FINAL REPORT

Levelised Cost of Energy (LCOE) calculator for Solar PV & battery storage, and Biomass Boilers

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1.0 EXECUTIVE SUMMARY

Australian Meat Processing Corporation (AMPC) members are receiving both solicited and unsolicited offers for the provision of alternative energy supply systems such as solar PV and biomass boilers. The offers are developed using broad assumptions for energy prices and escalation rates (e.g. CPI) and the equipment quality and functionality can be highly variable as well. Without a detailed knowledge of alternative energy supply systems, it is difficult to assess these offers on a consistent basis.

AMPC commissioned Energetics to develop tools and an AMPC advisory service to help members evaluate these offers for their plant(s)/site(s). To ensure that only members use the tool, AMPC will manage and maintain the tool inhouse and provide a service for AMPC members based on requests for support.

This project covers the development of Excel spreadsheet tools for the evaluation of solar PV and battery plus biomass boiler projects. The work includes the development of a user guide which doubles as a training guide for AMPC staff.

Two separate LCOE tools have been developed to provide inputs for the technical and financial elements of solar PV and battery systems and biomass boilers and to provide a comprehensive financial analysis of the renewable equipment offers.

The tools were developed using the following methodology:

1. Meeting with AMPC to confirm scope of the tool and service delivery model
2. Develop a functional specification for AMPC approval
3. Develop draft spreadsheet tool and guide workbook and conduct inhouse testing
4. Ask AMPC members to provide solar PV and biomass boiler offers to test the tool and provide AMPC staff with training
5. Present the tool, guide, webinar and service delivery model for final AMPC approval

The spreadsheet development was based on Energetics experience with similar projects across many Australian businesses in the last 10 years. The tools incorporate many functions and data sources from Energetics inhouse tools and services.

AMPC members provided proposals for biomass boilers and solar PV systems and additional data was requested such as energy bills, metering data and member financial requirements. The testing of the tool using the AMPC members projects provided a valuable insight into the data required to provide an accurate assessment of the project. Most vendor offers excluded aspects of the project required to complete the assessment such as boiler maintenance costs for the biomass boiler assessment, electrical switchboard upgrades required to connect solar PV system outputs, and engineering design required to fully define equipment and installation requirements. Therefore, the tools include default values for most factors to aid the system specification process. Many of these factors were included in the testing of the LCOE tools resulting in much more accurate financial evaluations for each project.

2.0 INTRODUCTION

// The purpose of the project is to develop LCOE tools to conduct a financial evaluation of solar PV and battery and biomass boiler projects.

// The scope of the research includes the solar PV and biomass boiler evaluation tool and projects from Energetics experience and information from AMPC research projects and proposals from AMPC members

// Project objectives are to develop tools and a service which will be delivered by AMPC managers.

// The tools and service are based on current technologies and market offerings. Further technologies are not included.

3.0 PROJECT OBJECTIVES

The project objectives as specified in the research agreement are as follows:

// Create a tool to evaluate the financial and technical feasibility of solar PV and battery projects

// Create a tool to evaluate the financial and technical feasibility of biomass boiler projects

// Provide guides, training materials and webinars as part of a complete AMPC service offering for members.

// Provide output reports for AMPC members.

4.0 METHODOLOGY

4.1 Kick off meeting

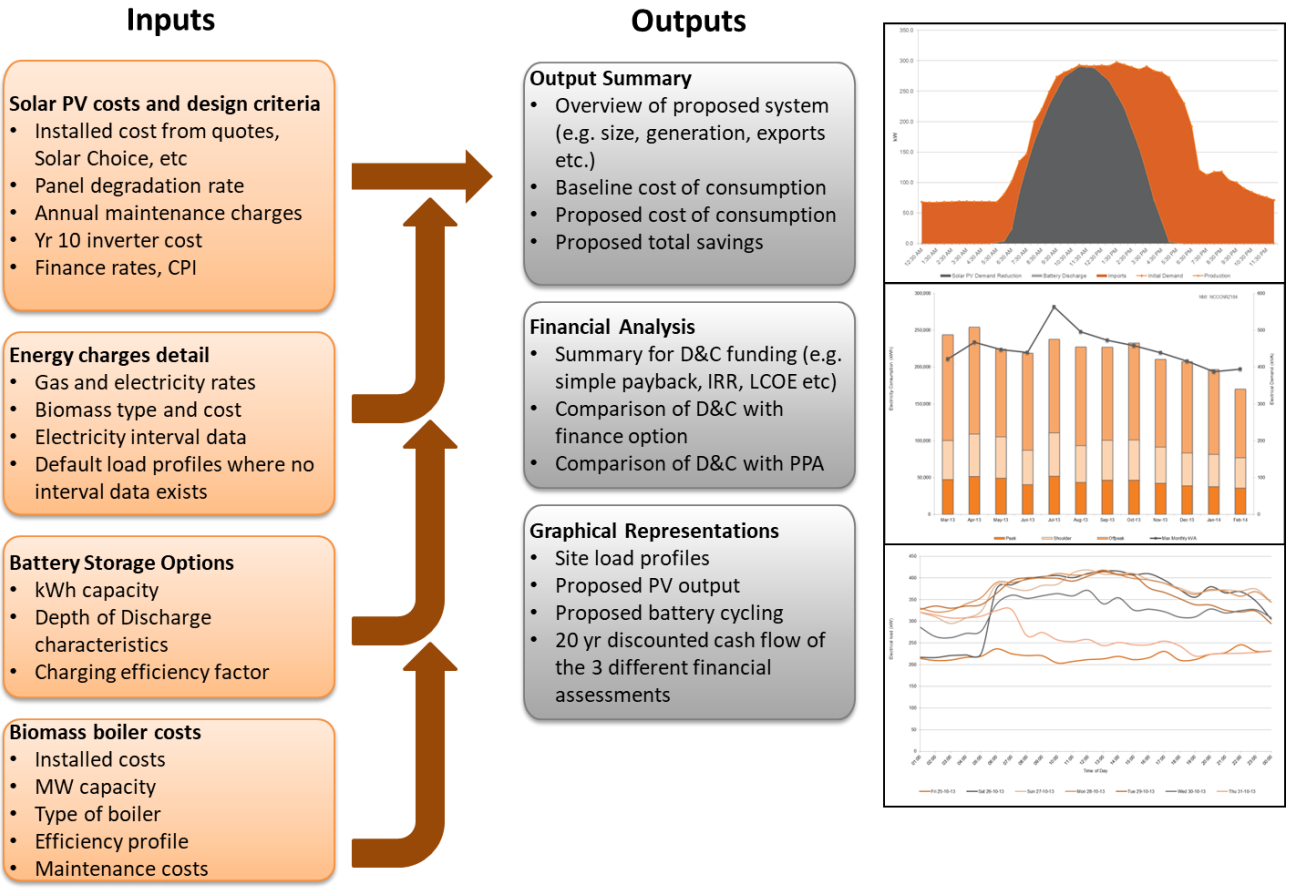
Our approach is built on continuous engagement with AMPC, beginning with an inception meeting with the AMPC project team to:

1. Meet key project personnel from AMPC and to understand roles and responsibilities from the client side
2. Discuss the scope and project milestones
3. Review the details of the proposed methodology and revise the methodology as required
4. Identify any requirements or limitation that apply to the tool or support guide
5. Discuss any potential risks to the project and how these will be minimised
6. Confirm critical success factors and key deliverables
7. Establish and confirm the preferred arrangements for project liaison and progress reporting.

Following the inception meeting, Energetics' Project Manager issued an updated project plan and associated timeline for all relevant stakeholders whichwas reviewed and accepted prior to implementation of the first phase of work.

4.2 Prepare draft input and output fields for review

Energetics prepared a summary of example input and output fields that are envisaged for use by the tool. As a starting point, these contained the requirements broadly discussed with AMPC during meetings in January 2020.



These fields were compiled into a "storyboard" using Power Point slides as part of the workshop process whereby AMPC was guided through each of the user experience steps from inputs (e.g. data entry and the selection of default options) through to the outputs (e.g. typical tables and charts). AMPC was given the opportunity to review and provide input and comment before the tool is further developed.

4.3 Develop draft tool and support guide

For the development of the required LCOE tool, Energetics used Microsoft Excel. Energetics has extensive experience in the development of tools and guides spanning several areas such as on-site assessments as part of energy audits, renewable energy options analysis and financial analysis.

Two separate tools were developed due to widely varying nature of the inputs and associated analysis required for solar PV and battery versus biomass boiler projects. Energetics delivered the

draft tools and guides for review by AMPC. Online reviews of the tools were conducted with AMPC representatives and comments were noted for further tool development.

4.4 Tool webinar and training

Energetics developed, with AMPC input, a presentation (in MS PowerPoint) which provides:

1. Introduction
2. Energy market background information and renewable energy trends
3. Overview of the challenges of assessing solar PV offers
4. Overview of biomass boiler assessment
5. AMPC alternative energy LCOE service description
6. Value for AMPC members
7. Steps to use the AMPC assessment service
8. Contact details

The webinar is suitable as a training tool and a general presentation for members. There is a guidebook for tool use.

4.4.1 AMPC personnel training

Once the draft tool, guide and webinar are available, Energetics will provide training for AMPC personnel to use and deliver the solar PV and biomass boiler assessment and support service. Personnel will need to have some technical and financial background and training. Up to 4 personnel will be trained over 2 days of 4 to 6-hour sessions (one day for Solar PV and another day for biomass boiler). The training process will be a hands-on approach utilising examples of solar PV and biomass boiler system offers and developing reports using the draft tool and materials.

4.5 User testing phase and development of the final draft

Proposals for solar PV and biomass boilers were sourced from AMPC members and used to test the LCOE tools and service delivery approach. Three solar offers and one biomass boilers offer were tested using the draft versions of the tools.

The proposed process for the AMPC alternative energy assessment service is as follows:

1. AMPC provides webinar for members
2. AMPC member requests assistance (this could be step 1)
3. The member provides the required information to populate the tool
4. The LCOE tool is used to generate a report assessing the value of the solar PV or biomass boiler offer
5. A report is provided to the AMPC member

6. Further support from AMPC with possible external assistance
7. A data base of solar PV and biomass boiler offers is developed to help benchmarking offers both financially and technically

Energetics utilised the comments and feedback received during the user testing phase to develop the final tool, guide and webinar.

4.5.1 Tool Updates

Where available, links to data sources for pricing and technology updates have been provided in the tool and guide including:

1. **Battery technology**
2. **Battery pricing**
3. **LGC pricing forecasts**
4. **STC pricing forecasts**
5. **Carbon emissions factors for Australian grid**
6. **Feed-in tariffs**
7. **Solar PV installed costs**
8. **Biomass boiler capital costs**
9. **Biomass costs**

Long term wholesale energy (electricity and natural gas), LGC and STC price forecasts are based on Energetics forecasted trends and will require updating periodically.

5.0 PROJECT OUTCOMES

The LCOE tools for solar PV and battery and biomass boilers were successfully developed and tested with AMPC members. Participating members were happy with the reports generated by the tools (see Appendix 1). Some improvements were required to ensure that data inputs such as fuel heating values and solar PV solar generation data could be incorporated in the tools to increase the accuracy of the assessments.

6.0 DISCUSSION

The results of the LCOE tool testing using AMPC member project proposals and data indicated that vendor proposals could be misleading and, in some cases, incorrect. This demonstrates the need for independent evaluation tools and expert support to ensure that AMPC members are using the best possible information to make decisions on these projects. The following sections discuss some of key factors needed to develop an accurate financial evaluation for solar PV and biomass boilers systems.

6.1 Solar PV assessment

The key areas of difference in the financial analysis in the solar PV proposals were:

- higher grid electricity price, (often peak costs are used in potential saving calculations instead of a mix of peak, shoulder and off-peak prices. Off-peak operation of the solar PV system is about 35% of the operating time, if this excluded or replaced with peak energy charges then the analysis will show a more favourable result.)

- higher grid price escalation rates, (in recent years, grid prices have been highly volatile however the escalation of the grid prices is expected to become much lower due to the continued growth of solar PV and wind power projects across Australia's grids. Escalation rates are more likely to be negative, based on the high current prices)
- lower loan interest rates, (vendor assumptions may include a lower loan rate based on a government funding scheme (this scheme will have a limited eligibility and time frame) or special loan rate offer from the vendor. This needs to be negotiated, a low loan rate may indicate that the capital costs could be lower)
- lower capital cost, (The vendor capital cost could be based on low quality equipment or installation costs based on general assessment of the site requirements. The overall cost of solar PV systems can vary by up to 100% when a full engineering design is conducted.)
- high feed-in tariff prices, (Feed-in-tariffs may or may not be available. Prices offered are reducing and some areas will not allow export to grid. A retailer agreement to buy the export power is an essential element of the solar PV system offer where there is at least 20% export expected.)

The report provided for the AMPC solar PV tool testing can be seen in Appendix 1.

6.2 Biomass boiler assessments

To generate an accurate assessment of a biomass boiler project, the following factors are required:

- Long term for biomass fuel supply with known price and escalation rates (preferably 5+ years long, sufficient to match payback period) contract. (Vendors may exclude the supply costs or utilise allow default cost which needs to be confirmed before finalising the business case assessment).
- Operating and maintenance costs can be very significant (not always shown in vendor offers, assumed to be part of site operating and maintenance budget).
- Capital costs that include all aspects of equipment supply and installation (often the installation costs will be as high as the boiler equipment costs, some vendors will only provide the equipment costs and exclude many aspects of the installation required for the project.)
- Sufficient space on the site to install biomass storage and fuel handling systems (This can cost as much as 30% of the total project costs and requires a full engineering design to provide an accurate cost estimate.)

The report provided for the AMPC biomass boiler tool testing can be seen in Appendix 2.

6.3 AMPC personnel training

The training and support for AMPC personnel providing this service is based on project examples and guidelines for the use of the LCOE tools. It is expected that some external support will be required for the first few project evaluations however as AMPC knowledge builds the need for support will most likely decrease.

7.0 CONCLUSIONS/RECOMMENDATIONS

In the next few years, as AMPC members strive to improve efficiency, decrease operating costs, and look for opportunities to reduce carbon emissions, they will wish to explore and develop business cases for biomass boilers, solar PV, and possibly batteries. The LCOE tools and AMPC delivered service for evaluating these renewable projects will be a valuable service for AMPC members. It is recommended that this service is strongly marketed to members and further feedback on member needs is sought to further develop this service.

AMPC personnel using the LCOE tools and providing the support for members will need to coordinate efforts so that the knowledge gained for each project evaluated is used to further enhance the service offering. It is recommended that a regular perhaps monthly review of LCOE tool evaluations is conducted initially to consolidate the learnings and to identify areas for further tool development and/or external support.

8.0 BIBLIOGRAPHY

Most of the references used to develop the LCOE tools were based on Energetics previous experience and some examples of solar PV and biomass boilers which were supplied by AMPC members. These references are confidential and not provided with this report.

9.0 APPENDICES

This section should include any supporting documentation which has been referenced in the report. Each Appendix must be named and numbered.

9.1 Appendix 1 – Test results for the AMPC Solar PV LCOE tool evaluations

EXECUTIVE SUMMARY

Many AMPC member businesses are implementing solar PV systems as part of a strategy to reduce costs and carbon emissions. The decision to go ahead with a proposal for solar PV and possibly battery can be challenging. AMPC has developed the Solar PV and Battery LCOE tool to help members assess the offers they receive.

The AMPC LCOE Solar Tool provides a financial analysis of AMPC member solar PV and battery offers. This tool uses site data and equipment supplier proposals to generate an independent financial analysis.

An AMPC member (confidential – referred to as AMPC M1) is looking at the feasibility of installing solar PV system at the grain storage site in Dubbo. Three solar PV proposals have been provided by local suppliers.

The following report provides a review of these proposals.

The proposal data was entered in to the AMPC LCOE Solar Tool and the results of the analysis compared with the supplier offers (see Table 1). All the offers provide paybacks lower than those calculated by the AMPC LCOE Solar Tool. The key areas of difference include higher levels of grid electricity price escalation, lower interest rates, lower capital cost and feed-in tariff prices. All the offers are for systems greater than 100kW which can claim LGCs.

Table 1 - AMPC LCOE Tool analysis versus Solar PV supplier offers

Supplier Solar PV kW Offer	Capital Purchase Payback (years)		LCOE (c/kWh, 25 years)	
	AMPC Tool*	**Supplier**	**AMPC Tool**	**Supplier**
Macquarie Energy 240kW	**4.7**	**~4.0**	**15.9**	**-**
Prana Energy 198kW	**6.9 for capital purchase**	**$8,500 saving per year based on loan @ 6% interest**	**17.8**	**17.4**
Smart Commercial Solar 150kW	**7.2**	**2.5**	**17.8**	**-**
AMPC default 100kW	**3.5**	**-**	**17.4**	**-**
Site before solar PV	**-**	**-**	**19.2**	**-**

*Using a feed-in tariff rate of 10c/kWh, LGCs sold and 50% demand cost savings

Due to the reducing LGC price forecasted over the next 10 years, all solar PV systems sized over 100kW will have poorer payback than a system under 100kW (which can claim upfront payment of STCs). An analysis by the AMPC LCOE Solar Tool confirms that a payback of 3.5 years is possible (see Table 1) which is better than all the other offers.

We recommend that suppliers are asked to provide proposals for the 100kW systems with no grid price escalation and STCs valued at ~$39/MWh (the average over the last few months). The offers should also include:

- Grid electricity price with no escalation
- Peak, shoulder, and off-peak rates to be used
- Interest rate for NPV to be shown
- kWh multiplier and source of data such as BOM climate data and NREL PVwatts[1]
- Interest rates for loan and PPA offers
- Allowance for maintenance in PPA offer
- Replacement period for inverters

The AMPC LCOE Solar Tool has provided a financial assessment however a technical assessment should also be conducted to ensure that the offer includes:

- Roof structure strength assessments
- Electrical switchboard assessments to ensure there is sufficient capacity for the solar PV inverters to be connected to the site electrical distribution system.
- Roof penetrations may cause some issues – panel mounting requirements need to be assessed
- Costs for network connection are included
- Installation costs for high roofs
- Safety plan for installation
- Australian standards for equipment and installation
- Cables and conduit materials (use metal conduits to avoid pest damage)
- Warranty for panels and other equipment

A key element of the solar PV offer should include supplier and sub-contractor experience and case studies of similar installations. An inspection of an installation in your area by qualified electrician and solar PV or structural engineer would also help to ensure that the supplier has the appropriate qualifications and experience.

A detailed analysis of the solar PV system offers is required to ensure that all safety and equipment, and installation standards are provided and that they meet the requirements for the site.

Detailed analysis of each offer can be found in the following pages.

[1] https://pvwatts.nrel.gov/ the location was set to Dubbo, NSW, Australia, using standard PV panels with 15% conversion efficiency, at a 20º tilt and 20º azimuth (NE orientation).

SYSTEM 1 – 240KW OFFER FROM MACQUARIE ENERGY

Table 2. Macquarie Energy offer summary

Item	Macquarie Energy	LCOE Solar Tool	Comments
System size	**240 kW**	**240 kW**	
Capital cost	**$245,000**	**$245,000**	**The offered capital cost is considerably lower than the tool's suggested value ($374,000). This may indicate low quality panels and inverters. The tool assumed this offer is credible and used the same amount in the analysis.**
First year generation	**386 MWh (1.61 MWh/kW)**	**385 MWh (1.60 MWh/kW)**	
On-site solar consumption	**311 MWh**	**281 MWh**	**The supplier predicted a lower export value. This may have a significant impact on the return, depending on the feed-in tariff rate (if any). The supplier applied a feed-in tariff that is equal to the peak electricity rate (16c/kWh)**
Excess / export	**75 MWh**	**103 MWh**	
Electricity rate	**Peak rates only**	**Peak, Shoulder, and Off peak rate**	**Macquarie Energy used the peak electricity rate to calculate the saving, which improved the return. In the LCOE Solar Tool, peak, shoulder, and off-peak rates were applied depending on when the energy was consumed. Weekend periods and public holidays have off-peak energy costs which account for about 30% of the solar PV energy generation.**
Electricity price forecast	**Decrease from 16 to 15c/kWh in the first 5 years, then steady increase to 26.4c/kWh in year 25**	**No escalation Peak: 16.0c/kWh Shoulder: 15.5c/kWh Off peak: 11.5c/kWh**	**The supplier applied a higher escalation in electricity price from year 5 to year 25, which increase the energy cost saving**
Feed-in tariff	**Same as peak electricity rate (16c/kWh in year 1)**	**10c/kWh**	**In general, a feed-in tariff is lower than the electricity rate. By applying the peak electricity rate, the supplier assumed that all exported generation provide as much saving as generated power consumed on site in peak hours.**

Demand rates	**None**	**Included 50% $16.64/kVA/month**	**Demand charges are treated separately and based on the possible number of cloudy hour periods that may reduce solar generation to near zero, 50% of the demand savings was used in the AMPC LCOE Solar Tool calculations.**

Financing option	Upfront payment $245k		
LCOE (over 25 years)	**Not specified**	**15.9c/kWh**	
NPV (over 25 years)	**$455,000**	**$250,000**	**The supplier estimated a significantly higher NPV. Both NPV and payback from Macquarie Energy's offer were not explicitly stated. These values were calculated from the provided cashflow, with a discount factor of 8.0%. This is the discount factor used in the LCOE Solar Tool.**
Payback (years)	**Approx. 4 years**	**4.7 years**	**The 4.7 years payback assumed a 10c/kWh feed-in tariff and LGC being sold for financial benefit** **Without a feed-in tariff, the payback increased to 6.8 years** **Without a feed-in tariff and LGC financial benefit for the exported component, the payback increased to 7.3 years**

SYSTEM 2 – 198KW OFFER FROM PRANA ENERGY

Table 3. Prana Energy offer summary

Item	Prana Energy	LCOE Solar Tool	Comments
System size	**198 kW**	**198 kW**	
Capital cost	**$247,000**	**$247,000**	**This is the system value suggested by Prana Energy (not paid upfront because of the loan structure). It is lower than the tool's suggested value ($309,000). This may indicate low quality panels and inverters. The tool assumed this offer is credible and used the same amount in the analysis.**
First year generation	**313 MWh (1.58 MWh/kW)**	**317 MWh (1.60 MWh/kW)**	
On-site solar consumption	**291 MWh**	**254 MWh**	**The supplier predicted a lower export value. This may have a significant impact on the return, depending on the feed-in tariff rate (if any). The supplier applied a feed-in tariff that is equal to the peak electricity rate (16c/kWh)**
Excess / export	**23 MWh**	**63 MWh**	
Electricity rate	**Peak rates only**	**Peak, Shoulder, and Off peak rate**	**Prana Energy used the peak electricity rate to calculate the saving, which improved the return. In the LCOE Solar Tool, peak, shoulder, and off-peak rates were applied depending on when the energy was consumed. Weekend periods and public holidays have off-peak energy costs which account for about 30% of the solar PV energy generation.**
Electricity price forecast	**Exponential increase from 16c/kWh in year 1 to 49c/kWh in year 25**	**No escalation Peak: 16.0c/kWh Shoulder: 15.5c/kWh Off peak: 11.5/ckWh**	**The supplier applied a higher escalation in electricity price from year 1 to year 25, which increase the energy cost saving**
Feed-in tariff	**Same as peak electricity rate (16c/kWh in year 1)**	**10c/kWh**	**In general, a feed-in tariff is lower than the electricity rate. By applying the peak electricity rate, the supplier assumed that all exported generation provide as much saving as generated power consumed on site in peak hours.**

Item	Prana Energy	LCOE Solar Tool	Comments
Demand rates	**None**	**Included 50% $16.64/kVA/month**	**Demand charges are treated separately and based on the possible number of cloudy hour periods that may reduce solar generation to near zero, 50% of the demand savings was used in the AMPC LCOE Solar Tool calculations.**
Financing option	**7-year loan with $44,300 annual repayment (approx. 6.0% interest rate)**		
LCOE (over 25 years)	**17.4c/kWh**	**17.8c/kWh**	
NPV (over 25 years)	**$628,000**	**$180,000**	**The financial return heavily dependent on the feed-in tariff. The $180,000 NPV was calculated with a 10c/kWh tariff With a 40c/kWh feed-in tariff (mentioned by Prana Energy), the NPV is $390,000 With no feed-in tariff, the NPV is $110,000 In all cases, the supplier estimated a significantly higher NPV**
Payback (years)	**Positive cashflow in year 1**	**6.9 years**	**The financial return heavily dependent on the feed-in tariff. The 6.9 years payback was calculated with a 10c/kWh tariff With a 40c/kWh feed-in tariff (mentioned by Prana Energy), the cashflow is positive from year 1 With no feed-in tariff, the payback is 9.4 years**

In the attached report, the CAPEX option was included for comparison.

SYSTEM 3 – 150KW OFFER FROM SMART COMMERCIAL SOLAR

Table 4. SCS Energy offer summary

Item	SCS	LCOE Solar Tool	Comments
System size	**150 kW**	**150 kW**	
Capital cost	**$158,000**	**$211,000**	**SCS framed their system as a "100kW + 50kW Ground Mount" system, and included a $53,200 STC rebate into the financial analysis. It is important to note that STC rebate is only available for systems below 100kW. Therefore, unless there are two separate systems, servicing two separate NMIs with no behind the meter connection, the system will not be eligible for the STC rebate. Therefore, we used the upfront capital cost of $211,000 in the LCOE Solar Tool (price quoted by SCS before STC rebate) as the system cost. This system cost is close to the default value shown in the AMPC LCOE Solar Tool ($234,000).**
First year generation	**264 MWh (1.76 MWh/kW)**	**240 MWh (1.60 MWh/kW)**	**The supplier assumed a higher generation yield, which improved the financial return**
On-site solar consumption	**242 MWh**	**212 MWh**	**The supplier predicted a lower export value. This may have a significant impact on the return, depending on the feed-in tariff rate (if any). The supplier applied a feed-in tariff that is equal to the peak electricity rate (19c/kWh)**
Excess / export	**22 MWh**	**28 MWh**	
Electricity rate	**Peak rates only**	**Peak, Shoulder, and Off peak rate**	**The supplier used the peak electricity rate to calculate the saving, which improved the return. In the LCOE Solar Tool, peak, shoulder, and off-peak rates were applied depending on when the energy was consumed. Weekend periods and public holidays have off-peak energy costs which account for about 30% of the solar PV energy generation.**
Electricity price forecast	**~3.0% annual increase from 19c/kWh in year 1 to 29c/kWh in year 25**	**No escalation Peak: 16.0c/kWh Shoulder: 15.5c/kWh**	**The supplier applied a higher escalation in electricity price from year 1 to year 25, which increase the energy cost saving**

Item	SCS	LCOE Solar Tool	Comments
		Off peak: 11.5ckWh	
Feed-in tariff	**Same as peak electricity rate (19c/kWh in year 1)**	**10c/kWh**	**In general, a feed-in tariff is lower than the electricity rate. By applying the peak electricity rate, the supplier assumed that all exported generation provide as much saving as generated power consumed on site in peak hours.**
Demand rates	**None**	**Included 50% $16.64/kVA/month**	**Demand charges are treated separately and based on the possible number of cloudy hour periods that may reduce solar generation to near zero, 50% of the demand savings was used in the AMPC LCOE Solar Tool calculations.**
Financing option	**Upfront payment**		
LCOE (over 25 years)	**17.4c/kWh**	**17.8c/kWh**	
NPV (over 25 years)	**$414k,000**	**$85,000**	**The supplier estimated a significantly higher NPV, due to lower capital cost.**
Payback (years)	**2.5 years**	**7.2 years**	**The supplier estimated a significantly shorter payback, due to lower capital cost**
Financing option	**10-year loan**		
LCOE (over 25 years)	**Not specified**	**18.7c/kWh**	**AMPC M1 is expected to make $21k annual repayments for 10 years. This is equivalent to about 0.6% interest on the loan. An interest of 8% has been applied for the AMPC LCOE Solar Tool calculations which increases the loan repayments to $32k per year.**
NPV (over 25 years)	**$391,000**	**$68,000**	
Payback (years)	**Positive cashflow in year 1**	**Positive cashflow in year 1**	
Financing option	**10-year PPA**		
LCOE (over 25 years)	**Not specified**	**17.9c/kWh**	**The PPA rate was increased in the AMPC analysis to reflect the rate that would be charged if an 8% interest rate is applied. This PPA rate is 12.2c/kWh whereas the average of SCS's offer is 8.7c/kWh which not enough**

Item	SCS	LCOE Solar Tool	Comments
			to recover the costs of the system in the 10 year PPA period.
NPV (over 25 years)	**$372,000**	**$71,000**	
Payback (years)	**Positive cashflow in year 1**	**Positive cashflow in year 1**	

9.2 Appendix 2 – Test results for the AMPC biomass boiler LCOE tool evaluations

INTRODUCTION

Many AMPC member businesses are implementing biomass boiler systems as part of a strategy to reduce costs and carbon emissions. The decision to go ahead with a proposal for biomass boilers can be challenging. AMPC has developed the Biomass Boiler LCOE (Levelised Cost of Energy) tool to help members assess the offers they receive.

The AMPC LCOE Biomass Boiler Tool uses site data and equipment supplier proposals to generate an independent financial analysis.

An AMPC member (confidential – referred to as AMPC M2) is looking at the feasibility of installing a biomass boiler system to replace an existing coal-fired boiler and reduce natural gas use in the other boilers on site. A proposal from Justsen for the supply of a biomass boiler and biomass supply has been provided. This proposal does not provide a financial analysis for the project. The following report provides a financial analysis of the biomass boiler and biomass supply using the installation and equipment costs provided by AMPC M2.

The financial analysis is based on the following assumptions:

- Installed cost for a 10.5MW biomass boiler and other equipment of $8.3million
- Replacement cost for an 8MW coal-fired boiler of $2.5million
- Coal cost of $6.76/GJ
- Natural gas costs of $10/GJ
- Biomass cost $30.80/tonne for pine chips with an average heating value of 9.47GJ/tonne (or $3.25/GJ)
- All fuel costs escalate annually at CPI rate (2%)
- The new boiler is running at 95% average operating load (calculated so that the amount of steam generated is sufficient to replace coal and natural gas consumption on site).
- A discount rate for NPV of 8%
- Loan arrangement:
    - 15-year loan
    - An interest rate of 8% p.a.
    - No upfront payment
- Power Purchase Agreement (PPA) arrangement:
    - PPA rate of $11.24/GJ (10% above the CAPEX analysis estimated LCOG)

BIOMASS BOILER ANALYSIS

Based on these assumptions, the project was calculated to provide the following financial outcomes:

Table 5. Biomass boiler analysis financial result

Item	CAPEX	Loan	PPA
Upfront payment	**$8,300,000**	**$0**	**$0**
Annual payment (excl. OPEX)	**$0**	**$970,000**	**$2,019,000**
Annual net cost savings ($/yr)	**$891,000**	**($79,000)**	**($185,000)**
NPV (15 yrs)	**$2,000,000**	**$1,400,000**	**$320,000**
Estimated payback (yrs)	**10.1**	**Positive cashflow**	**Positive cashflow**
IRR (15 yrs)	**13.75%**	**Positive cashflow**	**Positive cashflow**
15-year LCOG ($/GJ)	**$10.22**	**$10.62**	**$11.24**
15-year LCOE ($/GJ)	**$9.30**	**$9.62**	**$10.10**
BAU LCOE ($/GJ)		**$9.08**	

The calculation suggests that the CAPEX option will yield the best financial outcome in terms of NPV and LCOE. However, the 15-year LCOE of $9.30/GJ is still slightly higher than the Business as Usual (BAU) LCOE of $9.08/GJ.

On average, the Loan and PPA options do not provide an annual saving, as the loan and PPA repayment exceed the amount of fuel cost saving for the first 10 years of the project.

The cumulative cash flow for both the loan and PPA options was calculated to be positive because of the large positive cash flow from the loan amount and end-of-life saving for the coal-fired boiler ($2.5m) realised in the first year. For both options, the annual cash flow is negative from year 2, and becomes positive again in year 11 for the loan option, and year 14 for PPA. This was because of the escalation of fuel prices, which improved fuel cost saving. Therefore, loan and PPA are good options for projects where capital investment is limited. Figure 1 shows the annual and cumulative cashflow of each financing option.

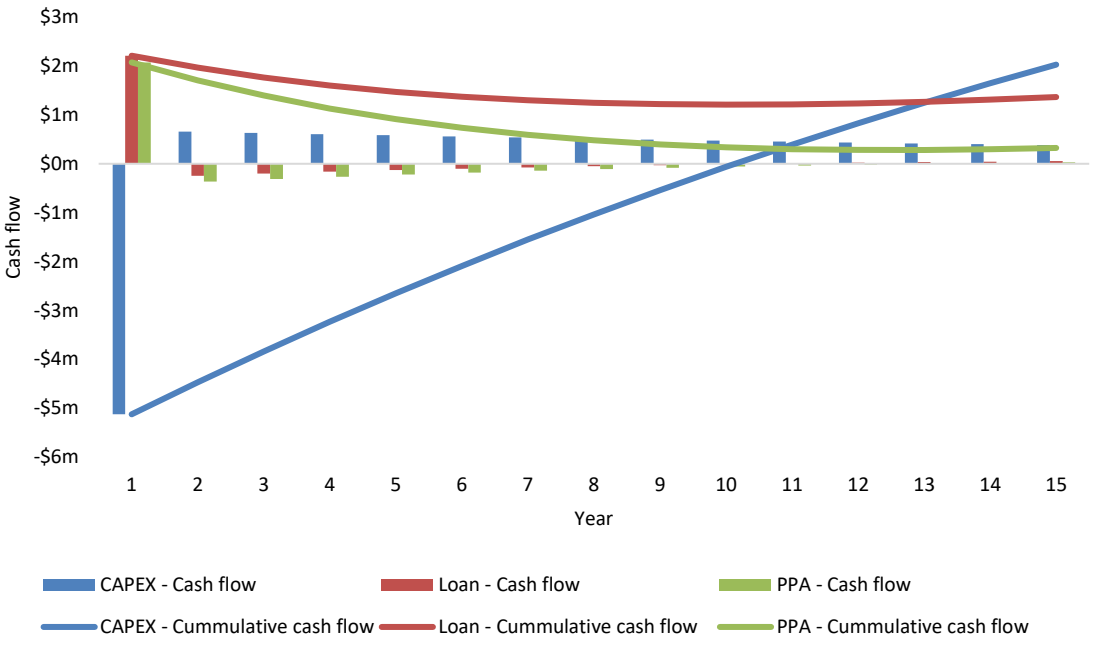


Figure 1. Financing options and cash flow

SENSITIVITY ANALYSIS

The financial analysis described in the above session is dependent on several assumptions. To explore the sensitivity of varying these assumptions to the final outcome, we performed some sensitivity analysis as below.

Natural gas price

The natural gas price used in the base case analysis was $10/GJ. We varied it by ±50% (to $5/GJ and $15/GJ), and the result can be found below. Natural gas price was chosen to be analysed for sensitivity instead of coal because coal price ($6.76/GJ) was calculated from the site's coal spend in 2019, and the natural gas price ($10/GJ) was estimated on a high level. The effect of varying coal price and natural gas is similar, as the biomass boiler was sized to replace both of them.

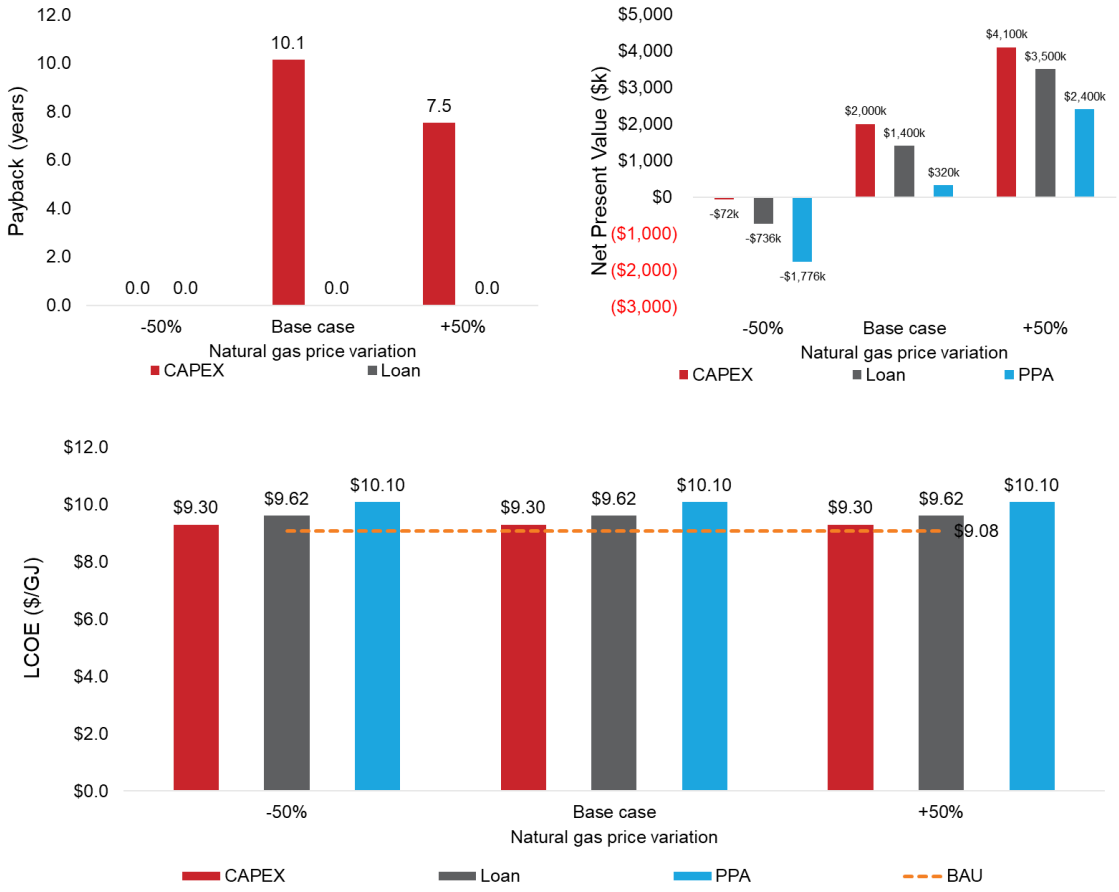


Figure 2. Natural gas sensitivity analysis

Natural gas price has a significant impact on payback and NPV, as a lower natural gas cost reduces the benefit to be realised from fuel cost saving. With a low natural gas price ($5/GJ), the NPV for all financing options are negative, and there is no payback. With a high natural gas price ($15/GJ), the NPV for all financing options are significantly increased, and the payback for the CAPEX option is shortened to 7.5 years.

Since all natural gas is assumed to be replaced by biomass, its price does not affect the LCOE.

In all cases, the payback for the loan and PPA options are immediate.

Biomass delivered cost

The biomass delivered cost used in the base case analysis was $3.25/GJ. We varied it by ±50% (to $1.63/GJ and $4.88/GJ), and the result can be found below.

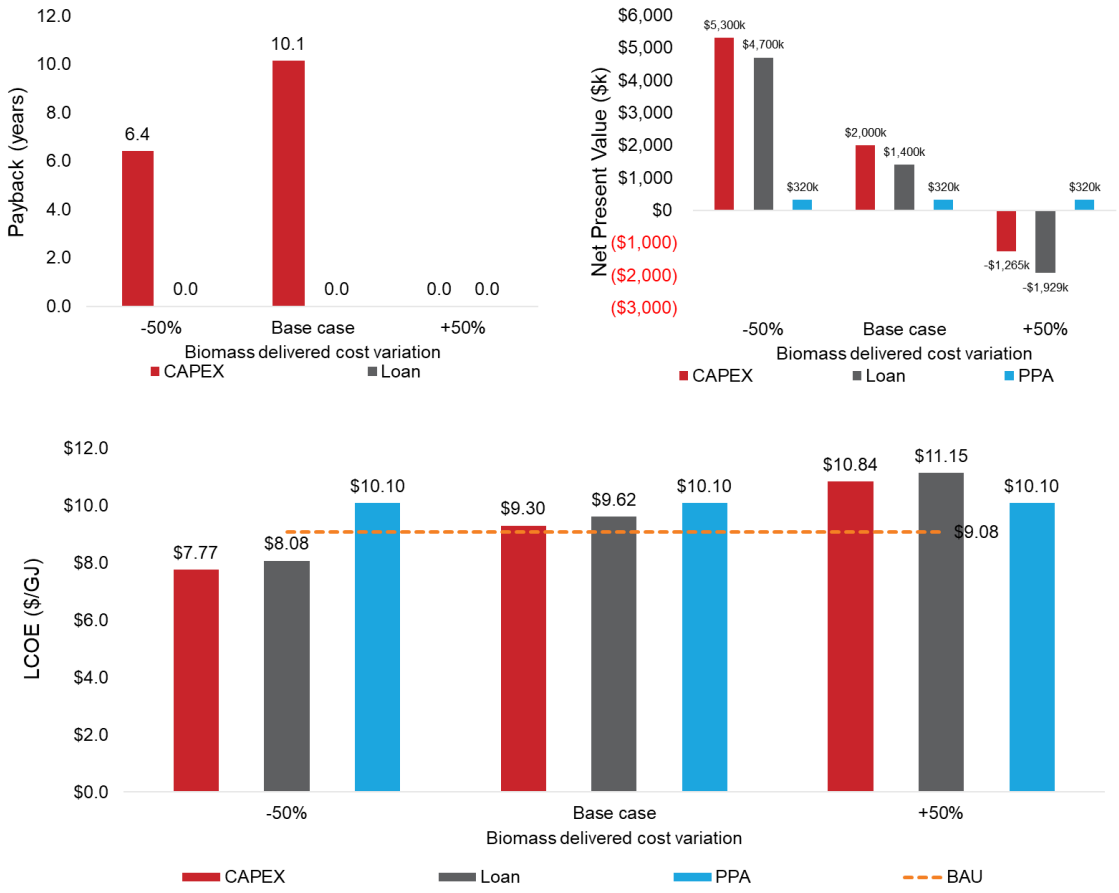


Figure 3. Biomass delivered cost sensitivity analysis

Biomass cost has a significant impact on all the financial outcome of the project for the CAPEX and loan option. Varying biomass price does not affect the PPA option result as the PPA provider will be paying for it, and the PPA rate was assumed to stay the same.

A low biomass cost ($1.63/GJ) significantly improved both NPV and the payback period. In terms of LCOE, the 15-year cost of energy was brought down to below the BAU level ($7.77/GJ and $8.08/GJ compared to the BAU value of $9.08/GJ).

A high biomass cost ($4.88/GJ) results in negative NPV and no payback.

Capital cost

The capital expenditure for installing the biomass boiler used in the base case analysis was $8.3m. We varied it by ±50% (to $4.2m and $12.5m), and the result can be found below.

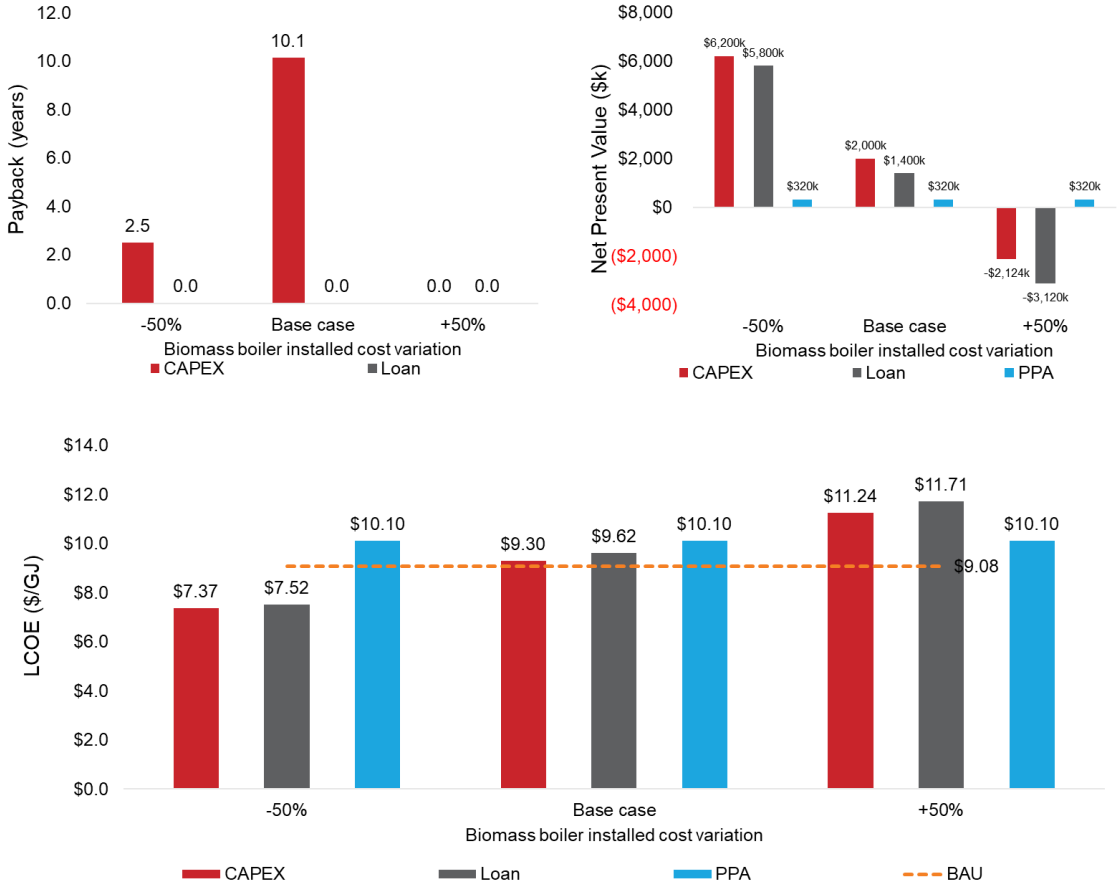


Figure 4. Capital cost sensitivity analysis

Varying the capital cost have a similar impact to the financial result as to varying the cost of biomass.

A low capital cost ($4.2m) significantly improved both NPV and the payback period. In terms of LCOE, the 15-year cost of energy was brought down to below the BAU level ($7.37/GJ and $7.52/GJ compared to the BAU value of $9.08/GJ).

A high capital cost ($12.5m) results in negative NPV and no payback.