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Quantifying the Impact of MLA's Supply Chain Sustainability Program in Contributing to the Australian Red Meat Industry's Social License to Operate

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Abstract

In order to assess the impact of the Supply Chain Sustainability Program, an evaluation of projects within its scope was conducted. A framework that identifies priority aspects aligned with strategy and links aspects to impacts and measurable indicators was developed. Projects under the Off-farm Sustainability program were mapped to products with directly-attributable impacts, which were assessed based on technological readiness and likelihood of adoption. Impacts were quantified using a calculation tool developed in this project. The results demonstrate appreciable reductions in industry greenhouse gas emissions, fresh water use and fossil energy use, while delivering economic value from R&D investments. This evaluation facilitates the evaluation programs in MLA, and can be extended to On-Farm programs. The integration of this framework at the project proposal stage can further enhance the Sustainability program by ensuring projects are primed to measure impacts toward completion.

Executive summary

This project presents an evaluation framework for the Supply Chain Sustainability Strategy by linking the imperatives from the Meat Industry Strategic Plan to the impacts of R&D products. Aspects that relate to strategic objectives were identified and these were mapped to impacts and potential indicators that can be measured. The aspects identified were Greenhouse Gas Emissions, Water Use, Energy Use, Waste Water Emissions, and Solid Waste Emissions. Impact measures related to economic and environmental impacts were identified as key performance measures.

Projects under the Off-Farm Sustainability sub-program were used as the test case for the evaluation framework. Following the Path to Impact approach, the projects were mapped to products. Eight active products with directly attributable impacts, with investments between 2015 and 2017, were identified for this evaluation. These products were the following:

- Concentrated solar thermal (CST) steam system
- Biosolids anaerobic digestion process (reactor)
- Covered Anaerobic lagoons (CALs)
- Electro-coagulation technology for removing Total Phosphate (TP)
- Water efficiency & recycling
- PV Solar and Battery Tech (Microgrid)
- Black soldier fly larvae (BSFL) feed production
- Rendering Cooker Flash Steam Heat Recovery

These products were then assessed for technological readiness, likelihood of adoption and potential impacts. The impacts were quantified using established means and current market valuation rates. The net present value of benefits were compared with total MLA investment within the study period. An evaluation spreadsheet to facilitate the quantification has been prepared for this purpose, and for future evaluations.

The aggregated cost-benefit ratio of the MLA investment to the red meat industry for these projects was calculated to be 3.67. The variety of products and corresponding projects demonstrate appreciable environmental benefits by reducing fossil fuel consumption and greenhouse gas emissions through use of alternative energy and implementing efficiency measures, and reducing fresh water consumption through water recycling.

There are further opportunities to integrate the Sustainability Strategy in existing project management systems to enhance collection of evaluation data and assist future evaluation. On-Farm Sustainability Projects can also be evaluated similarly.

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1 Background

The success of the meat industry is dependent on the sustained supply of natural resources, the predictability of climate, and the role of the communities in which we operate, among others. Improvements to make meat production more sustainable thus makes good sense since it enables high operational and financial performance while preserving the availability of valuable inputs, mitigating the risks of changing climate and being a good partner to the community.

One of the Meat Industry Strategic Plan (MISP) 2020 priorities under the pillar of "Customer and Community Support" is the stewardship of environmental resources (Red Meat Advisory Council, 2015). The strategies target minimising industry impact on the environment, sustainable management of the natural resource base, and adaptation to climate variability. In alignment with the MISP 2020, the MLA Strategic Plan has laid out specific strategies to address these industry priorities. In particular, the Supply Chain Sustainability Strategy (SCSS) has been developed to identify the activities that enable the Australian red meat supply chains to be regarded as socially, environmentally and economically responsible. The SCSS brought together expertise across the industry to highlight the focus areas for research, development and adoption (RD&A) from 2016-2020. The projects arising from these strategies target economic, environmental and social impacts such as supply chain optimisation, improved environmental performance, and the social benefits that stem from these initiatives.

In 2008, the Council of Rural Research and Development Corporations (CRRDC) conducted an evaluation of the impacts of a sample of projects across Australian rural Research and Development Corporations (RDCs). Of these projects a number of MLA projects were included among a subset of projects that have been determined "highly successful" as the projects have reached a stage where significant evidence of delivery was available (Council of Rural Research and Development Corporations, 2008). This assessment led to the CRRDC establishing standard and comprehensive impact assessment guidelines to use for the periodic CRRDC assessments, but also as a guide for RDCs conducting their own impact assessments. The guidelines were intended for ex post evaluations conducted after reaching a significant milestone; however considerations for ex ante assessments were also included in the guidelines (Council of Rural Research and Development Corporations, 2014).

In 2016, the impacts of MLA projects in the periods of 2010-11 and 2014-15 have been assessed with a methodology aligned with the CRRDC Impact Assessment Guidelines. In this assessment, projects under the Off-farm Environment sub-program were included. These projects are similar to the projects under the current SCSP. The assessment identified key impacts related to resource use efficiency, waste management and value-add to waste, mitigation of greenhouse gas emissions (GHG), environmental stewardship and compliance, and capability, knowledge and adoption of new technologies. Where it was appropriate, monetary value were also assigned to the impacts. From the total actual investment of $16 million for the study period, a total of $40 million of red meat industry (RMI) net income was estimated. This presented a benefit-cost ratio of 2.5 for this portfolio (The Centre for International Economics, 2016).

In the evaluation of costs and benefits of a project, the economic values are the easiest to determine, because these are almost always included in project proposals and reports. The impact to production, price, cost and subsequently, revenue and profit are readily available due to their importance in justifying investments. Moreover, the value of increased production, reduced inputs or improved efficiencies can easily be determined using their market price. Assigning value to environmental and social impacts are relatively difficult due to the nature by which these impacts occur. For instance, the economic impact of a project that improves efficiency can easily be determined by cost savings or a higher production yield, with likely savings in explicit environmental costs such as waste disposal or water and energy use costs. However, other social and environmental impacts cannot be assigned market values since markets for these quantities do not exist. For example, the reduction of air emissions below compliance levels may not have significant economic benefits, but lower pollution levels improve environmental health for both people and wildlife, and improve the reputation of the company. These are tangible benefits, but cannot be traded in a market, so the assignment of value is not straightforward. Methods such as revealed preference methods and contingent pricing to estimate the value of social and environmental impacts are also used, but the variance in the accuracy of these methods present some uncertainties. The evaluation of non-market impacts using qualitative methods (e.g. narrative assessment) can be appropriate, if the presentation of results aligns with review and feedback processes.

2 Project objectives

This project aims to undertake the measurement and evaluation of the impact of the Supply Chain Sustainability Strategy (SCSS) by assessing the impacts of projects within its scope. The overall project objective is to be achieved by the completion of the following tasks:

- Development of a framework through which the triple bottom line measurement and evaluation of MLA's SCSP could be completed
- Measurement and evaluation of the impact of the SCSP over the financial year 2016/17
- Determination of the contribution of the SCSS towards maintaining the industry's social license to operate

3 Strategic Link

The evaluation and measurement framework is not a standalone process. It should link directly to existing management and planning processes and seek to enhance the outcomes of current sustainability strategies.

This framework relates to the strategic imperatives of the current SCSS. These provide the input to the framework by identifying the priority aspects and their impacts for evaluation and measurement. The priority impacts are highlighted in impact assessment and measurement, and indicators for each impact are reported and assigned value, when appropriate. Non-priority impacts may also be monitored with the appropriate level of detail in consideration of these impacts potentially gaining importance in future. The framework enables a systematic top-to-bottom approach in determining what valuable sustainability performance measures should be evaluated from the portfolio of projects. The framework also facilitates the flow of information from bottom to top in the review of sustainability strategies. The framework presented in this way allows for the change in priorities over time without a drastic change in the framework. The cascade of priorities from strategies to the evaluation and measurement process is presented in the figure below.

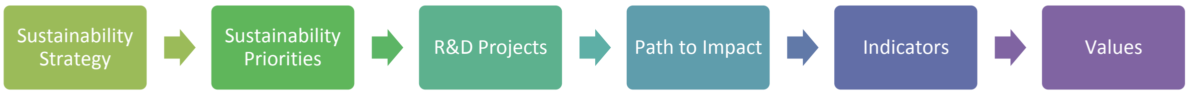

Figure 1. Strategic link of sustainability strategy to the values of sustainability impacts.

The Path to Impact box represents the approach taken by MLA to institute a simple approach towards transparent delivery. This was based on an industry *best practice* framework that provides consistency of project approval, delivery, and assessment. The link from the activities to impacts also facilitate the evaluation of cost-benefit ratios, which demonstrate the value of investment managed by MLA. The Path to Impact approach is shown in the figure below.

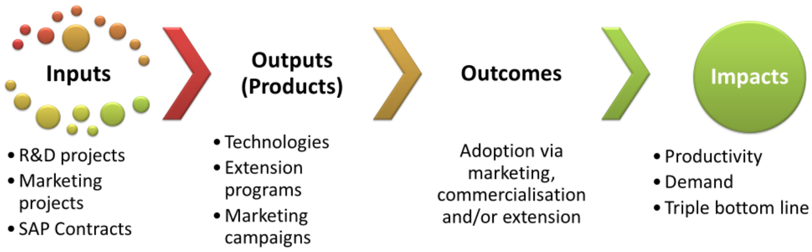

Figure 2. MLA Path To Impact Approach

An aspect, in the context of this framework, refers to a consequence of an R&D output that results in an impact. Aspects can occur just once, a number of times, or continuously. The aspects should be determined for the project or product, keeping in mind there are aspects that can be passive such as land use, which might not be easily identified. For instance, in the process of cattle production, the relevant aspects are fresh water use, methane emissions, solid waste generation, energy use, etc. When identified, these aspects can be easily linked to the sustainability priorities identified in overarching strategies. The aspects bridge the strategic view with the triple bottom line impacts of the activities, as well as across a wide variety of activities that involve the same aspects. On the project level, the aspects provide the targets for monitoring throughout the project. On the strategic level, focusing on priority aspects in evaluation allow for a consistent view across all products and other outputs.

An impact relates to the effect of the change in an aspect that can be evaluated. For example, a change in water use can be evaluated by measuring the cost of usage, savings from efficient water use, level of water reserves, community reaction, etc. The impacts can be direct or indirect, certain or uncertain, and can occur immediately or in future. Direct impacts pertain to effects that proceed immediately after the variation of the aspect, such as usage or disposal costs, odour, and regulatory fines. Indirect impacts refer to associated effects such as contamination of surface water from run-off. The certainty and timing of impacts are also pertinent in many cases. For instance, costs related to waste management are certain and immediate, while community displeasure after a pollution event can be uncertain and may not happen immediately. Therefore, it is important to identify the most significant impacts by focusing on certain and immediate direct impacts for measurement, to maximise the value of evaluation and subsequent mitigation. This is not to say that indirect, uncertain and/or future impacts are not important, but their values are slightly diminished by their smaller likelihood. Impacts that are related to compliance to legislation are by default, significant.

A mapping of aspects to impacts and indicators helps to demonstrate the value of evaluating a project or product with a particular indicator. The link is usually clear, but there are instances where it is not. A number of indicators can also relate to the same aspect, but can pertain to an economic, environmental or social impact. The applicability of aspects, impacts and indicators will vary across different projects or products, nonetheless, the framework provides for a set of potential items for projects of varying natures. The list of aspects, impacts and potential indicators is included in this framework to provide flexibility in capturing the costs and benefits of a project. The list was created considering the projects in scope for this evaluation and other relevant items can be added in future.

The indicators are chosen to yield qualitative and quantitative measurements, matching industry impact assessment practices. There was also consideration of the ease of quantitative valuation in selecting the indicators. Ultimately, the indicators should serve to meet the objectives for controlling the impact and provide information to the planning feedback loop. A subset of the indicators (in boldface) in the following table will be used for this evaluation. Other indicators included in the table will be considered based on the nature of the project or product.

Table 1. Aspect-Impact-Indicator Mapping

Aspect	Impact	Type	Indicator
GHG emissions	Carbon costs or revenues	Economic	**Carbon revenues (AUD/y)**
	Contribution to climate change	Environmental	GHG emitted (t CO_2e/y)
	Carbon neutral brand	Social	**Carbon footprint (t CO_2e/kg product)**
Low carbon energy use	Net GHG emissions	Environmental	CO_2 abatement (t CO_2e/y)
Fresh Water Use (extracted or purchased)	Water cost	Economic	**Cost or savings of water use (AUD/y)**
	Competition of source	Social	Narrative – community view
	Water consumption	Environmental	Water use efficiency (kL water/kg product)
Fresh Water Use (recycled or processed water)	Purchased water costs	Economic	Water savings (AUD/y)
	Water operational reliability	Environmental	**Amount of recycled water used (%)**
Recycled or generated energy	Purchased energy costs	Economic	**Energy savings (AUD/y)**
	Energy reliability	Economic	**Self-generated energy usage (%)**
	Competition in energy	Social	Self-reliance/dependence on grid (%)
Energy efficiency	Energy costs	Economic	Energy savings (AUD/y)
	CO_2e emission abatement	Environmental	CO_2 abatement (t CO_2e/y)
Fossil fuel-based energy use	Energy costs	Economic	Energy costs (AUD/y)
	Net GHG emissions	Environmental	GHG from fossil fuels (t CO_2e/y)
Waste water emission volume	Wastewater treatment cost	Economic	**Wastewater treatment savings (AUD/y)**
	Net wastewater emissions	Environmental	Net wastewater emitted (kL wastewater/y)
	Being viewed as a polluter	Social	Narrative – community view
Solid waste emissions	Solid waste treatment/disposal costs	Economic	**Solid waste treatment savings (AUD/y)**
Odorous emissions	Community complaints	Social	Complaints (#)
	Emission of odorous substances	Environmental	Narrative - measurement/abatement of odorous emissions
Change of land use	Reduced availability for biodiversity	Environmental	Converted land (ha)
	Change in scenic amenity	Social	Narrative – community view

Aspect	Impact	Type	Indicator
	Reduced availability for pasture	Economic	Available pasture land (ha)
Labour requirements	Job opportunities	Social	New jobs created (#)
	Capabilities and knowledge	Social	New jobs with new capabilities created (#) or new capabilities created
Information	Adoption of new tech	Economic	Likelihood to adopt
	Capabilities and knowledge	Social	Narrative – list of new skills developed
	Investment risk	Economic	Variance of NPV across options

Among the aspects presented here, the following aspects have been determined the priority aspects aligned with the Supply Chain Sustainability Strategy 2016:

- Greenhouse Gas Emissions
- Water Use
- Energy Use
- Waste Water Emissions
- Solid Waste Emissions

4 Evaluation

Projects under the SCSP are varied due to the different outcomes these projects present upon completion. One group of projects result in directly attributable economic, environmental and social impacts, while the rest may influence the adoption of technology or innovations that can then improve the triple bottom line performance. This framework focuses on projects or group of projects that deliver tangible attributable impacts. These are labelled ***products*** in this framework, similar to the terminology of the Path to Impact approach. When the word ***projects*** is mentioned in this framework, they refer to projects relevant to the products being evaluated. The evaluation at the product level facilitates the determination of attributable values of the priority aspects for the cost-benefit analysis. Where a quantitative market value can be determined, the cost or benefit is included in the quantitative cost-benefit ratio. The methods in determining the values are described here.

4.1 Assumptions

The following are the assumptions considered in the evaluation.

1. Lessons learned are more likely to be shared because they are seen as pre-competitive, and thus, there can be underestimations due to spillover benefits to similar firms and associated industries.
2. Second-round effects are evaluated to a very limited extent. This is to minimise misattribution of results solely to the projects in scope, in recognition of other significant factors such as market behaviour, regulation, and social trends.
3. Valuation methods are selected based on relevance to existing systems and markets.
4. Project outputs that are classified as tool or enablers are assumed to have values that cannot be directly attributed to an impact, except for those that directly led to a demonstrable output (e.g. waste to energy assessment informed option to implement a biosolids anaerobic digestion facility for a meat processor).

5. In modelling the adoption of technologies, it was assumed that the plants adopting have similar sizes and the costs and benefits for the industry are multiples of firms adopting.
6. All costs and benefits are evaluated using their present value in the base year specified. In this instance, the base year is 2018.

4.2 Mapping Projects to Outputs

The projects were mapped to outputs and products to systematically demonstrate the link of R&D inputs to outputs, outcomes and impacts. This also allows the evaluation to determine which projects are related to tools/enablers or products. The following table shows the mapping and classification of outputs prior to the evaluation.

Table 2. Project-Output Mapping

Output List	Projects	Enabler/ tool?
Concentrated solar thermal (CST) steam system	V.SCS.007 P.PSH.1074	Product
Red meat industry energy cost reduction calculator	(not assigned)	Enabler/Tool
Biosolids anaerobic digestion process (reactor)	P.PSH.0945 P.PIP.0739 P.PSH.0836 P.PIP.0547 P.PIP.0526 P.PIP.0508 P.PSH.0768 P.PIP.0430 P.PIP.0398 P.PIP.0486 P.PIP.0477	Product
Covered anaerobic lagoons (CALs)	P.PIP.0730 P.PIP.0460 P.PIP.0438	Product
Electro-coagulation technology for removing Total Phosphate (TP)	P.PIP.0567	Product
Bio-remediation of wastewater	P.PIP.0497	Product
Water efficiency & recycling	P.PIP.0732 P.PIP.0538 P.PIP.0525 P.PIP.0516	Product
Abattoir waste to energy assessment (AWEA)	P.PIP.0566	Enabler/Tool
PV Solar and Battery Tech (Microgrid)	P.PIP.0745 P.PIP.0735 V.SCS.0003	Product
Black soldier fly larvae (BSFL) feed production	P.PSH.0855	Product
Co-generation cost benefit analysis model	P.PIP.0733	Enabler/Tool
Hydrocyclone for wastewater primary treatment	P.PIP.0545	Product
Rendering cooker flash steam heat recovery	P.PIP.0521	Product
Odour sampling test rig	P.PIP.0472	Product
Energy efficient refrigeration	P.PIP.0458	Enabler/Tool
Beef processing plant energy assessment	P.PIP.0457	Enabler/Tool

Output List	Projects	Enabler/ tool?
Renewable energy assessment	V.SCS.0003 P.PIP.0429	Enabler/Tool
Sustainability strategy	V.SCS.0001 V.SCS.0006	Enabler/Tool

The products identified here were derived from the MLA Product List. The output names for some enablers/tools were assigned in this project to determine if there are projects that result in similar outputs, and hence, can be grouped together.

4.3 Adoption Assessment of Products

From the list above, there were only eight products which were currently active. The other products were classified as terminated or on hold. For the purposes of this evaluation, the assessment focused on the active products, because they can be considered as products which have or will continue to have impacts.

The assessment involved gathering information regarding the state of adoption of the products or their associated technologies. As these products are not applicable exclusively to the red meat industry, some information regarding the adoption on a wider scale was also considered in the assessment. The information used for the assessment includes the following:

- Deployment status in the red meat industry
- Global and local technical success – in the RMI or similar applications
- Adoption/commercial success in consideration of:
    - Risks
    - Impediments to adoption
    - Customer/consumer acceptability
    - Capability - research/ industry/ training
- Expected/actual impact – per firm / whole industry
    - Economic (including costs)
    - Environmental
    - Social

This assessment provides information of the current state and the outlook for further adoption. The assessment also includes qualitative assessment of impacts and augments the more comprehensive quantification of triple bottom line impacts in this project. The summary of the assessment is shown in the table below.

Table 3. Assessed product list

ID	Product List	Status	Technical success	Adoption/ commercial success	Expected/ actual impact
P1	Concentrated solar thermal (CST) steam system	R&D	High	Medium	Medium
P3	Biosolids anaerobic digestion process (reactor)	R&D	High	Low	Medium
P4	Covered Anaerobic lagoons (CALs)	Commercial/ Adopted	High	High	High
P5	Electro-coagulation technology for removing Total Phosphate (TP)	R&D	Medium	Low	Low
P11	Water efficiency & recycling	Trialling	High	Medium	Medium
P12	PV Solar and Battery Tech (Microgrid)	Trialling	Medium	Low	Low
P13	Black soldier fly larvae (BSFL) feed production	R&D	Medium	Low	Medium
P15	Rendering Cooker Flash Steam Heat Recovery	Trialling	High	Low	Low

The assessment also considered data from the multi-criteria analysis by an expert panel as described in an earlier study of the RD&A strategy for environmental innovation in the red meat industry (O'Hara, et al., 2016).

4.4 Impact Assessment

4.4.1 Scoping

The list of priority aspects are used to determine which impacts can be measured from the products. The aspects can be 'scoped-in' if the product causes a change to the aspect and produces an impact. The impacts of each aspect change can be market-based economic, environmental and social impacts, which with monetary costs, were used to calculate the benefit cost ratio. Non-market economic, environmental and social impacts can also be used alongside market values, and are particularly useful for impacts with no concrete direct monetary values. Some non-market impacts are usually evaluated qualitatively, however, when available, a monetary value can be assigned to an impact, even if there are no markets where these values can be traded, thus they are considered separately.

When an aspect is scoped in, it is important to document the description of aspect change and the determination if the impact is a cost or benefit. Other important information such as the description of the impact, the quantification of impacts and the factors used to convert the quantities of impacts to monetary value can already be subsumed in this framework and in the corresponding evaluation tool. The tool also assists in documenting the aspect change if adequate information is provided. The summary of aspect scoping for the processes assessed.

Table 4. Aspect Scoping for Projects

Aspects	P1	P3	P4	P5	P11	P12	P13	P15
Greenhouse Gas Emissions	x	x	x		x	x		x
Water Use					x			
Wastewater			x	x	x			
Energy Use	x	x	x		x	x		x
Solid Waste Emissions		x					x	

4.4.2 Quantifying Costs and Benefits

The direct costs and benefits identified in the projects such as capital costs and expenditures on inputs, energy, waste treatment, and benefits from additional revenue based on increased productivity, savings in energy or other inputs were used as is and included in the calculation of the benefit-cost ratio. Appropriate effort to quantify and assign value to other costs and benefits that have not been identified in the project reports was undertaken using methods explained below. An appropriate level of scrutiny was also exercised to ascertain the accuracy of the values in reports to ensure that projects are evaluated properly.

Greenhouse gas emissions

The definitions and methods in quantifying the change in GHG emissions follow *National Greenhouse and Energy Reporting Act 2007* (NGER Act) and related documents. The GHG in scope for this measurement are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The measurement primarily involves Scope 1 emissions[1]; and Scope 2 emissions and other GHG (i.e. hydrofluorocarbons and perfluorocarbons) can be considered in future or on a case-to-case basis. Nonetheless, a provision to estimate Scope 2 emissions from power consumption is provided in the evaluation tool. The estimation methods employed in this framework follow the NGER Act as close as practicably possible, although without the facility-generated data, the accuracy of a level required by the NGER Technical Guidelines (i.e. 95% confidence level) cannot be derived from this estimation. Entities registered under the NGER Act must conduct their own determination for the purpose of complying with the law. Estimates in this framework are only intended for internal evaluation purposes, unless firms provide their data.

If available, the final reports should provide the GHG-related information for quantification. When the relevant final reports provide the GHG information, these will be the data used in valuation. Otherwise, the NGER Technical Guidelines Method 1[2] will be used. In fuel combustion, waste and wastewater treatment NGER guidelines, the generation of CO_2 either through combustion of biomass or biomass-based fuels and the generation of CO_2 from the decomposition of waste biomass is not reported (Department of the Environment and Energy, 2017). These can be noted as

[1] The NGER Act Technical Guidelines 2017-18 define "scope 1" emissions as greenhouse gas emissions released by the facility as a direct result of an activity that constitute the facility, while "scope 2" emissions are greenhouse gas emissions released as a result of activities that consume electricity, heat, or steam at the facility.

[2] Method 1 is derived from the National Greenhouse Accounts national methodology as published in the National Inventory Report. The details of Method 1 for this evaluation are laid out in the Supplemental Procedures.

part of the CO_2 aspect, however, for this purpose the evaluation will follow the NGER guideline because this is also the basis of the valuation of the CO_2 emitted.

Three main GHG sources are considered in this framework: fuel combustion, waste disposal and wastewater treatment. These three areas were selected due to their potential to accrue carbon credits in accordance with the *Carbon Credits (Carbon Farming Initiative) Act 2011* through the Emissions Reduction Fund (ERF) and/or renewable energy certificates (RECs) in accordance with the *Renewable Energy (Electricity) Act 2000* through the Renewable Energy Target. Furthermore, these are sources specified in the NGER Act, with the other sources deemed inapplicable to this evaluation at this time. "Scope 2" emissions, while not directly involved in the carbon credits system can also be quantified in this evaluation, for a non-market evaluation of GHG intensity.

Many of these systems involve complicated engineering and operations; however, the NGER Technical Guidelines have provided uniform determination and reporting guidelines for entities covered by the law. The intent of this framework is not to make a detailed estimation, rather capture the estimates made by in the project reports or use relevant data from literature. Nonetheless, some simple calculations can be performed to generate the information needed to determine the value. These methods are provided in the Supplemental Procedures and are integrated in the evaluation tool.

The valuation of GHG reductions follow the guidelines set out by legislation. This predicates that the value, particularly estimates of values in future are speculative and can be subject to change. The uncertainties around potential changes to the economics of carbon and renewable energy dictate that the monetary values of GHG emission avoidance calculated in this evaluation should be used with caution. Due to the mechanisms by which GHG reductions are valued (e.g. carbon credits are sold at an accepted bid price), prices can vary widely. A fundamental change in how carbon and renewable energy are viewed can also drastically vary the values used in this framework. This also implies that values used in tools and procedures in this framework need to be updated periodically.

Water

The quantities of water included in this evaluation refer to either water extracted or any utility water delivered to the facility. The measurement and quantification of water streams for the project are expected to be consistent with routine methods to be able to accurately represent the change in water use arising from the project. If possible, the savings in water use should be based on complete plant water balance, otherwise a determination of water use reduction focused on the impact of the project will be adequate to estimate the impact of the change in water use. Recycled or reused water produced to replace water procured at cost in the business-as-usual case should have equivalent quality, unless adequate justification is provided. For instance, if a water treatment and recycling project yields in-house recycled water of equivalent quality as the water currently used, then the total water cost is reduced due to a lower volume bought from a utility. Otherwise, the recycled water should be valued at a price of the water with the quality it replaces.

The values associated with water use will be the cost or benefit arising from the change in water use, specifically, the quantity of additional water or water saved multiplied by the unit cost of water. Non-market 'water efficiency' or 'water intensity' metrics can also be reported to show the impact of sustainable operations as well as the reduced pressure on natural resources.

Energy

The values assigned for energy in this evaluation will be based on the net change in energy cost used from implementing the project and the price of the energy source. For instance, if the project includes the use of biogas to replace energy from natural gas, then the net energy cost will be the difference of the cost from using biogas and the cost of using natural gas.

The price of energy can vary across locations and applications. Large abattoirs, for example, can be charged higher rates due to high voltage requirements (Energex, 2018).

Solid Waste and Wastewater

The values used to represent wastes will be from the savings or costs borne by reduced or increased waste volume. It is also possible that waste costs change as the nature or composition of final waste changes. Changes to waste costs arising from adoption of products will be considered in the total operating costs and in the capital cost. Quantities from project reports will be used to quantify the amount of waste considered in the evaluation.

Other costs and benefits

Other relevant benefits such as revenues from resulting sales of outputs generated from the new technology (e.g. fertilizer) are also quantified and included in the analysis. The total annual operating costs reported were considered in the benefit cost analysis, because they usually include all the pertinent costs to achieve the benefits stated.

The values used to normalise the environmental impacts to product unit values are 1.4 kg/head/day gain for a feedlot (Wiedemann, et al., 2015) and 255 kg for HSCW of cattle and 20 kg for the HSCW of lamb (Meat & Livestock Australia, 2005).

4.4.3 Benefit-Cost Analysis

The benefit-cost analysis (BCA) considers market and non-market costs and benefits in evaluating the impacts of the projects. Market values of costs and benefits enable the calculation of the benefit-cost ratio (BCR), which follows the conventional calculation of the net present value of benefits divided by the present value of costs using a discount rate of 5%. For the market BCR, values incremental from business-as-usual were considered, so this analysis can be considered to have taken into account the counterfactual. The impacts considered in the market BCA are also determined to directly arise from the project and thus these the costs and benefits are attributed solely to the project. The calculations consider the benefit to the red meat industry, so the operating and adoption costs are deducted from the revenues or savings to come up with the total annual benefit. The formulas used to calculate the benefit cost ratio is given in Eq. 1-6.

$$Bnet_i = \sum(Market\ benefits) - operating\ cost \qquad \text{(Eq. 1)}$$
$$CF_i = Bnet_i - Adoption\ cost - R\&D\ cost \qquad \text{(Eq. 2)}$$
$$Inflated\ CF_i = CF_i(1+r)^i \qquad \text{(Eq. 3)}$$
$$Discounted\ CF_i = (Inflated\ CF_i)(1+d)^{-i} \qquad \text{(Eq. 4)}$$
$$NPV = \sum_{i=0}^{25} Discounted\ CF_i \qquad \text{(Eq. 5)}$$
$$BCR_{RMI} = \frac{NPV - R\&D\ Cost}{R\&D\ Cost} \qquad \text{(Eq. 6)}$$

Where:

- $Bnet_i$ is the total benefit for year i
- CF_i is the cash flow for year i
- R&D cost is the MLA investment for the product
- r is the inflation rate
- d is the discount rate set at 5%
- NPV is net present value over a fixed period of 25 years
- BCR_{RMI} is the benefit-cost ratio for the red meat industry

The evaluation considers a period up to 2040. As a default, one installation was modelled, with the R&D costs and capital investment spent at year zero, and revenues and operating costs starting to occur at year one. When the adoption model is incorporated, the number of installations for a given year serves as a multiplier for $Bnet_i$. CF_i is then calculated by deducting the capital investment from the $Bnet_i$ for a year i when an installation is built. The evaluation tool provides some option to model a constant adoption rate (years between adoption or its reciprocal, installations per year), or a variable rate, where the list of installations can be provided manually. A calculation of the project benefit-cost ratio (i.e. one installation) was also provided as a reference. For this evaluation, the BCR calculated was based on one installation on the year specified in the adoption list. The NPV including R&D costs was calculated, as well as an NPV excluding R&D costs.

Non-market costs and benefits are difficult to integrate into traditional economic measures due to methods by which monetary values are assigned to them. As such, even though it is possible to assign a monetary value to these impacts, they can be considered nominal indicators. This is in consideration of a lack of market mechanism where the values of these impacts can be traded. Other impacts that cannot be expressed in monetary values can be included as qualitative indicators of value or appropriate descriptive or relative quantification (e.g. on a scale or equivalence) will be employed. A cost effectiveness measure ($ cost/unit benefit) may also be used as appropriate.

Where necessary, the non-market costs and benefits will be evaluated against a reasonable counterfactual. Presentation of quantitative measures as percent reduction or improvement from baseline/pre-project values can be considered to have accounted for the counterfactual. This is a reasonable assumption especially for technical process-related quantities, where a change in process can be directly compared to a "do nothing" scenario.

4.5 Evaluation Tools

Spreadsheets containing numerical values for converting the quantified magnitude of impact to market values were developed to assist the calculation of the benefit-cost ratio. Other spreadsheets were also provided to facilitate the documentation of qualitative impacts and consolidate the impact statement into one document. The user guide for the spreadsheets are given in the appendices.

Due to the nature of the markets and regulations on which the quantities are based, the tools given in this framework needs to be periodically updated to ensure accuracy of the values.

5 Evaluation Results

5.1 Product Assessment

The following shows the results of the product assessment and evaluation. The evaluation focuses on eight products related to 29 projects from 2016 to present under the Environmental

Sustainability (Off-farm) sub-program. The product numbers used are not necessarily sequential as other products in the original scope were not evaluated due to their inactive status. The quantitative values of impacts were generated using the Evaluation tool spreadsheets. The statement of impacts for the different products taken from reports and other project documents may not be complete. Where gaps existed, the values was be estimated using the evaluation tool.

Product 1 (P1): Concentrated solar thermal (CST) steam system
Concentrated solar thermal involves the installation of mirrors or lenses that concentrate solar energy gathered across a large area onto a smaller area to achieve high temperatures. The heat can be used to produce heat or electricity for the grid or an adjoining facility.
Deployment status: R&D Concentrated solar has been developed in various sites globally (4.8 GW), but its applications are primarily directed towards electricity generation. Recently built facilities have also included thermal energy storage[3]. Solar heat for industrial processes was estimated at 291 MW_{th} in 2016, over 525 plants[4]. Applications vary from collectors spread over a large area of land to concentrated solar.
Technical Success: High Large scale solar thermal plants have been installed globally[5]. A few examples using CST for heat/steam are as follows: • Amul Fed Dairy in Gujarat, India installed a solar steam plant (parabolic trough collector) that replaces 50 000 m3 of natural gas for heat. Steam is used for pasteurisation of milk[6]. This is one of many concentrated solar heating plants (70 in 2012, planned 90 more through 2017) in India[7]. • Copper mining in Chile (27.5 MW_{th}), which highlights success despite operational challenges of a large field and dusty surroundings[8]. • CSP in Port Augusta, SA produces heat for greenhouses and seawater desalination as well as electric power, 36.6 MW_{th}[9] Higher capacities in power generation (CSP) benefit from economies of scale due to higher turbine efficiencies (10-50 MW), but overall efficiency of smaller systems can benefit from co-generation or use of waste heat from turbine outlet. CST for heat can be efficient even in small capacities[10]. Plants in Queensland are expected to have a more constant production, while plants in southern states might have significant variations[11].

[3] http://www.ren21.net/wp-content/uploads/2017/06/170607_GSR_2017_Full_Report.pdf
[4] ibid.
[5] https://www.science.org.au/curious/technology-future/concentrating-solar-thermal
[6] http://www.solarthermalworld.org/content/india-showcase-fast-growing-dairy-industry
[7] http://www.solarthermalworld.org/content/india-90-process-heat-projects-concentrating-collectors-five-years
[8] http://www.ren21.net/wp-content/uploads/2017/06/170607_GSR_2017_Full_Report.pdf

[9] http://www.aalborgcsp.com/projects/366mwth-integrated-energy-system-based-on-csp-australia/
[10] https://arena.gov.au/assets/2018/03/CST-RFI-Synthesis-Public-Report.pdf
[11] ibid.

Product 1 (P1): Concentrated solar thermal (CST) steam system				
Adoption/Commercial Success: Medium Costs have gone up and down for solar heat plants; however, policy support and continuous adoption of the technology have driven more expertise and lower costs over the years[12]. Technology and service providers with experience in various industries are available[13]. CSP levelised cost of electricity (LCOE) is high. For raising steam, CST is attractive as it is in the lower end of cost per GJ, only beaten by coal and hardwood chips[14]. Co-located industries can jointly fund CSP projects for heat/electricity. ARENA[15] and CSIRO support are present.				
Expected/Actual Benefits and Costs: Medium Per firm Economic: Reduced net energy costs, reduced sensitivity to changing energy price, potential RECs or ERF revenues, potential savings from power outages Environmental: Reduced consumption of fossil fuels, reduced net GHG emissions Social: Capabilities by service provider can be transferrable to other RMI firms, firms can be seen to take action regarding reducing energy consumption COSTS: Payback periods of 8-10 years, dependent on the price of fossil fuel replaced[16,17]. \$1300/kW_{th} for a large scale $3MW_{th}$ plant[18] Industry benefits: reduced sensitivity to uncontestable energy price (high), reduced production costs (low), reduced total energy costs (medium), reduced GHG emissions (medium), increased capabilities in concentrated solar thermal (medium), carbon neutral brand (medium) Estimated 3000-4000 direct and indirect jobs for a 100 MW_e plant, with 1000 in construction[19]. Construction is expected to last 3 years, with first generation at just over 2 years[20]. As such, projects commencing in 2018 will start to have impact in 2021. Spillover benefits to wholesale power prices if stored energy can be sold to the grid as additional supply. There is also potential to increase energy reliability from dispatchable energy from CST.				
Quantitative Evaluation of Impacts				
GHG	**Water Use**	**Wastewater**	**Energy Use**	**Solid Waste**

12 https://www.ethz.ch/en/news-and-events/eth-news/news/2017/09/concentrating-solar-power.html
13 http://www.sunwindenergy.com/content/solar-process-heat-surprisingly-popular
14 MLA V.SCS.0003
15 https://arena.gov.au/assets/2018/03/CST-RFI-Synthesis-Public-Report.pdf
16 http://www.solarthermalworld.org/content/india-showcase-fast-growing-dairy-industry
17 http://www.solarthermalworld.org/content/south-africa-solar-green-beer-production-creates-high-irr
18 MLA V.SCS.0003
19 https://arena.gov.au/assets/2018/03/CST-RFI-Synthesis-Public-Report.pdf
20 Ibid.

Product 1 (P1): Concentrated solar thermal (CST) steam system				
x			x	

Evaluation Basis	Concentrated Solar Thermal plant for a 30000 SCU feedlot, mid-fed beef, energy output replacing 1.4 MW heat requirements for steam flaking of feed, option for power generation. Base year is 2018, first installation in 2019.
Greenhouse Gas	Reduction of 2600 t CO_2e/y by forgoing LPG consumption for steam flaking
Energy Use	Energy from CST plant replaces 43,200 GJ/y based on 120 MJ/head on feed/month (Wiedemann, et al., 2015) and 30 000 SCU.
Projected BCR	35.10

Product 3 (P3): Biosolids anaerobic digestion process (reactor)
An anaerobic digestion (AD) process to convert organic wastes to methane and liquid digestate. The methane can be used to generate energy, which can be in the form of heat or electricity. In the case of heat and electrical generation, the adoption of this product includes boilers, generators, and electrical systems to deliver power. This product encompasses several projects that assess waste stream composition and volume, their suitability for anaerobic digestion, costs of adoption (per facility), estimation of benefits, and demonstration of the facility.
Deployment status: Trialling The principle behind this process is similar to bioenergy production from covered anaerobic lagoons (CALs), which has been successfully adopted by many RMI firms. Compared to CALs, the biosolids AD process is more complex and takes in waste streams that have higher solids concentration[21], thereby being more applicable for solid waste streams rather than wastewater.
Technical Success: High AD is a mature concept and has been implemented in similar applications. The production of methane and energy from wastes have been demonstrated in many commercial-scale AD plants globally. Specifically, the success of CALs in Australian RMI firms support the use of AD in bioreactors. Different reaction configurations have been implemented in AD plants globally, with numerous service providers offering design and construction, turnkey equipment. • Several plants globally using AD in on-farm applications for dairy, piggery and cattle[22]. • Richgro plant in Jandakot, WA, processing organic wastes (35 000 t/y) to produce power and fertiliser (2016), partnered with Biogass Renewables, financed with the Western Australian government and Clean Energy Finance Corporation (CEFC)[23]. • Yarra Valley Water, VIC, processing organic wastes to produce heat and power (2017), built by Aquatec Maxcon and Weltec Bio Power (Germany)[24].

[21] http://www.dairyingfortomorrow.com.au/wp-content/uploads/Dairy-Shed-Effluent-and-Biogas_1.pdf
[22] Beijing Yingherui Environmental Technology, http://www.yhri.cn/EN/index.aspx
[23] https://www.cefc.com.au/media/107567/the-australian-bioenergy-and-energy-from-waste-market-cefc-market-report.pdf
[24] https://www.aquatecmaxcon.com.au/images/Projects/WtE/yarravalley%20wte.pdf

Product 3 (P3): Biosolids anaerobic digestion process (reactor)
Adoption/Commercial Success: Low Commercial plants implementing this technology in poultry/RMI have been implemented in Australia: • Darling Downs Fresh Eggs in Pittsworth, QLD, processing poultry wastes and organic wastes to produce power and heat, financed by the CEFC, National Australia Bank and the Australian Government[25]. • Bindaree Beef in Inverell, NSW, processing abattoir wastes to produce power (2015), financed by a Clean Technology Investment Program grant and CEFC[26] Technology and service providers available in Australia (Biogass, All Energy, Aquatec Maxcon, Quantum Power, Wiley, University of Queensland, University of Southern Queensland) as well as industry and government support for R&D and commercialisation (AMPC, Bioenergy Australia, IEA Task 37, ARENA, CEFC, Clean Energy Regulator). Estimated 20 red meat processing plants (>60% capacity) and 25 feedlots (>50% capacity) in Australia can benefit[27].
Expected/Actual Benefits and Costs: Medium <u>Per firm</u> Economic: Reduced waste management costs (net savings from disposal costs and levies), reduced purchased energy costs, potential revenues from high-value AD products, potential RECS or ERF revenues Environmental: Reduced methane emissions from wastes, reduced use of fossil fuels for energy, reduced land use through alternative waste treatment technology with minimal footprint, reduced air pollutants borne from burning fossil fuels Social: Developed alternative capabilities in agriculture that can be transferrable to/from other industries, potential for new jobs, firms can be seen to take action regarding pollution, carbon neutral brand, minimised odour in closed systems COSTS: Capital expenditures can be large. Payback periods of ~10 years with potential for reduction from technological advances[28]. <u>Industry benefits</u>: reduced production costs (low), carbon neutral/green brand (medium), reduced waste streams (low), reduced reliance on external power or dampened effect of volatile energy price (medium), provision of sustainable baseload energy for plant (medium) Energy value of: $50-70/dry tonne of waste; replacement of 20-100% of energy requirements[29]. Industry benefit of $ 40 million/y by 2020, CBR of 1:20[30].

[25] www.cefc.com.au/media/63281/20130731-cefc-pdf-factsheet-darlingdownsfresheggs_lr.pdf
[26] https://www.cefc.com.au/media/76497/cefc-pdf-factsheet-bindaree_lr.pdf
[27] MLA V.SCS.0001
[28] MLA V.SCS.0001
[29] Ibid.
[30] Ibid.

<table>
<tr><td colspan="5">Product 3 (P3): Biosolids anaerobic digestion process (reactor)</td></tr>
<tr><td colspan="5">Potential for coupling with microbial protein production (R&D stage) to increase benefits.

Spillover benefits to waste management (through co-digestion) and agricultural industries (fertiliser availability), and potential to ease pressure in energy demand.</td></tr>
<tr><td colspan="5">Quantitative Evaluation of Impacts</td></tr>
<tr><td>GHG</td><td>Water Use</td><td>Wastewater</td><td>Energy Use</td><td>Solid Waste</td></tr>
<tr><td>x</td><td></td><td></td><td>x</td><td>x</td></tr>
<tr><td>Evaluation Basis</td><td colspan="4">This was assessed for a 66372 t HSCW/y processor to use an anaerobic digestion reactor. Base year is 2018 and first installation is in 2019.</td></tr>
<tr><td>Greenhouse Gas</td><td colspan="4">Reduction from 12585 tCO_2e/y from burning coal to 219 tCO_2e/y from burning biogas.</td></tr>
<tr><td>Energy Use</td><td colspan="4">Avoided purchase of 5784 MWh/y (20822 GJ/y) power and 22608 GJ/y heat from coal burning by using biogas.</td></tr>
<tr><td>Solid Waste</td><td colspan="4">26114 t/y of solid waste converted to 11851 t/y of compost.</td></tr>
<tr><td>Projected BCR[31]</td><td colspan="4">4.72</td></tr>
</table>

Product 4 (P4): Covered Anaerobic Lagoons (CALs)
This is a product that has ongoing development in the RMI. Anaerobic lagoons are secondary treatment processes for wastewater. The biological oxygen demand and chemical oxygen demand are decreased in CALs, producing effluent that can be released to the environment or further treated as recycled water.
Deployment status: Commercial/Adopted Around 30 CALs are in operation in the RMI, across 20 firms. CALs have been adopted since the 1990s and new lagoons are still commissioned in recent years.
Technical Success: High The demonstrated success of implementing CALs have resulted in more CALs being used particularly in abattoirs. An MLA assessment in 2016 reports that the funding supports more efficient operation of CALs, advancing installations, and longer operational life[32]. Installations completing an evaluation cycle can give rise to further developments that can improve design and operation of future installations. The use of produced biogas as a fuel has lagged behind the use of CALs; however, a number of firms with CALs have employed this technology.

[31] Excluding RECs
[32] Impact Assessment of MLA Expenditure 2010-11 to 2014-15

Product 4 (P4): Covered Anaerobic Lagoons (CALs)

Adoption/Commercial Success: High

The volatile energy market is driving the development of alternative energy sources. CALs are well-positioned to be the technology of choice for RMI firms due to the industry's experience and proven benefits.

Service providers with the right capabilities are available to install CALs and transfer knowledge to operators.

Deployment of CALs can be limited by available land area. Similar AD technologies that use tanks that have smaller footprint and can accommodate higher solids loading are starting to be used. This can drive some adoption away from CALs.

Expected/Actual Benefits and Costs: High

Per firm

Economic: Reduced waste management costs (net savings from disposal costs and levies), reduced purchased energy costs, potential revenues from high-value AD products, potential RECS or ERF revenues

Environmental: Reduced methane emissions from wastes, reduced use of fossil fuels for energy, reduced land use through alternative waste treatment technology with minimal footprint, reduced air pollutants borne from burning fossil fuels

Social: Developed alternative capabilities in agriculture that can be transferrable to/from other industries, potential for new jobs, firms can be seen to take action regarding pollution, carbon neutral brand, minimised odour in closed systems

COSTS: Capital costs are large for new CALs. Estimated cost of new, lined CAL is $4 million (2017)[33]. Feasibility is improved with use of biogas for energy.

Industry benefits: reduce production costs (low), carbon neutral/green brand (medium), reduce waste streams (low), reduce reliance on external power/dampen effect of volatile energy price (medium), provide sustainable baseload energy for plant (medium)

$ 380 000/y for a 500-head abattoir

Spillover benefits to agricultural industries (fertiliser availability), ease of pressure in energy demand.

Quantitative Evaluation of Impacts

GHG	Water Use	Wastewater	Energy Use	Solid Waste
x		x	x	

Evaluation Basis	A 90 000 t HSCW/y abattoir installing a new CAL and biogas use facilities to replace natural gas use for heating.
Greenhouse Gas	Avoidance of 29 340 tCO2e/y of greenhouse gases by burning biogas instead of fossil fuel natural gas.

[33] MLA P.PIP.0730

Product 4 (P4): Covered Anaerobic Lagoons (CALs)	
Wastewater	Reduction in COD and BOD as expected in anaerobic lagoons.
Energy Use	Reduction in purchased energy by using biogas.
BCR	0.23

Product 5 (P5): Electro-coagulation technology for removing Total Phosphate (TP)
An electrocoagulation (EC) process removes contaminants in waste water using an electric current and electrodes rather than chemical addition. EC has been shown to have marginally higher contaminant removal (total suspended solids, biological oxygen demand, and bacteria) than chemical coagulation, with lower chemical levels in the separated sludge. As with other primary treatment processes, the use of EC enables better performance of subsequent treatment (i.e. CALs).
Deployment status: R&D Numerous academic studies on the use of electrocoagulation have been published in journals[34]. There are also several suppliers of EC equipment for waste water plants.
Technical Success: Medium Electrocoagulation presents an uncomplicated process for primary treatment of wastewater. There is little evidence of widespread application of EC in abattoirs and other RMI firms. This could be due to the relative simplicity and affordability of alternative treatment processes. Some demonstrations have been conducted for other industries[35]
Adoption/Commercial Success: Low Previous study by MLA/AMPC (PRENV.011) in 2003 has demonstrated positive results for an RMP using EC to reduce total phosphate, total suspended solids, total grease, TKN and COD[36]. A study in 2014 by AMPC (2014.1044) concluded that EC was not used in Australian slaughterhouses. Comparisons show EC is more expensive than using chemical coagulants[37]. No information if EC unit demonstrated in 2003 (Burrangong Meat Processors/BE Campbell/Hilltop Meats) is still in operation.
Expected/Actual Benefits and Costs: Medium Per firm Economic: Reduced wastewater treatment/sludge disposal net costs (cost savings from improvements in CALs) Environmental: Reduced phosphorus emissions and prevent consequences (i.e. runoff, eutrophication) Social: Firms can be seen to take action regarding pollution

[34] https://www.tandfonline.com/doi/full/10.1080/21622515.2012.715390
[35] http://news.ubmthailand.com/Newsletter/2013/TW/Files/SessionI/05-Presentation_K.%20Boonyarit%20&%20Dr.%20Sompong.pdf
[36] MLA PRENV.011
[37] AMPC 2014.1044

Product 5 (P5): Electro-coagulation technology for removing Total Phosphate (TP)					
COSTS: Estimated $205 000 (CEPCI adj) for a 10kL/h unit; test operation at 4.5 kL/h yielded 70-90% TP removal[38] 2008 estimate using mild steel electrodes was AU$ 1.03/m^3 treated (2017 $)[39] 2006 estimate was AU$ 0.69/m^3 for cheaper iron electrodes, AU$ 1.2/m^3 for better performing aluminum electrodes (2017 $)[40] Both estimates did not measure total phosphate. Industry benefits: Reduced industry phosphorus emissions (low), Improved reputation (low)					
Quantitative Evaluation of Impacts					
GHG	**Water Use**		**Wastewater**	**Energy Use**	**Solid Waste**
			x		
Evaluation Basis		This was evaluated for an RMP.			
Wastewater		Wastewater was treated to remove 48% of Total Nitrogen, 99% of Total Phosphorous, 97% of BOD, 90% of COD, 99% of TSS, 98% of FOG, and 39% of Magnesium.			
Projected BCR		Not available			

Product 11 (P11): Water efficiency and recycling
This applies to process or process improvements in feedlots, abattoirs and meat processing plants. Feedlots consume water, but RMP water use is not consumptive, and only generating wastewater that can be recycled. For feedlots the target is to reduce losses through evaporation through feedlot redesign and other strategies, while for RMPs the focus is in improving water treatment processes to generate recycled water.
Deployment status: Trialling The principles behind this product are being implemented in other industries and applications. Specific application to the RMI is being trialled.

[38] MLA PRENV.011
[39] AMPC 2014.1044
[40] Ibid.

Product 11 (P11): Water efficiency and recycling
Technical Success: High Water recycling technologies are commercially available and applied successfully in non-meat processing industries, poultry meat processing and domestic red meat processing. R&D requirements are largely related to selection of "fit for purpose" process configurations, process optimisation and larger scale demonstration and would be suited to the MLA PIP program[41]. High N, moderate P, fat, oil and grease content of RMP waste water are critical quantities in developing technologies to recycle water. RMPs with Advanced Nutrient Removal Systems / Biological Nutrient Removal can consider Advanced Water Treatment to produce potable water[42].
Adoption/Commercial Success: Medium Water recycling plants have been implemented in other industries and in the RMI: • CUB Brewery in Yatala, QLD, reduced water intensity to better than industry best practice; 1.5-2ML/d recycled water from 3.4-4.3 ML/d effluents; re-use in process auxiliary purpose, cooling towers, and boilers[43]. • Ingham Poultry in Murrarie, QLD uses a biological, membrane and disinfection process to produce 4 ML/d of high quality water, 72% decrease in water consumption, recycled potable water used in contact with meat[44]. • Radfords Meats (RMP) in Warragul, VIC, ultrafiltration process to recycle up to 90% effluents to a potable standard; 40% decrease in water consumption[45]. Use of recycled water requires engagement with international regulators to develop an application process and facilitate application to export markets in consideration of the reuse of recycled water meeting hygiene standards. Some aversion from consumers to choose meat produced using recycled water (willingness to pay for tap water > $0) [46].
Expected/Actual Benefits and Costs: Medium <u>Per firm</u> Economic: Reduced water use costs (net savings from purchase and recycling costs), reduced wastewater emission-related costs Environmental: Reduced wastewater emissions, reduced net water draw from common reservoir/surface water Social: Developed alternative capabilities in agriculture that can be transferrable to/from other industries, potential for new jobs, firms can be seen to take action regarding pollution, firms can be seen to take action regarding fair share of water; reduced pressure/load to councils on wastewater treatment (as applicable)

[41] MLA V.SCS.0001
[42] AMPC 2017-1034
[43] Institute for Sustainable Futures (2013), Yatala Case Study; Building Industry Capability to Make Recycled Water Investment Decisions. Prepared by the Institute for Sustainable Futures, University of Technology, Sydney for the Australian Water Recycling Centre of Excellence
[44] AMPC 2016.1021
[45] Ibid.
[46] Consumer response to recycled water in food production, AMPC, http://www.awrdc.org.au/food-project-case-studies/meat-sector

Product 11 (P11): Water efficiency and recycling				
COSTS: Adoption costs (CAPEX); water reuse options evaluated to have a wide range of payback periods of 3.5-15 years (2005), which make them not financially attractive; assuming steady supply of potable water[47]. Payback period for ultrafiltration system is 5 years[48]. AMPC study of a full recycling plant reports payback periods of 9-18 years for $3.5/kL potable water scenarios, with NPV<0 for scenarios of $2/kL potable water over 20 year plant life. <u>Industry benefits</u>: reduced production costs (low), reduced waste streams (low), reduced reliance on water supply/dampen effect of volatile water price (medium), provision of sustainable water supply for plant (medium) 22-36% reduction in water consumption in RMI (livestock drinking) 1-1.4% reduction in water consumption in RMI (advanced water recycling) $18-25 million/y cost savings[49] Potential for coupling with wastewater to energy projects (CALs) to increase benefits. Spillover benefits if produced water can be used in agriculture, and potential ease of pressure in community water demand.				
Quantitative Evaluation of Impacts				
GHG	**Water Use**	**Wastewater**	**Energy Use**	**Solid Waste**
x	**x**	**x**	**x**	

Evaluation Basis	This was assessed for a 30000 SCU feedlot and a 1200 head/day abattoir. The feedlot case considers a water recycling facility for feedlot wastewater while the abattoir case considers a CAL for biogas production and an abattoir wastewater recycling facility.
Greenhouse Gas	The greenhouse gas savings are based on replacement of the electricity purchased by burning the produced biogas. The estimated scope 2 GHG avoided is 2270 tCO_2e/y.
Water Use	The feedlot is projected to use 6056 kL/y while the abattoir will use 237500 kL/y of recycled water.
Wastewater	The wastewater volumes recycled are 6056kL/y for the feedlot and 275000 kL/y for the abattoir.
Energy Use	The energy produced as power from biogas in the abattoir case is 50390 GJ/y (14 GWh).
Projected BCR	4.60

[47] MLA CN210520
[48] AMPC 2016.1021
[49] MLA V.SCS.0001

Product 12 (P12): PV Solar and Battery (Microgrid)
A microgrid system, including PV & diesel generation, energy storage system (battery storage), load shedding system and operational interface controls, is proposed for the site to resolve the effects of grid outages by providing a level of autonomy from the grid. The product focuses on implementing and testing a load-shedding interface that can enable uninterrupted power independent from the main grid.
Deployment status: Trialling Microgrids have been operational in many areas, although very limited in industrial applications[50]. The technology employed is industry-agnostic, since energy generation does not depend on the facility being powered. Energy sources or electrical loads that are specific to the facility can be accounted for in the engineering design, but this consideration is not unique to the RMI. Elements related to the use of pasture land for the solar array are covered in the projects related to this project.
Technical Success: Medium The microgrid similar to this application has been implemented in Australia: • Horizon Power in WA[51] • AusNet Services in Mooroolbark, VIC, mini-grid trial for solar PV roof generation and 10kWh battery storage[52], demonstrated supply of 22 hours independent from main grid[53]
Adoption/Commercial Success: Low Very limited applications of solar PV microgrids in the immediate future for RMP plants, especially if they are limited by available space for solar farms. Microgrid application can potentially be applicable for other generation (biogas) scenarios. Solar farm/microgrids can potentially be adopted by producers in on-farm applications or in feedlots, however, since (electrical) power makes up only 4% of farm energy[54], adoption might depend on adoption of electrification technologies (e.g. electric vehicles). PV solar generation and storage is determined to cost $0.27/kWh, making the economic benefit marginal, although this value is expected to decrease significantly in the near future. Installation of generation with minimal storage can improve economics but diminish benefit of energy independence from grid[55].
Expected/Actual Benefits and Costs: Low <u>Per firm</u> Economic: Reduced energy costs (net savings from spikes in price), potential RECS revenues Environmental: Reduced GHG emissions (primary if generating, scope 2 if buying power), reduced air pollutants borne from burning fossil fuels Social: Developed alternative capabilities in agriculture that can be transferrable to/from other industries, potential for new jobs, firms can be seen to take action regarding pollution, carbon neutral brand

[50] MLA P.PIP.0035
[51] https://horizonpower.com.au/our-community/projects/
[52] https://www.ausnetservices.com.au/Community/Mooroolbark-Mini-Grid-Project
[53] https://www.ausnetservices.com.au/Misc-Pages/Groundbreaking-trial-uncovers-new-possibilities
[54] MLA V.SCS.0001
[55] MLA V.SCS.0003

Product 12 (P12): PV Solar and Battery (Microgrid)				
COSTS: Payback period of 5.7 years, IRR of 18% for RMP studied (1.5 MW solar PV microgrid)[56] Industry benefits: stable production costs (low), carbon neutral/green brand (low), reduced reliance on external power/dampened effect of volatile energy price (medium), prevent downtime losses (high) Replacement of power generation by PV solar and a microgrid can vary between RMP plants. Recommended installation of 900 kWe without storage representing 6% power requirements in RMP plants, equivalent to $17 million/y gross savings in purchased power costs[57]. A 1.5 MW solar PV installation will reduce 3145 t CO2e/y[58], although if power was previously externally sourced, GHG reduction constitutes Scope 2 emissions. Hardwick's has estimated avoidance of $6 million in losses from power outages if uninterrupted power is supplied[59]. Spillover benefits to animal health, water efficiency if solar farms can provide shading and reduce heat exposure, evaporation, water intake of animals.				
Quantitative Evaluation of Impacts				
GHG	**Water Use**	**Wastewater**	**Energy Use**	**Solid Waste**
x			x	

Evaluation Basis	This was assessed for a mixed animal abattoir processing 3000 heads cattle and 30000 heads sheep per week. The microgrid will be attached to a 1.5 MW solar PV array.
Greenhouse Gases	The project reduces scope 2 emissions from purchased power by 2548 tCO_2e/y, which represents 30% of total power-related emissions.
Energy Use	The project facilitates use of 8492 GJ/y (2359 MWh/y) from the solar PV array.
Projected BCR	-0.91

Product 13 (P13): Black soldier fly larvae (BSFL) feed production
The development of a black soldier fly production plant to process red meat processing waste by growing larvae to be converted into protein-rich animal feed (fish food).
Deployment status: R&D The effect of the commercial production of whole live BSFL to market (e.g. saturation) to the market value is not well understood. The market value of Australian manufactured larvae meal and oil is not defined, due to the infancy of the process[60].

[56] MLA P.PIP.0735
[57] MLA V.SCS.0003
[58] MLA P.PIP.0735
[59] Ibid.
[60] MLA P.PSH.0855

Product 13 (P13): Black soldier fly larvae (BSFL) feed production
Technical Success: Medium Production of BSFL for feed has been demonstrated in a few sites globally, and in Australia[61]: • Enterra in Canada uses pre-consumer fruits and vegetable wastes to produce BSFL for fish food products and fertilizers[62] • AgriProtein's commercial scale plant in Philippi, South Africa (250 t/d food waste) to produce poultry and fish feed, oil and fertilizer[63] Study by QAFFI used RMP waste and reported moderate BSFL yields[64]. Determination of product standards and ability for the plant to meet those are required. There are concerns that pathogens can be transmitted from the use of RMP waste by the product BSFL.
Adoption/Commercial Success: Low BSFL facilities in Australia are just at a start-up/small commercial level, and just using non-RMI wastes. Some support by industry (WA Fishing Industry Council) is present[65] • Future Green Solutions in Geraldton/Perth, WA is producing marketable fish feed and fertilizer from BSFL grown with food scraps[66,67] • Goterra in Canberra, ACT operates a small commercial scale BSFL facility to produce fish feed[68] Potential profitability can be demonstrated, however its novelty as a product stream from RMI firms contributes to the lack of expertise and potentially low consumer acceptability. This can also be adopted by feedlots, as it can be viewed as adequately distant from the meat product. This can be adopted in consonance with an 'organic farming' strategy. Commercialisation is seen to start in 2021 for ACC.
Expected/Actual Benefits and Costs: Medium <u>Per firm</u> Economic: Reduced waste costs (net savings from disposal costs and facility operation costs), product revenues Environmental: Reduced solid wastes and wastewater Social: Developed alternative capabilities in agriculture that can be transferrable to/from other industries, potential for new jobs, firms can be seen to take action regarding pollution COSTS: (for RMP waste facility, 20 000 t/y): $3.4 million CAPEX, payback period of 11 years; IRR

61 Ibid.
62 http://www.enterrafeed.com/
63 https://agriprotein.com/our-products/
64 MLA P.PSH.0855
65 http://www.wafic.org.au/wp-content/uploads/2017/08/Media-Release-RDE-Award.pdf
66 http://www.abc.net.au/news/2017-05-15/maggots-eat-food-to-make-fish-food-for-aquaculture-industry/8528332
67 https://www.futuregreensolutions.com.au/
68 https://goterra.com.au/about/

<table>
<tr><th colspan="5">Product 13 (P13): Black soldier fly larvae (BSFL) feed production</th></tr>
<tr><td colspan="5">11.3% over 25 years, $0.3 million/y profit[69], BCR of 1.3.

<u>Industry benefits</u>: additional revenue for RMP (low), clean/sustainable business (low)

Spillover benefits to aquaculture industry through alternative supply of feed.</td></tr>
<tr><td colspan="5">Quantitative Evaluation of Impacts</td></tr>
<tr><td>GHG</td><td>Water Use</td><td>Wastewater</td><td>Energy Use</td><td>Solid Waste</td></tr>
<tr><td></td><td></td><td></td><td></td><td>x</td></tr>
<tr><td>Evaluation Basis</td><td colspan="4">This was evaluated for an abattoir with a capacity of 1280 head/day, and a BSFL plant processing 20000 t/y of solid waste.</td></tr>
<tr><td>Solid Waste</td><td colspan="4">The plant reduces solid waste costs of 9060 t/y.</td></tr>
<tr><td>Projected BCR</td><td colspan="4">14.33</td></tr>
</table>

Product 15 (P15): Rendering cooker flash steam heat recovery
Demonstration of an alternate means of recovering waste flash steam.
Deployment status: Trialling The use of this product was demonstrated in D A Holdings' rendering plant with positive results. Further development was recommended to reduce water hammering. Evaluation of the real value of the product needs to be done.
Technical Success: High The principles behind this technology are simple and tested in many steam plant operations[70]. The R&D related to this product is in the direct application in rendering plants.
Adoption/Commercial Success: Low The RMPs that can adopt this technology will be those that have rendering cookers. Some rendering plants already have flash steam recovery systems, which might not see benefit in adopting this technology. However, there is potential for retrofits since the system is touted to cost less and provide up to twice the energy savings. This demonstration can also refine the design and operation to make the tech more adoptable.
Expected/Actual Benefits and Costs: Low <u>Per firm</u> Economic: Reduced net energy costs Environmental: Reduced consumption of fossil fuels for steam, reduced net GHG emissions Social: Developed alternative capabilities in agriculture that can be transferrable to/from other industries, firms can be seen to take action regarding energy consumption COSTS: Payback period of <12 months; cost estimate is $ 146500 for one installation. <u>Industry benefits</u>: reduced production costs (low), reduced total energy costs (medium), lower GHG emissions (low)

[69] MLA P.PSH.0855
[70] https://www.energy.gov/sites/prod/files/2014/05/f16/steam13_vent_condenser.pdf

Product 15 (P15): Rendering cooker flash steam heat recovery				
Energy value of: $10 million/y, 30 000/y CO2e from waste heat in rendering cookers, 10-15% energy savings from rendering cookers[71]				
Quantitative Evaluation of Impacts				
GHG	**Water Use**	**Wastewater**	**Energy Use**	**Solid Waste**
x			x	

Evaluation Basis	This was evaluated for a 9000 t HSCW/y RMP with a rendering cooker.
Greenhouse Gases	The greenhouse gas reduction for this product is 315 tCO_2e/y, from forgoing LPG consumption due to higher thermal efficiency.
Energy Use	A reduction of 5191 GJ/y from 202 kL/y less LPG consumption.
Projected BCR	6.09

5.2 Quantified Economic Impacts

The results of the benefit-cost analyses for the various products are shown in the previous section. The range of benefit-cost ratio values varied widely for various reasons. Firstly, most of the BCRs were calculated based on ex-ante estimates from a number of projects. The projects evaluated provided estimations of impacts in support of recommending the installation for the firm and used different methods of quantification. The impacts also varied within products. For instance, the case used for Water Recycling and Efficiency (P11) for a feedlot involved only water recycling, but for the same product for a processor, there are additional benefits from producing biogas. The economic impacts of Electro-coagulation technology for removing Total Phosphate (P5) were not included in the total BCR since the valuation of the improvement in Total Phosphate cannot be established. Finally, products which are in the early R&D stages from MLA's perspective will tend to have higher BCRs due to the low R&D investments at this time. This presents more opportunities for the industry to increase research spending in these high BCR areas to ensure the investment risks are reduced and the impacts are maximised.

Among the products evaluated, Covered Anaerobic Lagoons (P4) and Rendering Cooker Flash Steam Heat Recovery (P15) are the only two evaluations that were based on cases from projects which implemented these products and reported the impacts through ex-post evaluations. To support further commercialisation and adoption of the other products, similar evaluations need to be carried out to clearly demonstrate the benefits of implementing them.

A particular issue that stood out in quantifying economic impacts was the value of reducing carbon emissions. This evaluation attempted to assign value to avoided GHG emissions through legislated mechanisms described in Section 4.4.2. However, feedback in the early stages of the evaluation recommended the exclusion of GHG-related revenues since there is great uncertainty to the value and status of these mechanisms. Nonetheless, the effects of these mechanisms are illustrated in the figure below.

[71] MLA P.PIP.0521

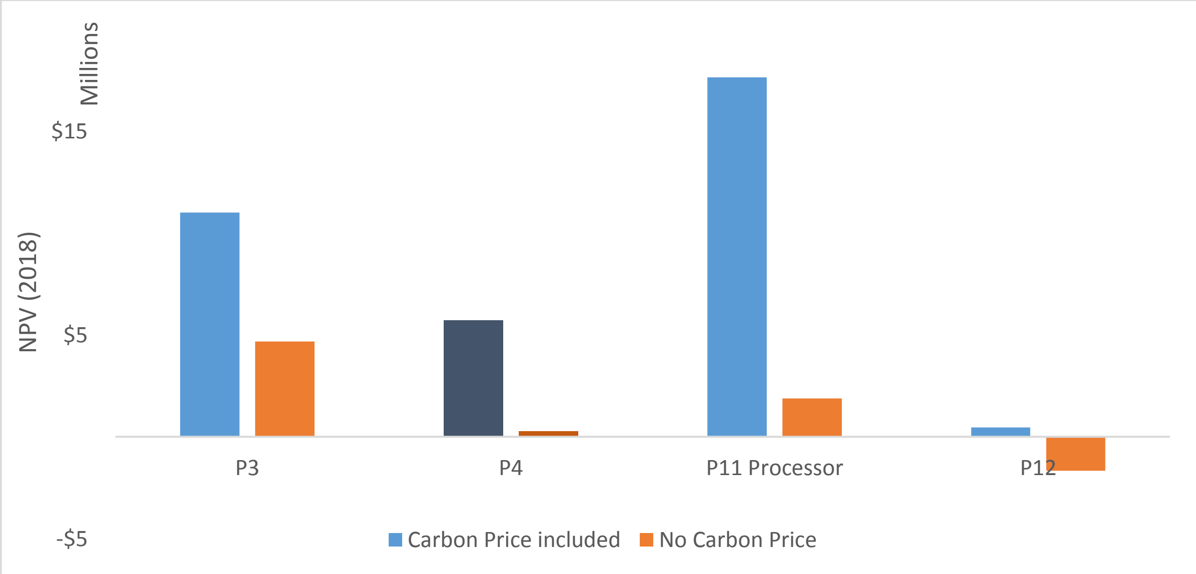

Figure 3. Effect of the value of GHG emissions reduction to net present value of products.

The carbon price values shown in Figure 3 are based on Large Scale Renewable Energy Certificates, except for P4, which was estimated using Emissions Reduction Fund carbon credits. The differences between the cases where the value of GHG emissions are mitigated and the cases where the GHG values are excluded are appreciable. For P12, in particular, the NPV goes below zero without revenue from the sale of RECs.

5.3 Quantified Environmental Impacts

The results of the quantitative evaluation of environmental impacts are presented here. To provide the proper context, the base values for Feedlots (Wiedemann, et al., 2016) and Processors (Ridoutt, et al., 2015) for comparison are presented in Table 5 and 6. These are average values from the reports cited. The values for each product are presented as a change (usually a reduction) per unit, based on the evaluations described in the previous section. The reductions (as negative values) do not signify a direct subtraction from the base value due to the differences in RMI firms, but are presented alongside base values to demonstrate scale.

Since most water-related products in this evaluation involve only recovery and reuse of water, the water use per unit produced does not decrease. The change illustrates only a reduction of water purchased from a utility or extracted from a natural source. Similarly, the energy intensity per unit produced also does not decrease, due to only a replacement of the energy source and no decrease on the total energy intensity. The changes discussed here are reductions in purchased fossil fuel energy or conventional electricity. These changes benefit the RMI firm in increasing self-reliance and decreasing sensitivity to high prices or low supplies. An efficiency product, on the other hand, can decrease the water use and energy intensity in an absolute sense. In contrast, the values around GHG emissions intensity reductions that are reported here represent total decrease from base values due to the decrease in use of total carbon-rich energy sources.

Among the products in this study, Concentrated solar thermal (P1) and Water efficiency and recycling (P11) were assessed for feedlot applications. Changes in water use, energy use, and GHG emissions intensity are compared in Table 5. The use of solar energy to produce heat for steam flaking reduces the fossil fuel energy use in a feedlot, and consequently the amount of GHG emissions decrease from avoiding the use of LPG. Greater GHG emissions reductions can be expected when CST replaces coal-burning in other facilities. The water recycling product for the feedlot in this application only marginally reduced freshwater. This is due to the small volume of water recycled. Water recycling and efficiency of larger water outlet streams can improve the water use intensity.

Table 5. Environmental Impact Measures in Feedlot Applications

	Measure per kg live weight gain†	Water use (L)	Energy use (MJ)	GHG emissions intensity (kg CO_2e)
	Feedlots Base Value	308	11.6	1.32
P1	**Concentrated solar thermal (CST) steam system**	---	-2.82	-0.17
P11	**Water efficiency & recycling (Feedlot)**	-0.4	---	---

†mid-fed export beef

For processor applications, five products are shown in Table 6. Electro-coagulation technology for removing total phosphate (P5) and Black soldier fly larvae (BSFL) feed production (P13) were not included in this comparison due to the lack of information for a meaningful comparison to base values. Furthermore, P5 addresses the quality of wastewater through phosphate removal and P13 focuses on the use of solid waste to generate high value by-products, which do not directly match the measures presented here.

Table 6. Environmental impact measures in Processor Applications

	Measure per tonne HSCW	Water use (L)	Energy use (MJ)	GHG emissions intensity (kg CO_2e)
	Processors Base Value	8600	3005	432
P3	**Biosolids anaerobic digestion process (reactor)**	---	-654	-186
P4	**Covered Anaerobic lagoons (CALs)**	---	-490	-326
P11	**Water efficiency & recycling (Processor)[72]**	-3116	---	---
P12	**PV Solar and Battery (Microgrid)‡**	---	-114	-34
P15	**Rendering Cooker Flash Steam Heat Recovery**	---	-577	-35

‡Assessed for a mixed (mostly lamb) abattoir

The relatively large environmental impacts in red meat processing plants also present opportunities to develop sustainability measures to improve performance. Compared with on farm processes, processors have more control over energy and water use as the processes do not rely largely on inputs and outputs of animal production. For instance, the energy source and efficiency of refrigeration, heating water or rendering in RMPs can be more easily changed, compared with the energy use in a farm, constrained by use of diesel and fertilisers (Wiedemann, et al., 2015).

The numbers presented in Table 6 further demonstrate this. From an average value of 3005 MJ, around 20% can be replaced by using biogas produced from RMP wastes (P3 and P4). A photovoltaic solar installation (P12) can conceivably replace some energy requirement, particularly during peak

[72] There are also Energy Use and GHG reduction impacts for the Processor P11 case; however, it is left out of the comparison in the interest of generalising the impact if a CAL is not used.

hours when energy is most expensive. On the other hand, even without replacement of fuel source, energy efficiency from recovering heat in the rendering process (P15) can reduce the total energy requirement. GHG emissions reductions follow the energy use reductions, with replacement of fossil fuel use with bioenergy having the most significant effects due to the calculations set by the NGER Act. The water recycling measure evaluated in P11 demonstrate remarkably significant reductions in fresh water use due to the large volume of water treated and reused. Water recycling and reuse, however, is limited by standards imposed for meats exported to other countries and the inherent risk of reusing water that has come in contact with meat.

Solid wastes disposed in landfills was considered in the quantification, but the relevant products evaluated did not properly differentiate the solid waste conversion and treatment with the counterfactual. The value of 5.9 kg/t HSCW of landfilled solid waste cannot be properly compared to the reported solid waste recovered.

5.4 Social Impacts

Social impacts are usually not explicitly stated in evaluations of sustainability technologies despite the clear social benefits that can be gained by implementing them. Some examples include reduction of odorous emissions, job creation, and positive visual impacts. Other impacts are harder to isolate and quantify such as the decrease in competition for energy and water in the community, or being a firm the community can be proud of due to sustainability measures. For these impacts, it might be more sensible to assess the social impact as an industry. This aligns well with objectives to align performance to community expectations and support carbon reduction initiatives.
On an industry-wide scale, the social impact measurements associated with sustainability projects that are likely to be meaningful to the public are the following:

- Carbon footprint (t CO_2e/kg product)
- New jobs created (#)

In addition, efficiency and renewable energy metrics might also assist to demonstrate climate change mitigation actions in the industry. This is in consideration of the public's view that the country's primary energy source must be renewable (Hunt, 2017) and the high energy price is a priority socio-political issue across all sectors.

5.5 Findings from Project Reports

The evaluation involved the review of project reports that are made available to the public as the output of R&D investments by MLA. While many of these reports provide pertinent information related to the technologies being considered, some information to encourage adoption across the industry was lacking. For instance, many reports focused on one facility, but failed to communicate the red meat industry facility size, which can help understanding of the scale of application. An extension can also be a demonstration of applicability of the evaluated technology in different RMI firm sizes, even as a simplified case study. There is also a need to present findings in the proper context, by evaluating impacts against counterfactual or 'do nothing' scenarios, comparing operational and triple bottom line results to the most current benchmark values. This can emphasise the benefits of the project and support adoption beyond financial viability. From a technical standpoint, the reports also need to show clear outcomes with clear methodologies to enable replication by other firms that may want to adopt the technology. Finally, in view of closing the research cycle, research outputs can be better aligned to the impact evaluation framework presented here to facilitate periodic evaluation and inform resource planning in future.

6 Conclusions and Recommendations

From this evaluation, it has been demonstrated that the products arising from the Supply Chain Sustainability Program have contributed to the Australian Red Meat Industry's Social License to Operate. The cost benefit ratio of 3.67 has been calculated for the R&D investment of the products assessed. Moreover, the environmental benefits of products based on average values are as follows:

- 24% fossil energy reduction in feedlots
- 4-22% fossil energy reduction in meat processing facilities using alternative energy
- 19% reduction in total energy use through rendering heat recovery
- 13-75% greenhouse gas emissions reductions from the use of alternative fuels, or implementing heat recovery systems
- 36% water use reduction from water recycling in meat processing

The figures may vary depending on facility size and the extent of adoption of sustainability measures.

The evaluation framework presented in this project has been developed for current priority aspects; however, these can change in future to align with changing strategies. The methodology employed in the evaluation was successfully tested on products under the Off-Farm Sustainability sub-program, but this can also be extended to On-Farm projects.

To further enhance the impact of the SCSP in future projects, the following are recommended:

1. Identify relevant aspects at the project approval stage and include a flag for a project relevant to the SCSP if classified in a different sub-program.
2. Include requirements in projects to quantify the magnitude of potential impacts identified in this framework to facilitate evaluation. Reporting of impacts measured after implementation can also be considered.
3. Include requirements in projects to present impacts or discuss benefits for a range of RMI firm sizes to encourage adoption. Impact measures should also be compared to baseline values to provide appropriate context.
4. Align measurements with associated programs such as Carbon Neutral 2030 to maximise the evaluation value.

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8 Appendices

8.1 Supplemental Procedures

8.1.1 Calculating GHG emissions

Calculations of GHG emissions are based on the NGER Technical Guidelines (Department of the Environment and Energy, 2017).

Fuel Combustion

GHG released from fuel combustion is calculated using the formula provided by Method 1 of the NGER Technical Guidelines method, shown in Equation 1 (Section 2.20 of the NGER Technical Guidelines).

$$E_{ij} = \frac{Q_i \times EC_i \times EF_{ijoxec}}{1000} \qquad \text{(Eq. 1)}$$

In Equation 1:
E_{ij} is the emission of GHG j from fuel i [kg CO_2e/y]
Q_i is the flow rate of fuel i [t, kL or m^3/y]
EC_i is the energy content per unit quantity of fuel i [GJ/t, kL or m^3]
EF_{ijoxec} is the emission factor of the fuel i for the GHG j [kg CO_2e/GJ]

Method 1 estimates the GHG emissions from combusting fuel to produce small-scale power (<30 MW or 50000 MWh/y), heat or steam, or for transportation.

Waste Disposal

For solid waste disposal in landfills, the GHG emissions can be estimated using the following procedure (Method 1 of the waste section) from the NGER Technical Guidelines. It is expected that partners can provide either the total calculated GHG emissions or the technical data shown in the equations needed to estimate the GHG emissions. In case there is a lack of information, an appropriate level of estimation (i.e. using data from similar facilities) can be used. For estimating the methane emissions of landfills, the formula shown in Equation 2 will be used (Section 5.4 of the NGER Technical Guidelines).

$$E_j = \left(CH_4^* - \gamma\left(Q_{cap} + Q_{flared} + Q_{tr}\right)\right) \times (1 - OF) \qquad \text{(Eq. 2)}$$

In Equation 2:
E_j is the emissions of GHG j [t CO_2e/y]
CH_4* is the estimated quantity of methane in landfill gas generated by the landfill in a year [t CO_2e/y]
γ is the conversion factor 6.784 x 10^{-4} x 25 to convert cubic meters to tonnes CO_2e
Q_{cap} is the quantity of methane in landfill gas captured for combustion in a year [m^3/y]
Q_{flared} is the quantity of methane in landfill gas flared from the landfill in a year [m^3/y]
Q_{tr} is the quantity of methane in landfill gas transferred out of the landfill in a year [m^3/y]
OF is the oxidation factor for near-surface methane and is equal to 0.1.

Emissions from flared landfill gas will follow the calculations for fuel combustion (Sec 5.19 of the NGER Technical Guidelines).

If the landfill is used for biological treatment of solid wastes, Equation 3 must be used (Sec 5.22 of the NGER Technical Guidelines).

$$E_{ij} = (M_i \times EF_i) - R \qquad \text{(Eq. 3)}$$

In Equation 3:
E_{ij} is the emissions of GHG j from fuel i [t CO_2e/y];
M_i is the mass of waste treated by biological treatment type i for a year [t/y]
EF_i is the emission factor of the fuel i for the GHG j [kg CO_2e/GJ]
R is the amount of methane recovered from the landfill from the biological treatment of solid waste for a year [t CO_2e/y], for N_2O, R is zero.

For wastewater handling facilities, Equation 4 is appropriate to estimate the methane emissions (Sec 5.42 of the NGER Technical Guidelines).

$$E_j = \left[CH_4^* - \gamma\left(Q_{cap} + Q_{flared} + Q_{tr}\right)\right] \qquad \text{(Eq. 4)}$$

In Equation 4:

E_j is the emissions of methane [t CO_2e/y]
CH_4* is the estimated quantity of methane in sludge biogas in a year [t CO_2e/y]
γ is the conversion factor 6.784 x 10^{-4} x 25 to convert cubic meters to tonnes CO_2e
Q_{cap} is the quantity of methane in sludge biogas captured for combustion in a year [m^3/y]
Q_{flared} is the quantity of methane in sludge biogas flared from the plant in a year [m^3/y]
Q_{tr} is the quantity of methane in sludge biogas transferred out of the plant in a year [m^3/y]

Emissions from flared sludge biogas will follow the calculations for fuel combustion.

8.1.2 Determining Eligibility for the Emissions Reduction Fund (ERF)

The eligibility of projects as emission reduction activities are described in methodology determinations (or "methods") prepared by the Department of the Environment. If a project falls under any of these methods, entities are eligible to apply for the project to be considered for claiming carbon credits with the Clean Energy Regulator (Clean Energy Regulator, 2018).

The complete list of methods are published on the federal Department of the Environment and Energy website and includes activities in the following sectors:

- Agriculture, including beef cattle herd management, carbon sequestration in soil, and reducing GHG emissions from beef cattle
- Energy efficiency, including industrial electricity
- Facilities
- Mining, oil and gas
- Transport
- Vegetation management, including savannah fire management
- Waste and wastewater

ERF-eligible activities with on-farm applications have been supported by the National Livestock Methane Program (NLMP). Off-farm applications such as wastewater treatment and new renewable energy projects are also considered here. The following table provides a pre-screening of projects for the estimation of values related to acquiring carbon credits from projects in the scope of the ERF. The resulting values should not be considered as basis for referring to a project as a qualified ERF project, as this is decided by the Clean Energy Regulator. The values here are meant to be ex ante evaluations of the GHG reduction measures.

8.1.3 Determining Eligibility to Create Renewable Energy Certificates (RECs)

Renewable Energy Certificates are another potential benefit type for projects that result in generation of electricity using renewable energy sources. To create RECs, generating entities must be registered with the Clean Energy Regulator and follow reporting requirements. The generation of 1 megawatt-hour (MWh) of electricity create 1 large-scale generation certificate (LGC), which can be sold to retailers that surrender the LGCs to the Clean Energy Regulator (Department of the Environment and Energy, 2018)

Table 7. Emissions Reduction Fund Applicability Screening Table

Project Requirements
All
Minimum reduction of 2000 t CO_2e/y on average over project life
Project has not commenced (i.e. prior to final investment decision, construction, or other actions described in subparagraph 27(4C) of the Carbon Credits (Carbon Farming Initiative) Act 2011) prior to registration with the Clean Energy Regulator
Project or resulting emissions reduction is not to done to comply with law
Project is not a result of another government programme (e.g. state energy saving scheme)
Wastewater (Department of the Environment and Energy, 2015)
Replacing a lagoon existing before 24 Apr 2014, treating domestic, commercial or industrial wastewater, must be a deep open anaerobic lagoon (> 2 metres, biological treatment of waste through anaerobic digestion, no methane capture)
The replacement project involves an anaerobic digester (i.e. covered lagoon or engineered biodigester) that captures the biogas generated
The replacement project includes a combustion device (i.e. boiler, internal combustion engine, or flare with at least 98% destruction efficiency) that combusts the biogas captured
Industrial Electricity and Fuel Efficiency (Department of the Environment and Energy, 2015)
A project that involves one or more of the following: - Modifying, removing or replacing existing energy-consuming equipment - Installing energy-consuming equipment as part of replacing, modifying or augmenting existing energy-consuming equipment - Changing the way existing energy-consuming equipment is controlled or operated - Changing the energy sources or mix of energy sources used by existing energy-consuming equipment - Modifying, installing, removing or replacing equipment that affects the energy consumption of existing energy-consuming equipment - Installing equipment that generates electricity at a location where existing energy-consuming equipment consumes electricity obtained from an electricity grid and the electricity generated by the installed equipment will be used in substitution for the electricity obtained from an electricity grid '*Energy-consuming equipment*' refers to equipment that consumes electricity or consumes fuel to produce electricity, useful physical work, or cooling, heat or steam for use.
The total of all electricity generated at the location is not 30 MW or more according to manufacturer's nameplates
The location has no capacity to export electricity to the grid
The project does not involve a vehicle or aircraft that could be covered by a project under other methodology determinations (i.e. Land and Sea Transport or Aviation)
The project does not use biomass that is not an eligible renewable energy source according to the Renewable Energy (Electricity) Act 2000. Eligible biomass includes energy crops, wood waste, agricultural waste, waste from processing of agricultural products, food waste, food processing waste, bagasse, black liquor, biomass-based components of municipal solid waste, landfill gas, sewage gas and biomass-based components of sewage, and other eligible biomass prescribed elsewhere. The project does not use fossil fuels and biofuels or materials or waste products derived from fossil fuels.
The project does not use off-grid electricity, heat, steam or cooling produced using ineligible biomass

8.2 SCSP Project List

Projects in the scope of this evaluation; MLA Program: Environmental Sustainability, MLA Sub Program: Sustainability (Off Farm)

Project Title	SAP Code	Product link
Investigation into a Concentrated Solar Thermal technology for Australian Feedlots	P.PSH.1074	Concentrated solar thermal (CST) steam system
Demonstration of a Concentrated Solar Thermal technology in the Australian Red Meat Industry		Concentrated solar thermal (CST) steam system
Development of an Australian RMI Energy Cost Reduction Application		Red meat industry energy cost reduction calculator
Evaluation of an electro-coagulation tec	P.PIP.0567	Electro-coagulation technology for removing Total Phosphate (TP)
NCMC energy & wastewater options assessment for energy self-sufficiency	P.PIP.0566	Abattoir Waste to Energy Assessment
Development and demonstration of an insect larvae production facility to produce insect-based protein for aquaculture feed from abattoir waste		Black soldier fly larvae (BSFL) feed production
Investigating centralised co-digestion of red meat processing and municipal waste	P.PSH.0945	Biosolids anaerobic digestion process (reactor)
Review of renewable energy technology adoption within the Australian Red Meat Industry	V.SCS.0003	Renewable Energy Assessment
Demonstration of an industrial microgrid as a means of enabling red meat processing facilities to operate independently of mains electricity	P.PIP.0745	PV Solar and Battery Tech (Microgrid)
Abattoir waste to revenue	P.PSH.0855	Black soldier fly larvae (BSFL) feed production
Development of a sustainable energy strategy for Kilcoy Pastoral Company	P.PIP.0739	Biosolids anaerobic digestion process (reactor)
Quantifying the impact of MLA's Supply Chain Sustainability Program in contributing the Australian Red Meat Industry's Social License to Operate	V.SCS.0006	Sustainability Strategy
Investigation into alternative wastewater treatments options for a large beef processing facility	P.PIP.0730	Covered Anaerobic lagoons (CALs)
Churchill Abattoir wastewater characterisation	P.PIP.0732	Water efficiency & recycling
Feasibility study into biogas fuelled co-generation at TFI Murray Bridge	P.PIP.0733	Co-gen CBA Model
Utilising Environmental Upgrade Agreements to drive investment in solar farming at Australian Abattoirs	P.PIP.0735	PV Solar and Battery Tech (Microgrid)
Conversion of biomass to renewable energy at a feedlot	P.PSH.0836	Biosolids anaerobic digestion process (reactor)
General feasibility review of an automated bio-energy and waste water treatment plant (Phase 1)	P.PIP.0547	Biosolids anaerobic digestion process (reactor)

Project Title	SAP Code	Product link
DAF Float Processing and Hydrocyclone Trial	P.PIP.0545	Hydrocyclone for wastewater primary treatment
Oakey Beef Exports Water Resource Sustainability	P.PIP.0538	Water efficiency & recycling
Feasibility of Recovery and Recycling to demonstrate water re-use strategies across ACC's feedlot and production operations.	P.PIP.0525	Water efficiency & recycling
Rendering Cooker Flash Steam Recovery	P.PIP.0521	Rendering Cooker Flash Steam Heat Recovery
Cost-Benefit Analysis and Preliminary Design of Energy Technologies for Opal Creek Feedlot (OCFL) and Emissions Reduction Fund Opportunities	P.PIP.0526	Biosolids anaerobic digestion process (reactor)
Feasibility of an Integrated and Automated Bio-energy and Waste Water Treatment Plant	P.PIP.0508	Biosolids anaerobic digestion process (reactor)
Value from Solid Waste Strategy for South-East Queensland Meat Processors	P.PSH.0768	Biosolids anaerobic digestion process (reactor)
Environmental value chain innovation RD&A strategy for the Australian Red Meat Industry	V.SCS.0001	Sustainability Strategy
Anaerobic Ammonium Removal (AAR) Waste Water Treatment Facility	P.PIP.0497	Bio-remediation of wastewater
Teys Australia Wastewater recycling Risk Assessment	P.PIP.0516	Water efficiency & recycling
Development of a prototype odour test rig concept to characterise and manage odour	P.PIP.0472	Odour sampling test rig
Developing Stanbroke Beef's capabilities in assessing and implementing a refrigeration optimisation plan	P.PIP.0458	Energy efficient refrigeration
Base line energy consumption analysis and development of Stanbroke Beef's energy optimisation plan	P.PIP.0457	Beef Processing Plant Energy Assessment
Investigating potential benefits of biomass recirculation in a covered anaerobic lagoon	P.PIP.0460	Covered Anaerobic lagoons (CALs)
Development and application of the anaerobic digester for the biological degradation of meat processing effluent	P.PIP.0430	Biosolids anaerobic digestion process (reactor)
Oakey Abattoir methane capture storage & re-use	P.PIP.0398	Biosolids anaerobic digestion process (reactor)
Design measurement and verification of wastewater emissions reduction and biogas capture to offset Natural Gas/Coal consumption	P.PIP.0348	Covered Anaerobic lagoons (CALs)
Techno-economic evaluation of EEI self-regulating suspended biogas collectors (EEI- SSBC) for abattoirs	P.PIP.0486	Biosolids anaerobic digestion process (reactor)
Feasibility Study of Organic Waste Value Adding and Cost Reduction	P.PIP.0477	Biosolids anaerobic digestion process (reactor)
Feasibility Study for Alternative Boiler Fuels	P.PIP.0429	Renewable Energy Assessment

8.3 Impact Evaluation Tool User Guide

An impact evaluation tool was developed in Microsoft Excel as part of this project. The workbook does not contain macros and has minimal links to internet websites. The workbook is composed of 11 spreadsheets. Sheet tabs are coloured for convenience. Orange tabs represent sheets that contain information. These do not require input, except for the DataSourceLog sheet. The yellow tab was assigned to ProjectSum sheet, which summarises the information contained in the workbook. Blue tabs are for the impact summary sheets. Lastly, green tabs are for the specific aspect group spreadsheets. The sheets are explained in detail in the following sections.

<u>How to Use This Workbook</u>

1. Go to **START** for general instructions to understand the workbook.
2. Go to **ProjectSum** to enter project/product information and scope in relevant aspects. **ProjectSum** specifies which sheets need data based on scoped-in aspects.
3. Proceed to the relevant sheets and enter data. Take note of required values. Some sheets allow for a "supplied" data calculation of impact per unit. This refers to data per hot standard carcass weight (HSCW) or per head input of impacts. If this option is chosen, the user is required to supply the number of units per year. Choosing the "calculate" option requires more data as explained in the following sections.
4. Check if the sheets calculate the values properly in the summary section in each sheet. The summary section is usually on the upper right hand corner of the sheet, except for **CBA**, where it is on the lower left corner.
5. The last sheet to be completed will be **CBA**, since it requires inputs from the other sheets.
6. Also check back on **ProjectSum** since it will also indicate the data status and the summary of economic indicators.

Notes:

- Some sheets will have a functionality to exclude values that may be extraneous to the relevant calculations. Feel free to use these to assist in analysing the results.
- Some sheets will also allow for calculating the amount and percent change by specifying a current or past value as a reference. The amount change may also be an input to the **CBA** sheet.
- Some help text is available in comments on cells marked with a red triangle on the upper right hand side of the cell.

<u>Spreadsheets</u>

START

This sheet contains the instructions and cell guide for the workbook. It also indicates the date of last update to guide the user on the currency of data and calculation methods in the workbook. There is no expected input for this sheet. This sheet contains the guide for different cell colours in the workbook as follows:

Appearance	Type	Function
	Choice input	These cells require an "x" to indicate a positive response. These are usually restricted such that only "x" is accepted, and only one choice can be chosen. The use of "x" is important due to the coded formulas. Upon entering x, the cell is filled with yellow to indicate a choice.
	Freeform input	Any form of input can be entered in these cells. Errors can occur in calculations if the data entered do not agree with the formula.
	Dropdown list input	These cells require a selection from a predefined list of inputs. These lists are defined in the Vald sheet. Population of these cells usually trigger a calculation for other cells.
	Calculation cell	These cells contain formulas that process inputs. These cannot be edited without removing sheet protection.

ProjectSum

Purpose: This sheet provides the information about the project or product and scopes in aspects that are relevant. It provides a summary of the results of the evaluation.

Required inputs: Aspect Scoping. Indicate scoped-in aspects by typing an "x" on the choice input boxes (col B). The selections are highlighted and the required data (col G) appears. For help with aspect definitions, hover over the red markers. When the aspect is selected, the status of data entry is also indicated in column L, as well as the calculated unit measures in column N.

The aspect choices are:

- Greenhouse Gas Emissions
- Water Use
- Wastewater
- Energy Use
- Solid Waste Emissions
- Employment Generated
- Air emissions
- Others

Optional inputs: Project information, product type, unit basis. The unit basis values (if selected) are used in calculating Unit Measures (col N), but if not filled, the Unit Measures default on a per year basis Economic indicators are shown in rows 33-36. The inputs in this sheet do not affect inputs in other sheets.

Outputs: Summary of evaluation.

CBA

Purpose: This sheet calculates the economic indicators by pulling data from other spreadsheets, or from manual inputs. This sheet is heavily operated by formulas, making required inputs important.

Costs and Benefits section

Required inputs:

- Basis. Typically the basis is year, since most of the other sheets calculate yearly values. However, there is an option to calculate based on a day rate. If "Day" is chosen, the number of operating days/year should be filled.
- Aspect identification. Choose the relevant aspects from the dropdown list. "Product revenue or cost" was also included for any product-based revenue or cost. Upon selection of Aspect cells in the specified aspect row calculate the values relevant to the aspect.
- Rate. The rate is usually the $/unit value that calculates the monetary value of the aspect. Ensure that the rate specified agrees with the units shown. If a different value in a different unit is available, a calculation outside of the tool can be done to align the units and values. Otherwise, the rows at the bottom of the table can be used since the units are free text.
- Net Annual Operating Cost. Unless the operating costs are already inherently included in the aspect values (e.g. product revenue is an amount net of production costs), this is required to make an accurate calculation.
- Reported CAPEX. This is a major required value to properly calculate the economic indicators.
- R&D Costs (Project, Year and Cost). These values are used to calculate the benefit cost ratio. The Year entry is used to get the present value (to the specified Year 0 in *Cash Flows*) of the R&D cost. The Project field is for information.
- Adoption List (Firm/Installation, Year Installed). These values are used to calculate the cash flow as it considers the number of installations over the study period.

Optional inputs:

- State
- Operating days/year. Only if Basis is "Day".
- Description of benefit or cost. Not required but important to keep track of calculated values.
- Amount (Manual Input). Required only if there are no values in other sheets, or if calculated values do not agree with units. Calculation formulas can be used, i.e. if converting a calculated value to a different unit.
- Other Economic CF/yr. Only if there are other cash flows that do not fit with aspects or operating costs. Particularly useful for modelling cases.
- Exclude in R&D. If this is ticked, the amount for that row will not be included as an R&D investment.
- Exclude cost/benefit. This is useful for case studies or quick exclusion of items that are not relevant but still need to be reflected on the table.

Cash Flows section

Required inputs:

- Inflation (rate). This is used to calculate the inflated cash flows for each year.
- Discount (rate). This is used to calculate the discounted cash flows for each year.
- Lifespan (years). This is used in calculating the cash flows over the installation lifespan.
- Start Year. Enter the year in YYYY format. This is used as basis for the cash flow calculations.
- Adoption Model. The options are "Constant" and "Variable". By default, the adoption is calculated as "Variable" using the default value of 0 facility at year zero, unless the adoption list is filled up.
- [For "Constant" Adoption] Adoption rate. The rate is expressed in terms of years between installations. If the adoption is rapid (i.e. more than 1 installation per year), then a fractional rate can be used (i.e. rate = 0.5, 2 installations per year).
- [For "Constant" Adoption] First Installation Year. The specified year is used to calculate the periods between adoption specified in the adoption rate.

Optional inputs:

- Exclude capital cost. If this is ticked, the capital cost will not be included as a cost in the cash flow array.

Outputs:

- Cash flow array (P18:AP26)
    - Actual cumulative installations. Calculated number of installations for each year.
    - BTCF. Before tax cash flow. This is the sum of net annual benefit, net operating cost and other annual cash flows, multiplied by the number of current installations.
    - Capital cost. This is the specified/reported CAPEX and occurs as a multiple of installations specified for each year.
    - Inflated BTCF. This is calculated as the net of BTCF and CAPEX for each year (as applicable), multiplied by an inflating factor $(1+r)^i$, where r is the inflation rate and i is the number of years from start year.
    - Discounted CF. This is the discounted value of the yearly cash flow. It is calculated by multiplying the inflated BTCF with a discounting factor $(1+d)^{-i}$, where d is the discount rate and i is the number of years from start year.
    - Cumulative PV. This is the cumulative present value for year i. This is calculated by adding the current Discounted PV to the running sum of cash flows from year i-1.

- Economic results (P2:R10). The study period was fixed up to 2040. The spreadsheet calculates only from specified start year to the "Max Study Year". The "Max Study Year" can be changed as required.
    - Total annual cash flow per Installation. This is similar to BTCF, but showing only for one installation.
    - Total MLA R&D Investment. This is the sum of all R&D project costs specified at the specified base year.
    - NPV (inflated) inc. R&D costs. This is calculated using the inflated cash flows and discount rate, including R&D costs spent at the base/start year.
    - IRR (inflated). This is calculated using the inflated and discounted cash flows. The result shows returns above the discount rate.
    - PV Benefits exc. R&D costs. This is the sum of all the discounted, inflated net benefits without R&D costs.
    - BCR. This is calculated as the ratio of PV Benefits and Total MLA Investment.

- Net Annual Benefit (ex CAPEX). Simple sum of revenue and operating costs.
- Annual CAPEX Cost. This is a simple annual CAPEX cost calculated by dividing total CAPEX by the lifespan of the equipment.
- Net Annual Benefit (inc CAPEX). This includes the annual CAPEX cost to the net annual benefit.
- Installation Payback (years). This presents a simple calculation of the number of years the net annual benefit goes towards recovering the CAPEX.
- R&D cost (PV). Sum of all R&D costs brought to the base/start year.
- Single Project BCR is also calculated when total installations = 1, which shows the BCR for one installation.

GHG Emissions

Purpose: This sheet calculates GHG emissions from fuel burning, waste management and electrical power use. Fuel burning and waste management are Scope 1 emissions and can be directly quantified and attributed to a GHG-producing activity. Power consumption is Scope 2 and it is more difficult to ascertain if the power produced has emitted a defined amount of GHG (since electrical energy is homogeneous as supplied and the source cannot be distinguished easily). The sheet estimates the GHG produced for fuel burning, waste management and electrical power as guided by the NGER Act guidelines.

GHG rate is a required input for this sheet. To calculate the GHG emissions using this spreadsheet, select "Calculate". If "Supplied" is selected, the GHG rate, unit basis and number of units per year are required inputs. Inputs in the Calculation section are only required if the activity applies. For instance, if the activity is heat production by burning fuels, then only the *Fuel Burning* section is required. If the activity is biogas-producing waste treatment, there is a prompt to consider the emissions for burning the biogas if applicable.

Calculation section
The Calculation section provides for calculating the new scenario impacts and the business-as-usual impacts. These automatically fill up the table that calculates the difference between the two cases and returns the difference value to **CBA**.

Required inputs:

- Fuel burning
  - Type of fuels. This is a dropdown list containing a number of fuels listed in the NGER Act. The fuel table reference is linked on D24 for convenience. When a fuel is selected "Form" and "Unit" is populated for that row, which indicates the unit of input required for the fuel. Some fuels have different unit specifications, which should be followed.
  - Amount used. For solids the amount is in tonnes, for liquids kilolitres and gases in cubic meters. When specified by the fuel type, ignore the unit on the "Unit" cell and enter "Amount Used" as specified in the fuel type (e.g. For liquefied petroleum gas, report quantities in kilolitres since the energy content and GHG constants are based in kilolitre amounts).

- Waste Treatment
  - Estimated methane generated (m^3/y). This can be calculated by other means or as reported.
  - Methane from landfill/wastewater combusted (m^3/y). Amount of methane burnt in the facility.
  - Methane from landfill/wastewater flared (m^3/y). Amount of methane sent to the flare.
  - Methane from landfill/wastewater transferred (m^3/y). Amount of methane stored or sent to another facility.

- Externally purchased power
  - State sourced. This is a dropdown list containing the state/territory areas for power sourced. This triggers the state emission factor for power.
  - Power. This is required to calculate the electricity-sourced emission estimates.

- GHG Change. This section automatically calculates based on new scenario and business-as-usual input and is linked to the **CBA** sheet.

Optional inputs:
- Calculation notes. This space is included to record any pertinent notes in calculation to assist in understanding the calculation method.

Outputs:
- GHG Emissions Summary. The calculated GHG emissions are summarised in I12:L20. The values are given in tonnes CO_2 equivalent per year. Percentages are also shown. There is an option to exclude one or more activities by ticking the "Exclude" box on column N. The total GHG and scope 1 GHG are calculated at the bottom of the table.
- Amount change. The amount of GHG emissions with respect to the business-as-usual amount is calculated in cell V13:V20. This value in V19 (Scope 1 emissions) is transferred to the **CBA** sheet. A negative value for amount change indicates GHG emissions avoidance, and returns the absolute value to **CBA**. A positive value indicates an increase in GHG emissions and returns a zero value to **CBA**, since there is no perceived economic value in increased GHG emissions.
- Percent change. This is calculated using the amount change and total GHG emissions calculated in the sheet.

Water-WW

Purpose: This sheet records the changes in water use, wastewater treatment and water recycling. This sheet only considers changes in volumetric flows in kilolitre per year. Changes in wastewater quality produced are not documented. These can be entered as a cost avoidance or revenue in **CBA**. Or as a non-market impact in **NMI**.

Inputs: Water rate is a required input for this sheet. To calculate the water use and wastewater changes using this spreadsheet, select "Calculate". If "Supplied" is selected, the water rates, unit basis and number of units per year are required inputs. Inputs in the Calculation section are only required if the data is available. If only water use is relevant, then only Water In and/or Recycled Water are required. If only wastewater is relevant, only Water Out is required. If the activity is biogas-producing waste treatment, there is a prompt to consider the emissions for burning the biogas if applicable. Calculation notes is an optional input used for documenting calculation considerations.

Outputs: The water summary is indicated in I12:K16. This summarises the calculations in the spreadsheet. One or many quantities can be excluded in calculation by ticking the "Exclude" box with an "x" in column M. To calculate Water Use Change, supply the previous values in kilolitre per year. The Change (amount) is transferred to **CBA** if either Water Use or Wastewater is selected as an aspect.

Energy

Purpose: This sheet records the changes in energy use. The inputs here are similar to the **GHG Emissions** sheet, except for the waste treatment part. The calculations are multiplying the amount of energy used and the energy content of fuels. While it is understandable that fuels may have different energy contents depending on quality, source, etc., as a default the values in the NGER Act were used to provide a consistent approach. If the unit energy content is available, that can also be supplied to calculate total energy used. The consumption of electrical power is also documented in this sheet. Changes due to energy efficiency can be documented here. Similar to **GHG Emissions**, there is also a provision here to calculate new scenario and business-as-usual energy consumption. The difference between the two cases are calculated and automatically returned to **CBA**.

Inputs: As in **GHG Emissions**, the input required is the type of fuel and amount consumed per year. Unless indicated in fuel type, the units for Amount Used should follow the unit indicated in column G. If the fuel is different from the items in the list, the most similar fuel type can be chosen. A cell for supplying the energy content manually is also provided. When this is filled up, the total energy used is calculated using the manually supplied energy content. Otherwise, it reverts to using the NGER factors. Electrical power consumption is also an input, although unlike in **GHG Emissions**, the state from which electricity is sourced is not pertinent. Energy Change is automatically calculated from the values in new scenario and business-as-usual. The Amount Change in energy is transferred to the **CBA** sheet for valuation.

Outputs: The Energy Use summary is indicated in G14:J19. Either Fuel Burning or Power can be excluded in the summary by toggling the exclusion in column N. The energy from electrical power is converted from MWh to GJ using a factor of 3.6 GJ/MWh. Energy change calculations can be seen in V14:W19.

Solid Waste

Purpose: This sheet records the changes in solid wastes. The inputs here are similar to Water-WW except that all quantities in this sheet are all process outputs. This sheet requires the mass of solid wastes in kilograms per year. Changes in the condition of solid waste if for example, using a different solid waste treatment process are not documented in this spreadsheet. The implications of this condition or quality change can be documented in **CBA** if a cost is associated, or in **NMI**.

Inputs: Solid waste rate is a required input for this sheet. To calculate the total solid wastes using this spreadsheet, select "Calculate". If "Supplied" is selected, the solid waste rates, unit basis and number of units per year are required inputs. Inputs in the Calculation section are only required if the data is available. The inputs in the Calculation Section are the amounts of Organic and Inorganic Waste produced per year and the amounts treated in-house and disposed. Ideally, the total of organic and inorganic waste is equal to the total of treated and disposed. However, some processes might have complex set-ups, so complete balance may not occur. Waste Change is also calculated similar to other sheets. Previous values can be supplied and the Amount Change is calculated.

Outputs: The Solid Waste summary is indicated in I12:K17. Solid Waste categories can be excluded in the summary by toggling the exclusion in column M. The Treated% value is also calculated based on the amount solid waste treated against the total organic and inorganic waste generated. The outputs are reported in tons/year.

NMI

Purpose: This sheet records the other non-market impacts of the product or project. These are impacts that cannot be amalgamated with impacts that can be valued in existing markets.

Inputs:

- Quantitative
    - Aspect. This is similar to the selection in **CBA**, but with more aspect types available in the dropdown box. New aspects are Employment Generation and Air Emissions.
    - Description of cost or benefit. This is a free text field used to describe the impact related to the aspect chosen. This is a key field for this spreadsheet because it contains the definition of the cost or benefit being recorded.
    - Cost or Benefit. This is a dropdown box to indicate whether the impact is a cost or benefit.
    - Amount. In this cell, specify the amount of the impact.
    - Units. Specify the units for the amount. (e.g. full time equivalent, FTE)
    - Unit Value. Indicate in this cell the value of the impact, as applicable.
    - Unit. Indicate the unit of the unit value (e.g. $ per FTE)
    - (Annual Value) Unit. Indicate the resulting unit for the annual value (i.e. unit/y)
- Qualitative
    - Aspect. Similar to the Quantitative section, the aspect can be selected through the dropdown list.
    - Description of cost or benefit. This is a free text field used to describe the impact related to the aspect chosen. This is a key field for this spreadsheet because it contains the definition of the cost or benefit being recorded.

Outputs: The only output for this sheet is the calculated annual value of the non-market impact. Some impacts will not have a directly calculable value, so the annual value for those impacts can be blank. The main output for these impacts will be the quantities stated. Other outputs will be the list of qualitative impacts and narratives of their effects.

DataSourceLog

Purpose: This sheet records additional data sources that are used while filling up the spreadsheets. This assists in keeping track of the data used in calculations.

Inputs: The only inputs are data type and source. There are no restrictions in input, and the information in this sheet are not referenced anywhere.

Outputs: No special output. This is for the user's reference only.

Data

This spreadsheet contains the data inherent to this spreadsheet. It is advised not to alter the data in this spreadsheet to maintain the integrity of calculations. Alterations in case of changes should be documented.

The data included in this sheet are:

- List of fuels, energy contents and GHG emission factors (National Greenhouse Accounts Factors 2017)
- Scope 2 Power GHG emission factors (National Greenhouse Accounts Factors 2017)
- Poisson table p values for r=1.0 to r=5.0 (currently unused)

Vald

This spreadsheet contains the lists used in dropdown boxes and look-ups in the other sheets. It is advised not to alter the data in this spreadsheet to avoid errors.

Screenshots of Impact Evaluation Tool (sample calculations for illustration purposes only)

Scoping (ProjectSum)

Aspect Scoping (x to scope in) *Hover over red markers for help on aspects*

		Required data:	Status
x	Greenhouse Gas Emissions	Greenhouse Gas Emissions Estimation Worksheet	DONE
	Water Use		N/A
	Wastewater		N/A
x	Energy Use	Energy Use Estimation Worksheet	DONE
	Solid Waste Emissions		N/A
	Employment Generated		
	Air emissions other than GHG		
	Others		

Economic calculations (CBA)

Aspect	Values In Workbook?	Description of Benefit or Cost	Amount (Calculated)	Amount (Manual Input)	Units	Rate	Unit	Total Unit Value	Unit	Annual Value	Unit	Excl
Greenhouse Gas Emissions	NO VALUES		36508.903		tCO2e/y		$/t	$ -	$/y	$ -	$/y	x
Energy Use	NO VALUES			463314.400	GJ/y	10	$/GJ	$ 4,633,144.00	$/y	$ 4,633,144.00	$/y	
									$/y		$/y	
									$/y		$/y	
									$/y		$/y	
									$/y		$/y	
									$/y		$/y	
									$/y		$/y	
									$/y		$/y	
									$/y		$/y	
Other								$ -	$/y	$ -	$/y	
Other								$ -	$/y	$ -	$/y	
Other								$ -	$/y	$ -	$/y	

Gross Annual Benefit	$ 4,633,144.00	$/y
Gross Annual Operating Cost	$ 500,000.00	$/y
Net Annual Benefit (ex CAPEX)	$ 4,133,144.00	$/y
Other Economic CF/yr		
Reported CAPEX	$ 8,000,000.00	
Annual CAPEX Cost	$ 400,000.00	$/y
Net Annual Benefit (inc CAPEX)	$ 3,733,144.00	$/y
Installation pay back (years)	1.94	
R&D cost PV	$ 519,750.00	
Single Project BCR (NPV/CAPEX)	6.66	

R&D Costs

Project	Year	Cost	PV Cost	Exclude in R&D
Project A	2017	$ 150,000.00	$ 157,500.00	
Project B	2016	$ 250,000.00	$ 275,625.00	
Project C	2017	$ 82,500.00	$ 86,625.00	
			$ -	
			$ -	
			$ -	
			$ -	
			$ -	
			$ -	

	START	
Year YYYY	2018	
Year i	0	
Calculation Row		
Actual Cumu Installations	1	
Before Tax Cash Flow (BTCF)	-$ 519,750	$
Capital Cost	-$ 8,000,000	$
Inflated BTCF	-$ 8,519,750	$
Discounted Cash Flows	-$ 8,519,750	$
Cumulative Present Value	-$ 8,519,750	-$
Adoption Model	Variable	
Constant Rate Adoption		
Adoption Rate (Years bet Inst)		
Adoption Rate (Inst/y)	#DIV/0!	
First Installation Year		
Exclude capital cost		
Variable Adoption Model	(Fill up Adoption Table)	
Year	2018	
Firms Adopting in Year	1	

GHG Emissions calculation based on NGER conversions (GHG Emissions)

Inputs

GHG rate

x	Calculate	> Go to Calculation Section		
	Supplied	> Supply CO2 rate & # of units		t CO2e/unit

Unit basis / **Number of units**

x	Hot standard carcasse weight >>>	90000	tonne HSCW/y
	Head of cattle/sheep >>>		heads/y

GHG Emissions Summary			Percent
Fuel Burning	37,926.9	tCO2e/y	100.0%
Landfilling	-	tCO2e/y	0.0%
Wastewater	-	tCO2e/y	0.0%
Power	-	tCO2e/y	0.0%
Total GHG	37,926.9	tCO2e/y	100.0%
Scope 1 GHG	37,926.9	tCO2e/y	100.0%
GHG Intensity	421.41001	kgCO2/unit	

Calculation - Supply data on a per year basis

Fuel burning FUEL TABLE FOR FULL LIST OF FUELS

Type of fuel/s	Form	Amount Used (unit/y)	Unit	Energy Content (GJ/y)	CO2 emissions (t CO2e/y)	CH4 emissions (t CO2e/y)	N2O emissions (t CO2e/y)	Total GHG (t CO2e/y)
Bituminous coal	Solid	10,000.00	tonne	270,000.00	24,300.00	8.10	54.00	24,362.10
Natural gas distributed in a pipeline	Gas	8,000.00	cubic metre	314.40	16.16	0.03	0.01	16.20
Diesel oil	Liquid	5,000.00	kilolitre	193,000.00	13,490.70	19.30	38.60	13,548.60

Water Use calculation (Water-WW)

Calculation notes: Total water calculation after trial A

Inputs

Water rate

x	Calculate	> Go to Calculation Section		
	Supplied	> Supply water rate & # of units	11000	kL fresh water/unit
				kL wastewater/unit
				kL recycled water/unit

Unit basis / **Number of units**

x	Hot standard carcasse weight >>>	600	tonne HSCW/y
	Head of cattle/sheep >>>	100	heads/y

Summary			Exclude?
Water Use	181,808.2	kL/y	
Wastewater	72,345.2	kL/y	
Recycled	18,927.1	kL/y	
Recycling %	10.4%		

Water Use Change

Previous values (kL/y)	%change
213,522.00	-15%
77,882.00	-7%
-	NO PREVIOUS RECYCLING

Calculation - Supply data on a per year basis

Water In

Water inlets	Amount Used (kL/y)
Inlet A	18,927.06
Inlet B	52,326.10
Inlet C	110,555.00
TOTAL	181,808.16

Recycled Water

Recycling Amounts	Amount Recycled (kL/y)
Recycling Plant A	18,927.06
TOTAL	18,927.06

Energy Use calculation (Energy)

Inputs

Energy rate

x	Calculate	> Go to Calculation Section	
	Supplied	> Supply energy rate & # of units	GJ/unit

Unit basis	*Number of units*
Hot standard carcasse weight >>>	tonne HSCW/y
Head of cattle/sheep >>>	heads/y

New Scenario Summary		Percent	Exclude?
Fuel Burning	476,510.0 GJ/y	100.0%	
Power	- GJ/y	0.0%	
Total Energy	476,510.0 GJ/y	100.0%	

Business-as-Usual Summary		Percent	Exclude?
Fuel Burning	463,314.4 GJ/y	97.2%	
Power	- GJ/y	0.0%	
Total	463,314.4 GJ/y	97.2%	

Calculation – Supply data on a per year basis

Fuel consumptio FUEL TABLE FOR FULL LIST OF FUELS

Type of fuel/s	Form	Amount Used (unit/y)	Unit	[Manual Input] Unit Energy Content (GJ/unit)	Energy Content using NGER factors (GJ/y)
Sludge biogas that is captured for combustion (methane only)	Gas	7,500,000.00	cubic metre		282,750.00
Biodiesel	Liquid	5,600.00	kilolitre		193,760.00

Business-as-Usual

Fuel consumption FUEL TABLE FOR FULL LIST OF FUELS

Type of fuel/s	Form	Amount Used (unit/y)	Unit	[Manual Input] Unit Energy Content (GJ/unit)	Energy Content using NGER factors (GJ/y)
Bituminous coal	Solid	10,000.00	tonne		270,000.00
Natural gas distributed in a pipeline	Gas	8,000.00	cubic metre		314.40
Diesel oil	Liquid	5,000.00	kilolitre		193,000.00

Solid Waste calculation (Solid Waste)

Calculation notes: Total waste calculation for case prior to implementation

Inputs

Solid waste rate

x	Calculate	> Go to Calculation Section	
	Supplied	> Supply water rate & # of units	tonne organic solid waste/unit
			tonne inorganic solid waste/unit
			total tonne waste treated/y
			total tonne waste disposed/y

Summary		Exclude?
Organic	83.3 t/y	
Inorganic	110.6 t/y	
Treated	18.9 t/y	
Disposed	18.9 t/y	
Treated %	9.8%	

Waste Change

Previous values (t/y)		%change
200.00	116.74	-58%
35.00	75.55	216%
52.00	33.07	-64%
90.00	71.07	-79%

Unit basis	*Number of units*
Hot standard carcasse weight >>>	tonne HSCW/y
Head of cattle/sheep >>>	heads/y

Calculation - Supply data on a per year basis

Organic waste Produced

Organic wastes	Amount Used (kg/y)
Process A	18,927.06
Process B	52,326.10
Side-process C	12,011.00
TOTAL	83,264.16

Wastes Treated In-house

Treated Waste Amounts	Amount Treated (kg/y)
Landfill	18,927.06
AD reactor	
TOTAL	18,927.06