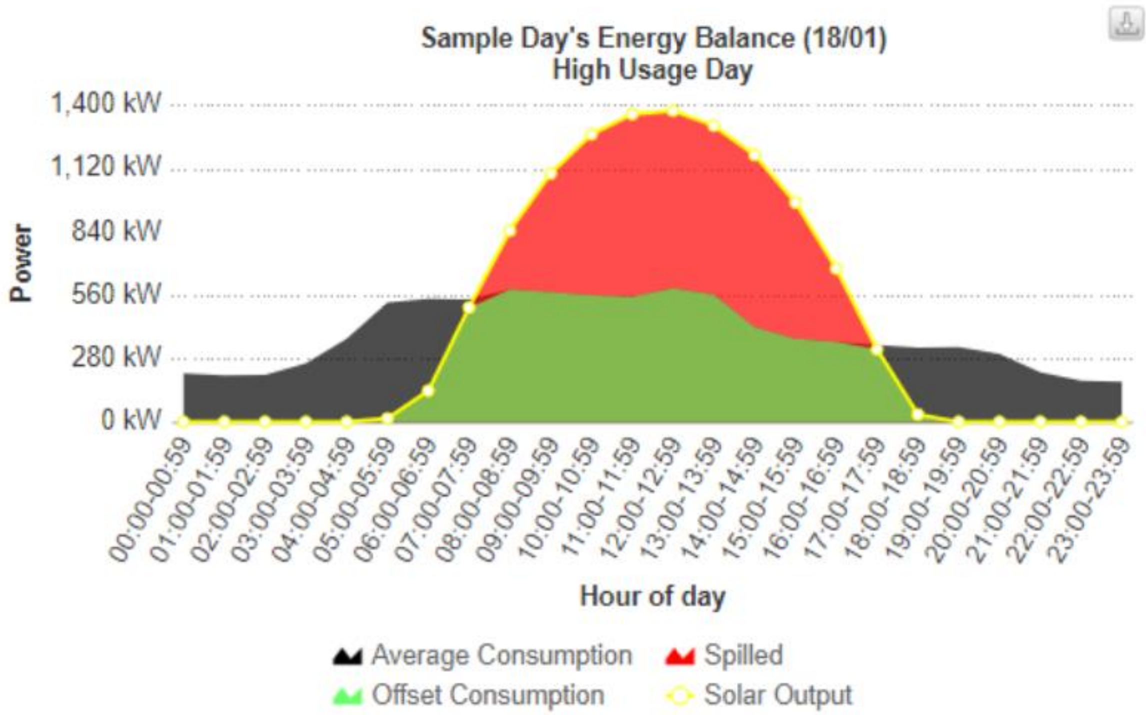

Figure 5 Weekday energy production and consumption

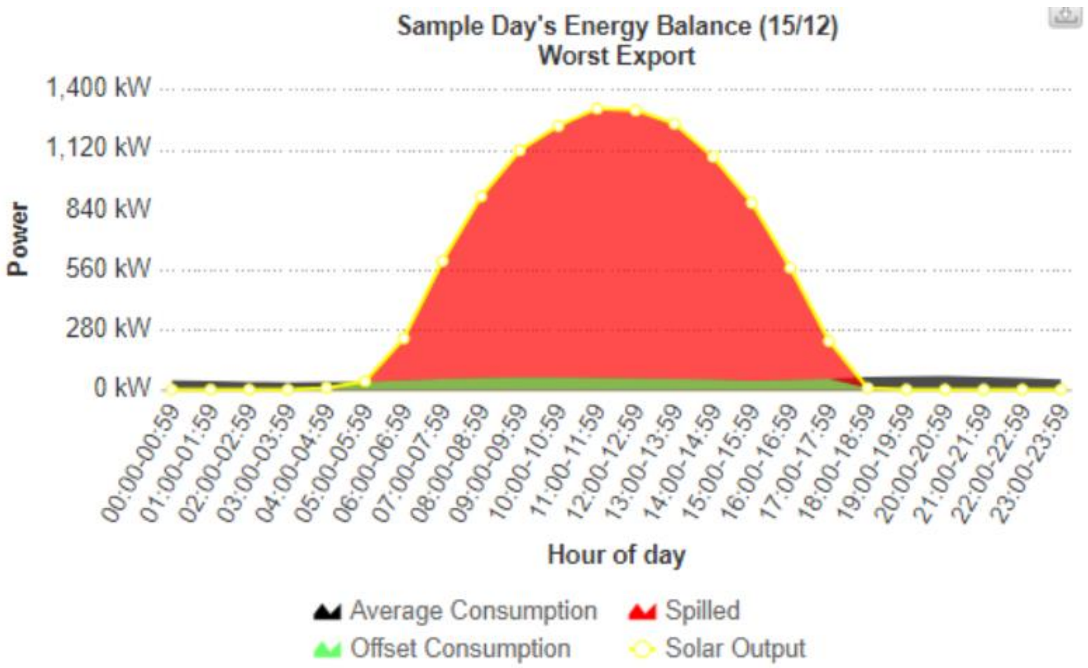

Figure 6 Weekend energy production and consumption

3.1.3.4 The cost of a solar asset

The capital required for a solar asset has a large impact on the overall asset business case viability. Through this investigation, Wiley have uncovered installed costs for solar ranging between $1.30/Watt and $2.1/Watt. The factors that contribute to this substantial variation in capex must be evaluated to enable sound decision making on project viability. Some of the contributing factors are presented in the following table:

Variable	**Impact on price**	**Indicative price ($/watt)**
Baseline	-	$1.40
Rural installation compared to metropolitan	+5-10% install cost	$1.50
Ground mounted compared to roof mounted	+20% install cost	$1.70
Single axis tilt (do not also consider ground mount cost)	+30% install cost	$1.75
Size of facility	>5MW leads to 5% reduction in cost	$1.30

Table 5 Solar asset pricing variables

Note that the baseline cost of solar for the case studies is $1.70/Watt. This is a result of quotes Wiley received from expert solar providers when researching this project. This gives a conservative estimate of the profitability of a solar asset through the sensitivity analysis.

3.1.3.5 Solar incidence

The solar incidence measured in kWh/m^2/day in a given location has a direct impact on the viability of a solar asset. This parameter determines the amount of solar energy available at a given location. One can determine the solar incidence of a facility by comparing their location to the following map.

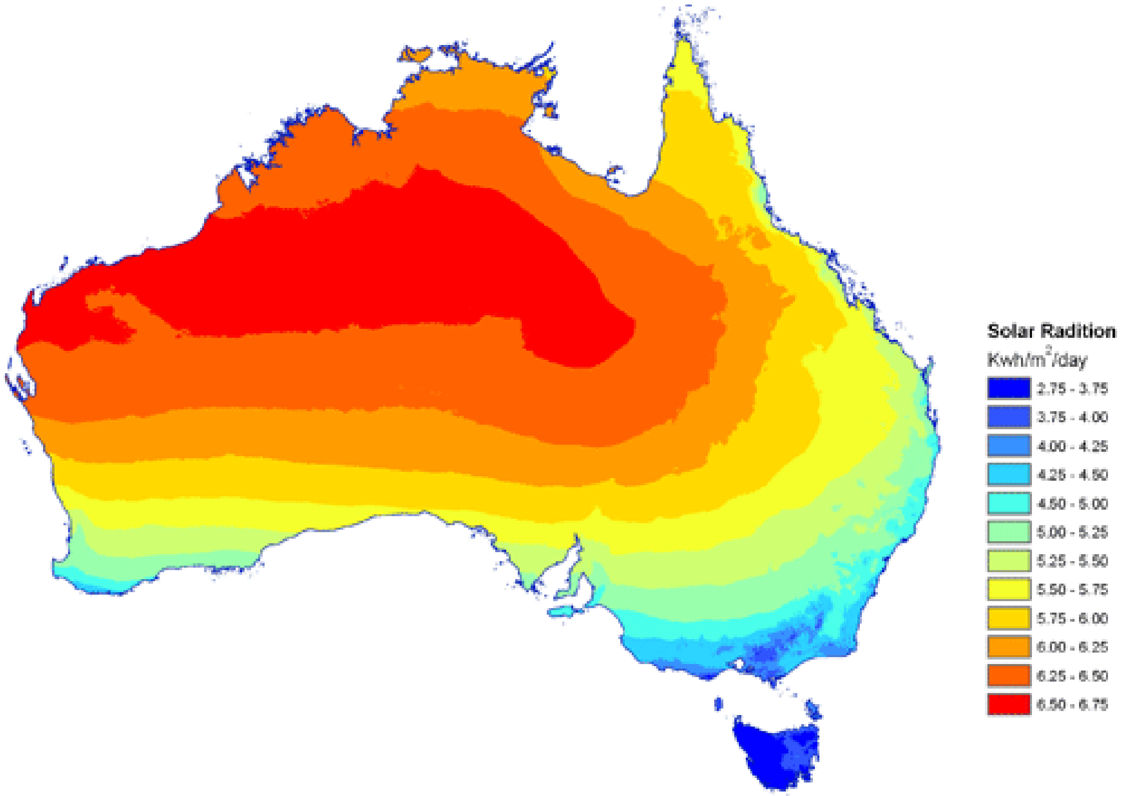

Figure 7 kWh/m2/day map of Australia (University of Technology Sydney, 2013)

The bounds chosen for the sensitivity analysis were 4.2kWh/m^2/day to 4.6kWh/m^2/day this does not cover the entirety of Australia however it does cover large numbers of red meat businesses in NSW, Victoria and South Australia.

Solar incidence cannot directly be used in calculations, it must be converted from kWh/m^2/day to kWh/kW/day. In order to achieve this, the array efficiency factor is used. The efficiency factor takes into account the fact that solar panels are non-tracking and other installation-specific imperfections. For the purposes of this investigation a factor of 0.9 was used based on the recommendations of the AVPI Solar Potential Tool (Australian PV Institute , 2019).

3.1.3.6 Project specific logistics – price of power

Finally, the state in which a solar asset is located has additional impacts on the viability of a solar asset. These variables include legislative controls and Large Scale Generation Certificates (LGCs). The following table summarizes findings by Solar Choice and presents the IRR of solar assets in different states. It is important to note that the findings in the following table are independent of and in alignment with the investigations in this report.

Table 6 payback periods of commercial solar assets (Solar Choice, 2019)

State	ACT	NSW	NT	QLD	SA	TAS	VIC	WA
Payback period (years)	3.6	5.4	2.5	5.2	4	5.4	5.7	3.3
Internal Rate of Return (IRR, %)	29%	20%	40%	21%	26%	19%	18%	34%

3.1.3.7 Project specific logistics – Cost of geotechnical analysis

The average cost of a geotechnical analysis is typically not more than $10,000. This is an important step in the implementation of a ground mounted solar asset as it will provide valuable insight into the cost of footings and foundations for the solar asset to be installed. Wiley has found that a ground mounted asset can be entirely inhibited by poor geotechnical conditions.

3.1.3.8 Project specific logistics – Cost of site survey

The cost of a site survey is roughly $10,000, similar to the geotechnical analysis, this assessment is only required for ground mounted systems. The gradient of a site is important to the viability of a solar asset. Specifically, it becomes more challenging to install a ground mounted asset as the gradient increases. It is possible for the slope of a hill to have a favourable impact on the productivity of a solar asset. This is rarely the case however and it is very unusual for this to have a material impact on the business case of a ground mounted solar asset.

3.1.3.9 Project specific logistics – Cable routing

Wiley has found through interactions with facilities looking to implement an energy asset that routing the cables for the asset can be challenging. In particular, a client had land for their solar asset across the road, with a number of underground conduits and overhead cables running through the area. This did not prevent the installation of a solar asset however it did make implementation more challenging.

3.1.3.10 Project specific logistics – Civil engineering assessment

In some cases, a civil engineering analysis may be required for a roof mounted system, an engineering analysis will cost $5,000 to $10,000 depending on the size of the roof. A civil engineering analysis will determine the structural integrity of the roof upon which the solar asset will be installed.

3.1.3.11 Project specific logistics – The cost of batteries

The cost of batteries is a key challenge to the business case for solar battery assets. The price of battery storage asset used for this investigation was $877.2 per kWh. While it can be expected that the price of batteries will decrease in years to come batteries are still prohibitively expensive for most industry applications.

3.1.4 Ex-ante cost benefit analysis

This ex-ante cost benefit analysis takes data from four real-world food production facilities, simulates them using the Wiley hourly solar energy model and determines the business case for each. Each asset has two solar size options and two battery capacity options. These side-by-side comparisons will give the reader insight into the effect of solar and battery sizing on IRR. The Ex-ante cost benefit analysis includes an energy balance for each site as well as cashflows for each asset either purchased outright.

3.1.4.1 Case study 1

The first case study is a medium sized food processing client based in regional NSW. This client has a desire to be as green as possible, making up as much of their energy requirements as possible with solar. The energy consumption and production of the two proposed solar assets is presented below:

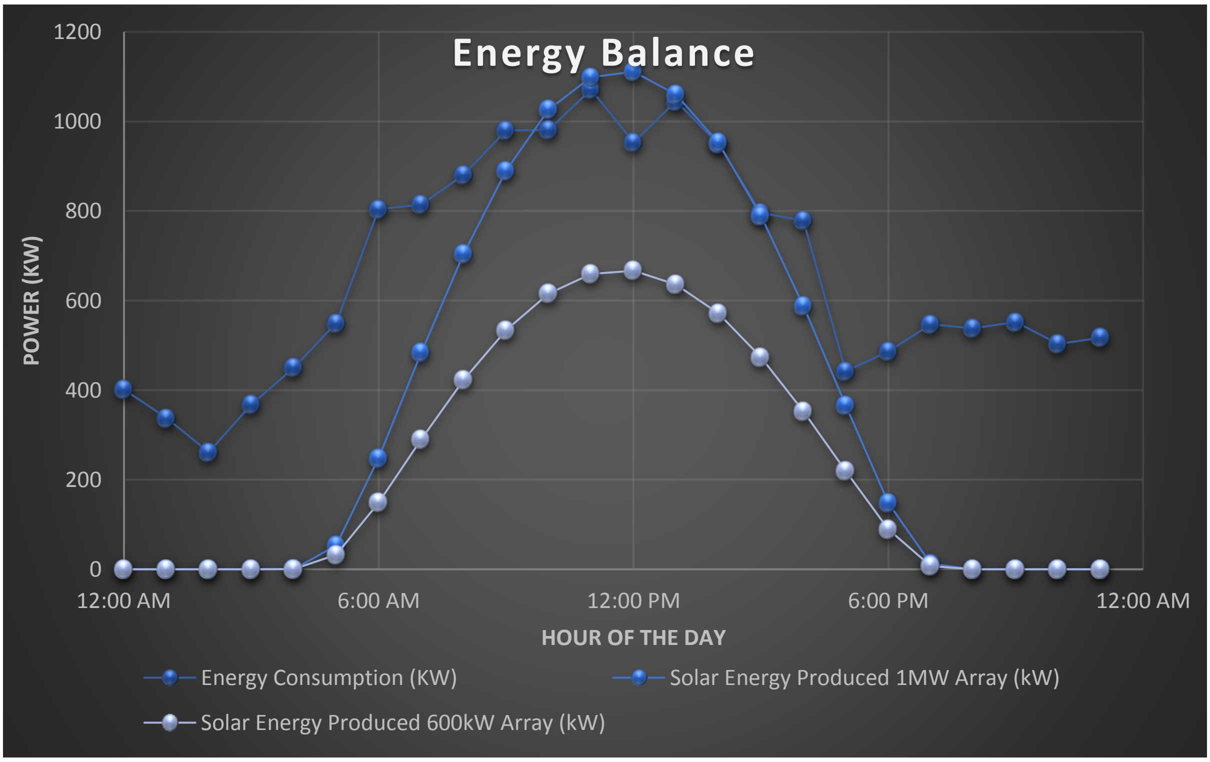

Figure 8 Case Study 1 Energy Balance

The energy consumption profile of this client could be referred to as typical of a food production facility. The facility has a sharp increase in energy consumption at the start of the day and a similar decrease at the end of the day and refrigeration maintained through the whole 24hr period.

The following table details the parameters specific to this site. Note the relatively high price of power per kWh at $0.166/kWh.

Parameter	Value
Cost of solar	$1.40/W installed
Energy consumption charge	$0.1656/kWh
Energy demand charge	$8.5/ KVA
Local solar energy availability kWh/m^2/day	4.5
Cost of battery installed ($/kwh)	$877

Table 7 Case study 1 parameters

The outcomes of this Ex-ante cost benefit analysis are as follows:

System	1MW Solar	1MW Solar 456 kWh Battery	600kW Solar	600kW Solar 228 kWh Battery
CAPEX	$1,400,000	$1,800,000	$840,000	$1,020,000
IRR	15.7%	12 %	21%	17%

Table 8 Case Study 1 Economic Outcomes

The best solution for this client is the smaller – 600kW solar system. This system is capable of achieving 21% IRR, or roughly a five year payback.

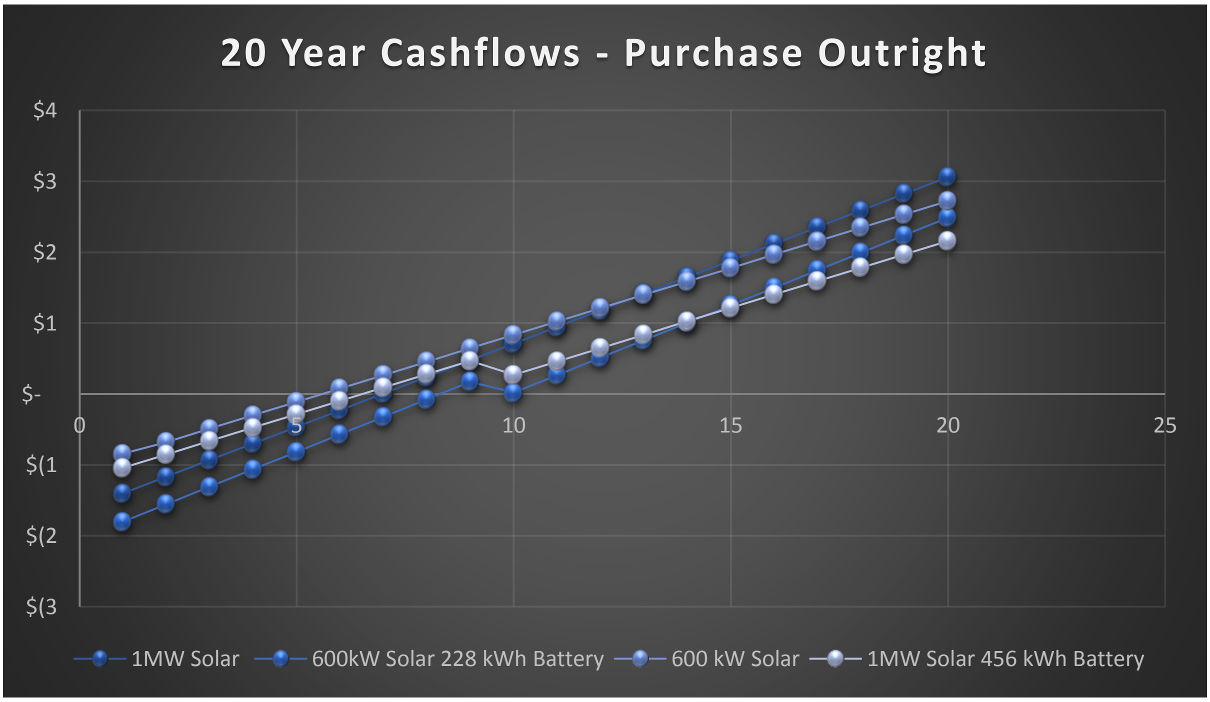

Figure 9 Case study 1 cashflows

The cashflows show that the 600kW system has the shortest payback period. One should note that the battery assets have a dip in return in year ten. This is due to the fact that the battery asset needs to be replaced after ten years, another challenging aspect of the business case of solar battery assets.

3.1.4.2 Case study 2

The second case study is a much smaller facility, with an average maximum demand of only 120kW. The facility has a low energy consumption charge ($0.107/kWh) and a high demand charge ($17.5/ KVA). This facility would be a particularly good business case for batteries due to the ability of batteries to reduce demand charges. The energy consumption and production plot of this facility is pictured below:

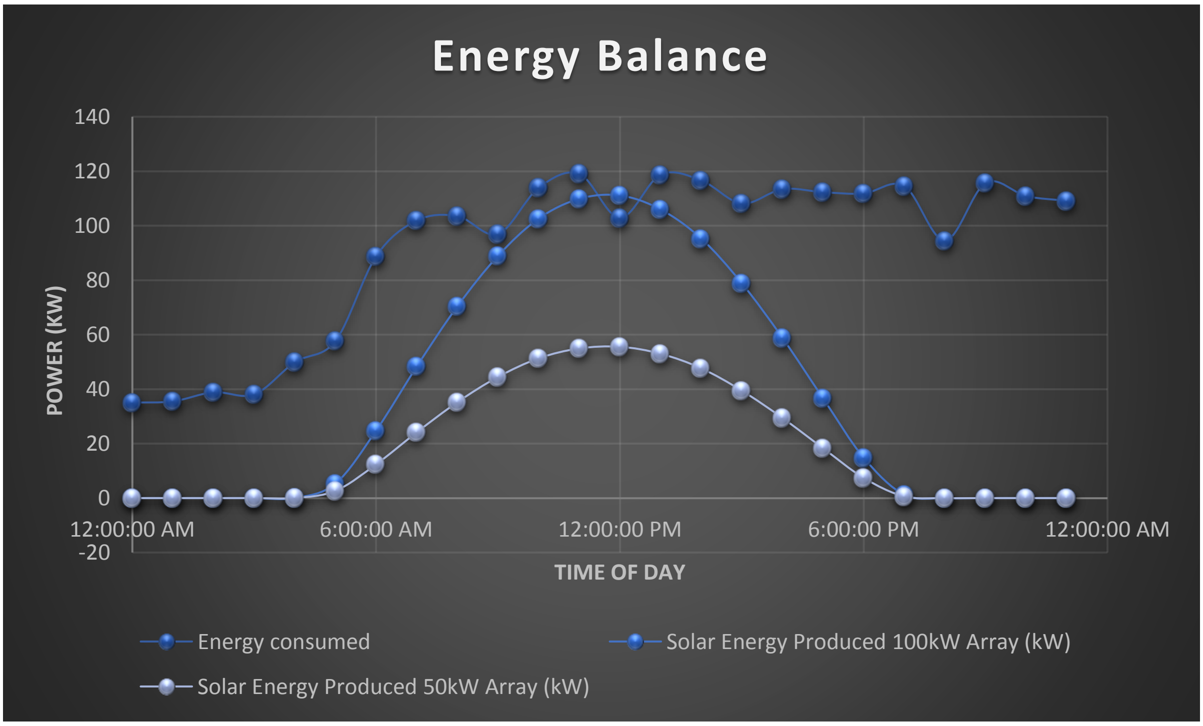

Figure 10 Case study 2 energy balance

The energy balance in this case is somewhat unusual as it has high energy consumption continued into the night. This is due to relatively large refrigeration assets on site. The late night energy demand means solar will be able to provide a reduced portion of the site's overall energy requirement but this will have no negative effect on the IRR.

Parameter	**Value**
Cost of solar	$1.40/W installed
Energy consumption charge	$0.107/kWh
Energy demand charge	$17.5/ KVA
Local solar energy availability kWh/m^2/day	4.5
Cost of battery installed ($/kwh)	$877

Table 9 Case study 2 parameters

The outcomes of this case study are as follows:

System	**100kW Solar**	**100kW Solar – 45kWh Battery**	**50kW Solar**	**50kW Solar – 20kWh Battery**
CAPEX	$140,000	$179,000	$70,000	$89,500
IRR	17.7%	13.8%	21.5%	17.49%

Table 10 Case study 2 outcomes

The following figure shows the cashflows of each of the proposed assets for this site. The best asset for this client is the smaller, 50kW system. This system produces a 21.5% IRR and reduces draw from the grid by 20%.

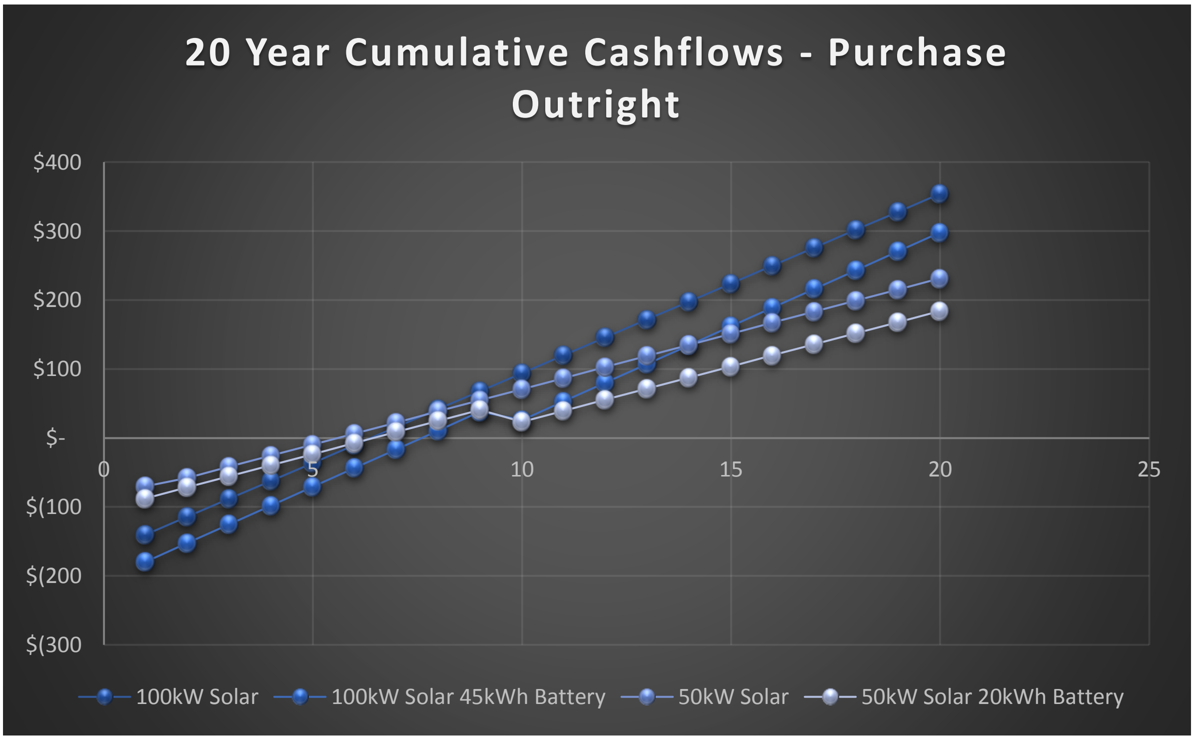

Figure 11 Case study 2 cashflows

The cashflows in this study tell a different story to the others, the smaller solar facility still has the shortest payback period, but the larger solar asset has an only slightly longer payback and offsets much more of the client's energy demand.

3.1.4.3 Case study 3

The third case study is a medium sized facility with a relatively large refrigeration load at night. This facility has a 600kW and a 1MW solar asset proposed. The facility has a low price of power at 12c/kWh. Additionally, the available sunshine on this site is lower than the other sites in this investigation at 4.2 kWh/m^2/day compared to the 4.5 kWh/m^2/day of other facilities.

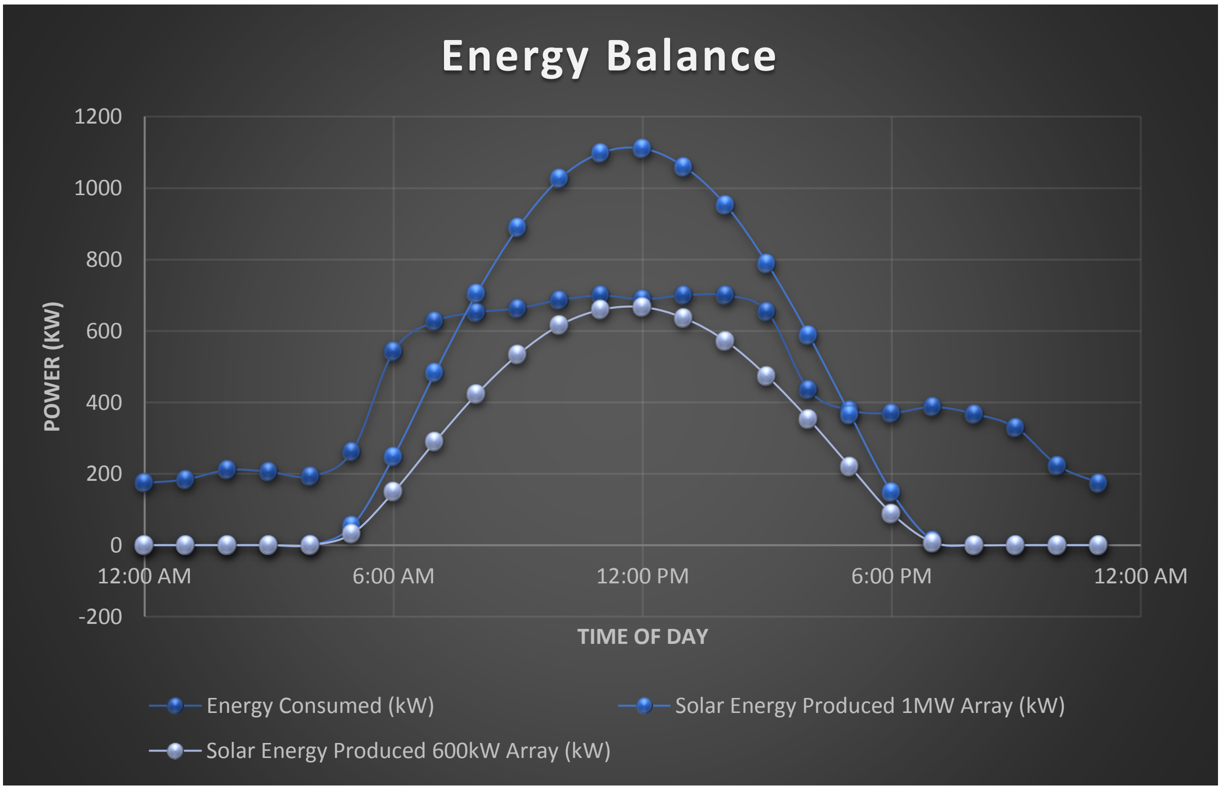

Figure 12 Client 3 energy balance

Parameter	Value
Cost of solar	$1.40/W installed
Energy consumption charge	$0.126/kWh
Energy demand charge	$9/ KVA
Local solar energy availability kWh/m^2/day	4.2
Cost of battery ($/kwh)	$877

Table 11 Client 3 parameters

System	1MW Solar	1MW Solar 228 kWh Battery	600kW Solar	600kW Solar 114 kWh Battery
CAPEX	$1,400,000	$1,600,000	$840,000	**$940,000**
IRR	11.7%	10.6%	15.2%	14.1%

Table 12 Client 3 business case analysis outcomes

As can be seen from Table 11, the ideal asset for this site is the 600kW solar facility as it has the highest return. Due to the low price of power at this site and the low energy availability, the solar asset doesn't perform as well in terms of IRR as other comparable solar assets.

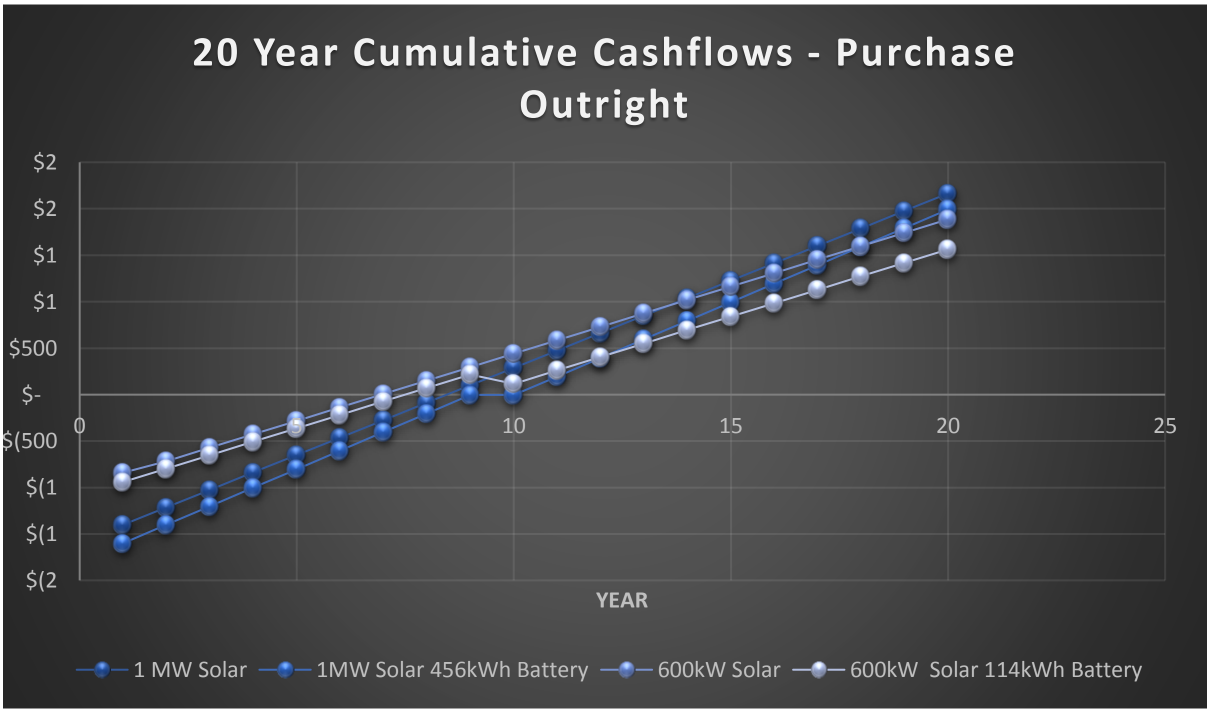

Figure 13 Case study 3 cashflows

As we can see from the cashflow analyses, the facility with the shortest payback is the 600kW solar asset. The 1MW solar asset does end up with the highest income over the 20 year period including loan repayments however, it takes over 10 years to pay off the loan.

3.1.4.4 Case study 4

The final case study facility is a larger energy consumer, in this case, a 1MW solar facility and a 2MW solar facility were proposed. As can be seen from the figure, the 1MW asset is better suited to the energy consumption of the facility. It is important to note that the price of power paid by this facility is 13c/kWh, somewhere in the middle of the case studies thus far. Further, due to the size of solar asset required, it is likely that this asset would not fit entirely on roof. Note how the energy consumption of this facility continues later into the night as compared to other case study facilities.

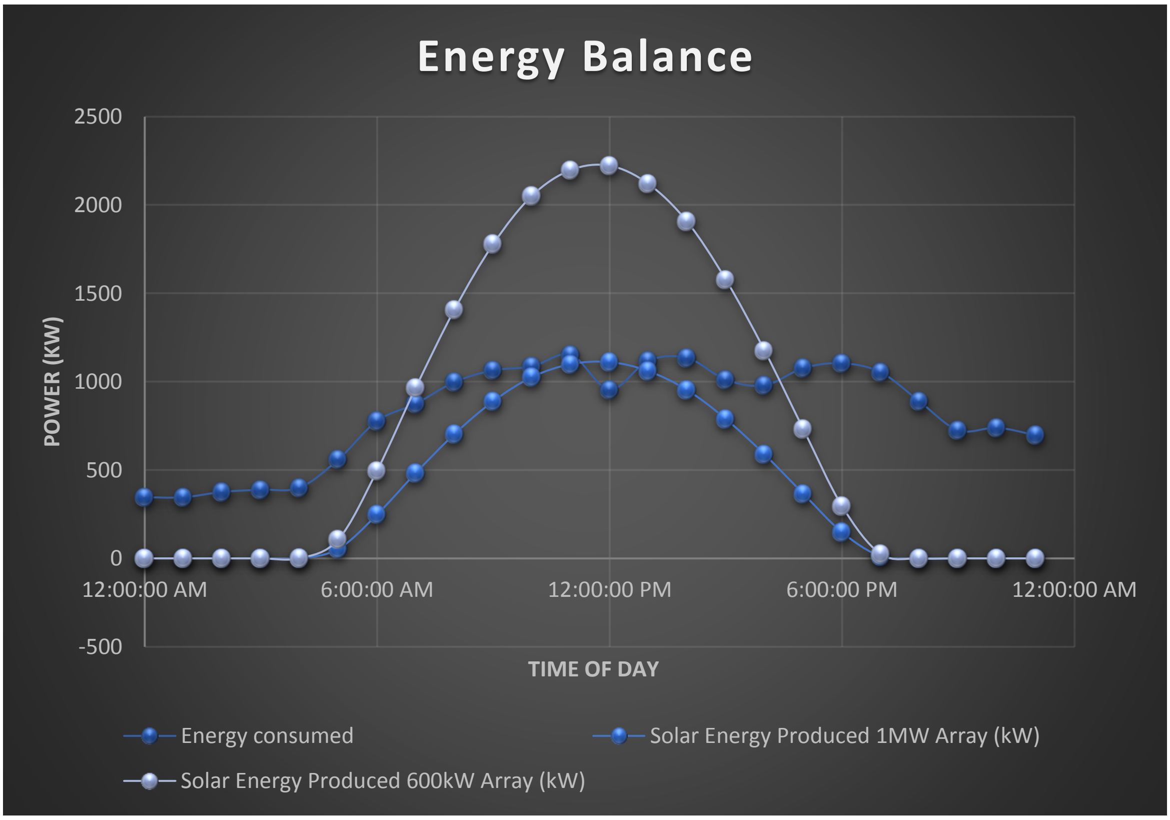

Figure 14 Case study 4 energy balance

Parameter	Value
Cost of solar	$1.40/W installed
Energy consumption charge	$0.1339/kWh
Energy demand charge	$8.0/ KVA
Local solar energy availability kWh/m^2/day	4.5
Cost of battery ($/kwh)	$877

Table 13 Case study 4 parameters

System	2MW Solar	2MW Solar 912 kWh Battery	1MW Solar	1MW Solar 456 kWh Battery
CAPEX	$2,800,000	$3,600,000	$1,400,000	$1,800,000
IRR	12.4%	9.4%	16.9%	13.2%

Table 14 Case study 4 outcomes

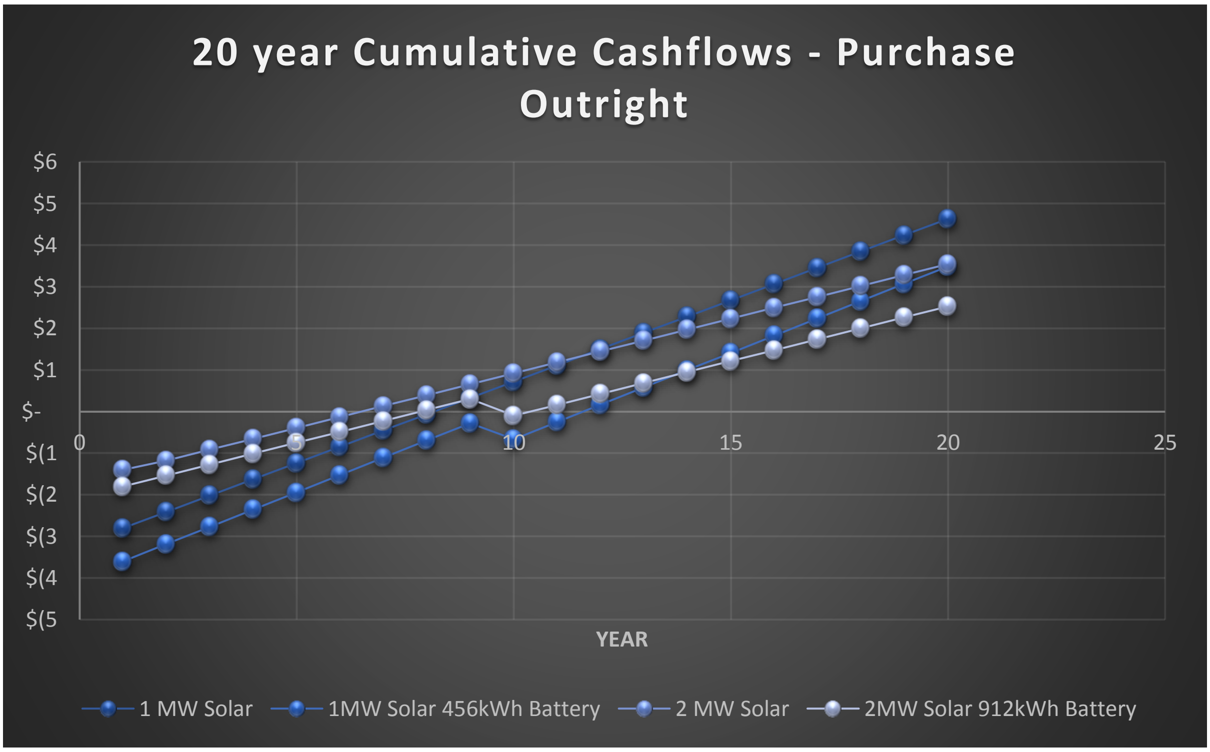

Table 15 Case study 4 cashflows

As we can see from the outcomes, the IRR of the 2MW and 1MW facilities are similar, this is reflected in the cashflow charts. The 2MW solar facility, achieves the best lifetime returns but the IRR is less than that of the 1MW facility. Wiley recommends a 1MW asset for this facility.

3.1.4.5 Case study summary

The following table gathers the best business cases for each case study. These case studies found that in each case the smaller solar asset had the superior IRR. This is due to a reduction of leaked energy. Further, in each case the addition of a battery had a negative effect on the business case. While the battery will reduce demand charges, this is typically not enough to make the battery worthwhile.

	Client 1	**Client 2**	**Client 3**	**Client 4**
Price of power	$0.1656/kWh	$0.107/kWh	$0.126/kWh	$0.1339/kWh
CAPEX	$840,000	$70,000	$840,000	$1,400,000
System size	600 kW Solar	50kW Solar	600kW Solar	1MW Solar
IRR	**21.05%**	**21.56%**	**15.26%**	**16.99%**

Table 16 Case study summary

These case studies show the average IRR for these assets lies between 15% and 22% depending on the price the client is paying for power. In the following section, Wiley will discuss how it is possible to implement a solar asset off balance sheet through power purchase agreements and other innovative business models.

4 Commercialization and Further R&D

The ex-ante cost benefit analysis illustrated the IRR one can expect from a solar-storage asset if purchased outright or financed. The current section investigates the innovative ways to implement a solar-storage asset without incurring capital cost as well as the relationships and models one requires to successfully implement a solar asset or PPA.

4.1Recommended business models & commercial arrangements

4.1.1 Market Overview

The market for integrated solar-storage solutions has developed rapidly within Australia and globally over the past few years. This reflects improvements within existing technologies, investment in new storage technologies, government subsidies and intervention, and the recognition that energy storage solutions are an essential element in the transition to a renewables-based energy network. In particular, the intermittent nature of solar generation (when combined with its significant uptake) at the same time as the closure of coal fired generation has driven interest in battery storage as a mechanism to improve network operating and price stability.

Government Intervention in storage solution markets

State Government have been particularly pro-active in providing funding for storage solutions (both battery and non-battery) with programs such as the Victorian Government Renewable Action Plant ($40.8m funding subsidies for both grid-connected and behind the meter battery installations) or the South Australian Governments $180m home battery scheme. Although the current Federal Government has been relatively slow to provide any specific storage scheme Federally. The Federal Labor Party has also announced a target of 1 million households with batteries by 2025 (with initial funding for 100,000 household battery installations). The table below sets out the current Government incentive schemes regarding battery installation.

Current Energy Storage Schemes

Scheme	Government	Details
South Australia Virtual Power Plan	South Australia	Funded installation of 50,000 home solar PV and Tesla Power Wall batteries in South Australia
South Australia Home Battery Scheme	South Australia	Subsidised program for 40,000 homes to install battery (and additional solar)
Solar Battery Rebate Program	Victoria	Rebate provided to subsidise battery installation for up to 10,000 households in Victoria
Next Generation Energy Storage Grant	ACT	Subsidy provided to 5,000 households and small businesses for installation of a battery
Affordable Energy Plan – Solar PV & battery storage system finance	Queensland	Interest free loans and grants provided for 3,200 household and small businesses for battery systems combined with solar

Table 17 Battery storage schemes by state

Growth in battery installations

At a broader level, the increased focus of Government intervention reflects the relatively low level of penetration of storage technologies at either a grid or customer level. As at January 2019 there were over 2 million PV installations in Australia with a combined capacity of over 11.1 gigawatts of generation (Australian PV Institute, 2019). However, the most recent forecast for installation has total storage installation to increase to only 70,000 during 2019 (Bloomberg New Energy Finance, 2019).The cost-value trade off to date has been insufficient for significant market take-up which consistent at a global level. Assuming the 2019 growth rates are achieved, Australian households will potentially represent 30% of the global household battery market (reflecting the low level of market penetration on a global scale).

Utility grade battery installations

The installation of a utility grade battery by the South Australian Government (The Hornsdale Power Reserve) has however represented a game-changer within the energy storage market. With a relatively short installation time, the facility has clearly demonstrated the value industrial and utility level storage can provide at a market and grid level. This installation has been closely followed by further grid supporting projects such as the Ballarat Energy Storage System (30MWh) and the Gannwarra Battery Energy Storage System (50MWh) in late 2018. All installations provide value to the grid through the provision of Frequency Control & Stability (FCAS) services, generation and network support and energy cost arbitrage in the general electricity market. The key to value extraction of these assets is however, directly achieved from the energy market (something that is largely unavailable to behind the meter battery installations).

Virtual Battery Installations

As an alternative to utility grade solutions, a small number of energy retailers and State Governments have been working upon the establishment of 'virtual' battery and powerplant installations. A virtual installation is implemented through the controlled storage and dispatch of multiple solar-battery installations. The solar-battery installations are located "behind-the-meter" and are generally installed at residential household or small business premises. The installations enable an energy retailer to obtain value directly from the electricity market through the provision of market services, similar to a utility grade battery or power generation asset. Current programs are being facilitated in a number of jurisdictions including the ACT Virtual Power Plant (Canberra) and South Australia's Virtual Power Plant project. The value and usage of the installation is typically shared between the local installation site and the virtual battery operator.

Commercial and Industrial Solar-Battery Installations

The marketplace for commercial and industrial level solar-battery installations (between 100KW and 5MW) has lagged the broader market with around 100MW of generation capacity installed during 2018 (Bloomberg New Energy Finance, 2019). Barriers to significant installation vary although access to finance, available funding models, the lack of a reliable Government incentive schemes, and a lack of proven market solutions are significant issues. These issues are discussed in more detail below.

Corporate PPA Market

An alternative approach taken by a number of significant corporate customers has been the usage of Power Purchase Agreements (PPA's) signed with third party providers of solar or solar-storage solutions. During 2018 there were 20 Corporate PPA's signed however the market currently remains in early stages. During 2018 the Business Renewables Centre-Australia was launched to facilitate growth in the market. Contracts signed to date are generally larger customers that are either direct energy market consumers or alternatively, are utilising on site-generation. The involvement of retailers within PPA arrangements is growing, with Origin Energy involved in the construction of on-site generation (provided under PPA) in addition to utilising "sleeved" agreement in broader arrangements. Agreements are however largely focussed upon the sale of renewable energy and the usage of storage have not been included in the PPA market to date.

Available Battery Storage Solutions

Within the Australian marketplace a variety of technical battery solutions are available as part of commercial or industrial solar-battery installations including:

- Lithium-ion Batteries;
- Flow Batteries;
- Sealed Lead Acid;
- Flooded Lead Acid; and
- Gel Batteries.

Batteries may be produced either domestically or offshore with key countries for production including Germany, China, South Korea and the United States of America.

4.1.2 Australian Red Meat Processing Sector Energy Users

The Australian red meat processing sector is a significant user of energy and has traditionally been open to the use of onsite generation as a means of improving cost outcomes and managing risk. The industry has a long history of biogas reclamation and has recently commenced investment in solar generation capacity. Investment in battery storage has been more limited with only a handful of sites utilising relatively small battery installations.

The most significant project announced to date that includes solar storage is the Low Emissions Energy Hub (LEEH) project announced by Teys Australia ($42 million capital spend). The project aims to provide an integrated energy solution utilising biogas generation, solid waste digestions, solar panels, energy storage and biomass technologies (Beef Central, 2019)

Observations regarding the profile of red meat processing energy users more broadly are:

- *Processing operations are geographically dispersed across Australia* - Processing locations are centred around meat production areas and logistics hubs (i.e. with access to roads, rail, etc). Locations may have an impact on both the reliability, cost and access to grid provided energy solutions;
- *Energy costs are an important element of cost but are not the largest cost component* – The manual nature of current processing techniques places labour as the most significant

operating cost within a processing facility. Energy is an important element in processing however management of energy costs is less important than managing labour efficiency;

- *Ownership structures are diverse* – Although there is significant concentration within the industry to larger international ownership groups the broader industry also contains large numbers of smaller facilities that are locally, or family owned;
- *Energy usage patterns are relatively consistent across the industry* – Energy usage is tied to processing plant shift approach and the usage of processing and chilling equipment;
- *Capital expenditures are prioritised, and projects typically require high ROI (and rapid payback)* – This reflects the volatility of profitability within the sector and a desire to optimise capital investment outcomes. This approach does not always favour solar-storage projects that have longer payback periods;

4.1.3 Understanding the Incremental Value of Batteries as part of a Meat Processor Solar installation

Solar Only Economic Value

The economics of solar-only installations are relatively well understood within the Australian marketplace. Put simply, the value within a solar only installation is created primarily from the reductions in grid provided energy (via energy charges) and grid provided capacity (demand charges). Project economics are driven largely by the cost of generation (capital and operating costs) versus the cost of substitute energy and capacity. Where appropriate, Government incentive programs may also be considered as additional value either through reductions in capital costs or through the provision of additional revenue streams. For commercial and industrial installations within Australia, this has included the value of Commonwealth Government programs such as the creation of Large-scale Generation Certificates (LGC’s) for installations above 100kW or Small-scale renewable Energy Certificates (STC’s) for installations below 100kW.

In an industrial installation setting, alternative benefits may also be available through the reduced need for local and network physical energy infrastructure (transformers, network connections, etc). This is generally the case where plant expansion or refurbishment is required, and the installation of an on-site solar solution may enable a reduction in the level of replacement or new network connection.

The Economic Value of Batteries as part of a solar installation

The economic value of storage as part of a local solar installation varies depending upon:

1. The size of the installation;
2. The cost of alternative energy sources;
3. The value to be obtained from export of surplus solar generation from the network;
4. The cost of network capacity (demand charges) ; and
5. The reliability of the network

Currently there are no Government incentive programs that are provided for the installation of commercial and industrial sized storage solutions. The table below sets out the three areas of value that are created to an industrial customer from the installation of a behind the meter storage solutions as part of a solar installation.

Economic Value provided directly to a Red Meat Processor by local battery installation

Value	Description	Economic Benefit
a. Peak Shaving	Battery Storage is discharged to meet onsite demand peaks	Avoids cost of network provided capacity to supply peaks of highly variable load.
b. Load Levelling	Storage of power during daylight generation hours and discharging at night.	Improved usage of locally generated solar energy with less spillage back to the network Reduced demand from the grid during non-generation hours
c. Uninterrupted Power Supply	Depending upon the capacity of the local battery it may provide sufficient capacity to operate the complete site where other generation fails.	Allows for orderly shut-down in the case of power interruption May allow for reduced capital or capacity costs for alternative generation solutions Benefit is dependent upon reliability of energy network

4.1.4 Current Solar-Storage Project Funding solutions

A review has been performed regarding the current commercial offerings provided within the market space for solar-storage solutions. Although the current models are available the ability of their attractiveness to the red meat sector varies and the inclusion of storage as part of the solution creates further difficulties to the overall economic viability of potential projects.

The marketplace for solar-storage commercial solutions offered within the red meat processing sector for behind the meter installations currently include:

1. Purchase generation and storage infrastructure outright using internal capital;
2. Purchase generation and storage infrastructure outright using externally sourced debt or lease funding; and
3. Engage a third-party specialty provider to purchase and manage infrastructure to be funded via a power purchase agreement (PPA).

These solutions are considered in more detail below.

Utilisation of Internal Capital

At a base level the simplest opportunity for project funding is through internally generated or maintained capital. Within the red meat sector however this is generally not considered to be the optimal model for the deployment of solar-storage projects due to the challenges outlined below.

Key Challenges

Utilising internal capital is rarely an option for red meat processing participants due to;

- *Internal capital holdings are insufficient for project delivery* – Although the profitability of the red meat processing sector has somewhat improved the levels of internal capital holdings are generally relatively low and are managed against existing debt levels.
- *Opportunity costs of internal capital investment* – Although an important element there are generally other alternative investments in capital that can be made that return higher ROI.

Utilisation of debt or lease funding

Within the marketplace a significant number of providers are available to provide debt or lease funding in the acquisition and installation of solar and storage projects. These include:

- *Bank Funding* – All major banks will provide funding for the completion of energy generation and storage program through traditional senior debt arrangements (subject to standard lending assessment criteria);
- *CEFC Funding Arrangements* – The CEFC provides subsidised funding for projects both directly to projects upon application but also via designated funding lines administered by the major banks; and
- *Alternative Lease Funding Providers* – A significant number of alternative non-bank funders are also available to provide funding that is performed on a traditional basis.

Key Challenges

Although funding solutions exist in principles the update within the red meat sector utilising these approaches has been limited due to the following challenges;

- *The term of debt provided through traditional financing channels (Banks, etc) is largely limited to a 5-year term* - The impact of this is that only those projects with very strong cashflows will be cashflow positive in the initial 5-year period (reducing the number of projects that are viable). Many projects that have longer payback periods will be uneconomic utilising this funding approach;
- *The credit profile of many meat processors is sub-investment grade* – Although larger processors are likely to have easier access to external funding there are many processors that will not be eligible for additional debt/lease funding without credit support;

- *Impact of new funding to existing debt lines* - Additional debt and lease funding lines may create issues in dislodging pre-existing funding arrangements and debt covenants (particularly where security is required);

Utilisation of PPA and third-party providers

The limited attractiveness of traditional debt providers has driven alternative funding solutions provided by non-bank providers. The model utilised currently within the Australian marketplace includes:

- Third Party Provider agrees to build, own and operate generation and storage assets (on client premises);
- Client enters into a long-term PPA with the Third-Party provider for energy;
- The PPA will include a cost of providing energy generated generally on a take-or-pay basis; and
- At the end of the agreement the facility transfers to the client for an agreed value.

The benefits of this approach are;

- *PPA terms are longer than traditional debt funding* – Funders underwriting PPA's have an appetite for longer term funding that can stretch to 15 years (significantly longer than debt funding). This enables a better matching of project cashflows for longer payback projects;
- *Zero Initial Cash Outlay* – PPA's are structured to have no initial cash requirement and are generally cashflow positive from day 1;
- *Credit Appetite is often greater than traditional funding* – Underwriting arrangements for PPA providers are generally more open to non-investment grade credit;
- *Arrangements do not impact existing debt arrangements* – Funding is un-secured and the agreement does not impact existing debt covenants or security arrangements; and
- *Operational Performance & Maintenance is managed* – The asset is maintained and managed under a service agreement;

This approach represents the most attractive commercial arrangement for the majority of red meat processors due the better match of the agreement tenure to the underlying project economics in addition to a larger credit appetite than traditional funding. This model has been a preferred approach for participants within the red meat industry to date however there are a significant number of challenges in applying this model to solar-storage installations.

The challenges to this approach are;

- *Funding costs are high and reflect the tenure of debt and risk profile of the customer* – Whereas debt funding costs may be 5-6% for secured funding the cost of longer term unsecured PPA funding may be 12% or higher;
- *PPA term length can limit future strategic flexibility for processors* – Although a longer PPA may be advantageous in improving project economics it can also limit the future flexibility of operational requirements or changing energy usage;

- *Take or Pay Requirements can be onerous* – The take-or-pay requirement often means that the client will pay for energy regardless of usage. This may prove financially problematic during production downturns;
- *Battery storage project economics do not change regardless of the funding approach* – Regardless of funding large scale storage remains largely non-economic or push project payback levels to beyond the appetite of PPA providers;
- *Extended agreement durations* – many industry members will be hesitant to enter into a 10 – 15 year agreement, Wiley understands this is a substantial roadblock for many producers.

4.1.5 Specific Challenges in implementing storage solutions

Beyond the economic challenges of implementing a solar-storage solution there are a number of additional barriers that prevent a significant uptake:

- *Limitations on Value Realisation behind the meter* – The current approach to value creation for battery installation are set out at 1.1.3. Utility grade installations have been more successful economically due to their ability to obtain value from the energy market operator via the FCAS market and through actively trading (and arbitraging) energy pricing. Local distribution networks may also be interest in providing 'grid credits' as part of local network stabilisation activities. These revenue streams are largely unable to be accessed currently due to a lack of available market products;
- *Price and technology improvements drive a 'wait and see' approach* – Although project economics are improving as the cost of storage reduces (similar to the experience of solar panels) this dynamic reduces the desire to invest today and instead wait until paybacks are stronger;
- *Battery technologies and usages are evolving* – The market for storage is relatively immature with the technical lifecycle knowledge still developing. Accurate modelling of efficient battery usage is a evolving field. When considered against some of the newer battery technologies there exists significant longer-term performance risk.

5 Conclusions and Recommendations

Following our review and desktop analysis we make the following conclusions;

1. Solar assets are generally viable for many red meat processors with payback periods that are reasonable (provided sizing is optimised to minimise market spillage)
2. Battery assets are however largely not viable due to the significant economic barriers of acquisition and the impact that significant battery installations have on investment payback
3. The price of power and the price of the solar asset are the most important factors in determining the viability of a solar asset. Location and demand charge have less impact
4. The average IRR from the four case studies performed in this investigation was 14.76%
5. There are many subsidy and incentive programs available to aid in the uptake of solar in Australia however these are largely targeted at residential installations. More recently programs have been developed for storage that are also targeted at residential installations.
6. According to our analysis, a solar asset can provide a meat processing client with a 20-30% off grid solution before the increase in spillage diminishes the IRR
7. For clients who are capital constrained, a power purchase is an excellent option and many members of the industry are singing long term PPAs to lower their power costs and decrease risk. PPAs do however come with risk and will not necessarily cover the economic cost of a battery installation;
8. Battery installations are also limited by the value that is currently available. Obtaining market facing value would improve the business case significantly.

The following recommendations are made:

1. Although current government policy has focussed on the implementation of solar-storage solutions at the residential and utility level, scope exists to support the development of solutions for industrial and commercial users. This may include:
    a. Direct subsidies or improved tax deductibility policies;
    b. Regulatory support to improve the access to market facing value from behind the meter installations;
2. The PPA market is a viable solution for many red meat processing customers although battery solutions are likely to only be a small part of the solution;
3. While solar battery assets are not viable currently, they will become increasingly viable as technology improves and the economic value is better realised. Continual monitoring of the market for opportunity is recommended.

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