AMPC
AUSTRALIAN MEAT PROCESSOR CORPORATION

Economic impact assessment of 10 projects completed in 2023/24

AMPC Impact Assessment Program – FY20-24

Milestone 24: (Year 5 Task 4)

Project Code
2021-1044

Prepared by
GHD Pty Ltd

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Contents

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Abbreviations

AMPC	Australian Meat Processor Corporation
APCO	Australian Packaging Covenant Organisation
AMIC	Australian Meat Industry Council
BCR	Benefit Cost Ratio
CEFLEX	Circular Economy for Flexible Packaging
CRRDC	Council of Rural Research and Development Corporations
DAFF	Department of Agriculture, Forestry and Fishing
DiVA	Data-integrated Visualization and Analytics
EIDs	Electronic Identification Devices
FMD	Foot and Mouth Disease
IMF	Intra Muscular Fat
IoT	Internet of Things
IRR	Internal Rate of Return
MIRR	Modified Internal Rate of Return
MLA	Meat & Livestock Australia
MSA	Meat Standards Australia
NPV	Net Present Value
O&M	Operation and Maintenance
OH&S	Occupational Health and Safety
PPE	Personal Protective Equipment
PV	Photovoltaics
R&D	Research and Development
RD&E	Research, Development and Extension
RDC	Research and Development Corporation
RFID	Radio Frequency Identification Devices
RMAC	Red Meat Advisory Council
RMP	Red Meat Processing
VR	Virtual Reality
WHS	Workplace Health and Safety

1.0 Introduction

This report presents the results of 10 ex-post impact assessments completed on a representative sample of AMPC projects finalised during the 2023/2024 financial year.

Evaluations were completed in line with the Council of Rural Research and Development Corporations (CRRDC) *Impact Assessment Program: Guidelines* (2018). They were informed by a desktop review of project outputs, literature review and consultation with researchers, industry representatives and other relevant stakeholders.

The results provide an objective and independent assessment of the qualitative and quantitative outcomes likely to be realised from the evaluated projects. Where necessary, the evaluations rely on informed estimates of unknown parameters, such as economic benefits from practice change, potential rates of adoption and attribution of benefits.

2.0 Project Objectives

Specific objectives of this impact assessment were:

1. To provide an assessment, in line with the CRRDC Impact Assessment Guidelines, of a representative sample of AMPC investments completed between 1 July 2023 and 30 June 2024.
2. To collect, on behalf of AMPC, relevant industry data to support an understanding of industry issues, and the delivery of future investments.
3. To identify and analyse key drivers of investment success, including investment outputs, industry awareness, industry adoption, cost of adoption, adoption benefit, benefit attribution.
4. To identify and analyse key lessons learned, for future investments.
5. To identify and outline key messages relevant for service providers, AMPC members and key stakeholder groups (including MLA, AMIC, RMAC and the Commonwealth Government).

3.0 Methodology

Economic impact evaluation

As per the *CRRDC Impact Assessment Program: Guidelines* (2018) GHD considered and modelled the project case (with project scenario) against the counterfactual (without project scenario) to determine the likely change in net economic benefit and, therefore, return on investment.

GHD reviewed project reports and outputs, and consulted with key stakeholders, to determine reasonable assumptions for the following:

- Potential impact if/when project outputs and findings are utilised by industry;
- Likely rates of adoption over the coming years (adoption profile); and
- Attribution of benefits, i.e. the extent realised benefits are attributable to the project investment, as separate from previous related research, future implementation costs and other factors.

Impacts were modelled over a 30 year timeline and discounted to present day amounts (applying a 5% discount rate) to determine the:

- Net Present Value of Benefits (NPV): Net benefits minus net costs;
- Benefit Cost Ratio (BCR): Net benefits divided by net costs;
- Internal Rate of Return (IRR): Interest rate at which the NPV of all the impacts from a project (both costs and benefits) or investment equal zero; and
- Modified Internal Rate of Return (MIRR): Similar to the above IRR, but assuming more realistic returns from reinvested benefits and financing of initial outlays (5% applied for both, as per CRRDC guidelines).

All past costs and benefits were expressed in 2023/2024-dollar terms using the Implicit Price Deflator for GDP. The AMPC components of project investment costs were all multiplied by a factor of 1.1 to accommodate program management costs. All costs and benefits after 2023/2024 were discounted to 2023/2024 dollars using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a high level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2023/2024) to the final year of benefits assumed.

Sensitivity analysis was used to test results against changes to key assumptions and discount rates, for both individual projects and aggregate results. For each evaluation GHD also specified confidence ratings in terms of coverage of benefits and accuracy of assumptions.

Project selection

From a total population of 40 projects completed during the 2023/24 financial year, GHD removed any projects with a total budget of less than $100,000 as well as any projects considered unsuitable for evaluation (e.g. non-R&D related investments). From this remaining population, GHD independently selected 10 project (or cluster) investments for evaluation to ensure a balanced representation across AMPC program streams.

Table 1presents the 10 projects (or clusters) selected for evaluation. Note similar projects were clustered together for evaluation purposes:

Table 1 Selected Projects (or clusters)

Program Stream	Code	Project Name
1. Advanced Manufacturing	2020-1040	Hot Carcass Grading: Driving Quality Assurance and Processing Efficiency
	2023-1038	Beef Striploin Fat Removal - Stage 2B: Controlled Variable Thickness Robotic Fat Trimming
	2018-1050	In Plant Trial of Robotic Picking and Packing System
2. Sustainability	2021-1047	Low-cost Assessment and Arrangement of Solar PV Opportunities
	2022-1055	Diverting Packaging from Landfill – Business Scenario Study
	2023-1005	Transport Emissions, Efficiency and Sustainability Roadmap
3. People and Culture	2023-1061 2023-1062	Empowering Women in Maintenance Trades
4. Markets and Market Access	2023-1047	Beyond Border Analysis of Regulatory and Related Costs
	2024-1087	Kokumi Flavour Peptide Production from Beef Offal Co-Products
5. Products and Process Integrity	2022-1127 2022-1128 2022-1129 2022-1130 2022-1131 2022-1139	Smallstock Traceability Pilot Studies (5 plants) and Evaluation

Evaluation assumptions

Impact evaluations relied on assumptions adopted from:

- Industry data: e.g., plant numbers, throughput volumes, operating costs, prices and profitability;
- Targeted consultation with relevant researchers and project leaders; and
- The consultants informed judgement.

All results are subject to rounding error.

All assumptions and sources are referenced in the individual project evaluations (in Section 7.0 Appendices).

Investment

Table 2 below shows AMPC investment in the selected projects over the respective financial years. The total investment by AMPC (excluding overheads) in the selected projects was $3.2 million over the period 2019/20 to 2023/24, which represents 49% of the total investment by AMPC in projects completed in the 2023/24 financial year.

Table 2 AMPC investment into evaluated projects by year ($ nominal, excluding overheads)

Project Code	2019/20	2020/21	2021/22	2022/23	2023/24	Total
2020-1040	$100,000	$725,000	$425,000		$50,000	**$1,300,000**
2023-1038				$144,000	$101,700	**$245,700**
2018-1050	$88,000			$87,000	$27,500	**$202,500**
2021-1047			$161,200	$49,200	$16,400	**$226,800**
2022-1055			$79,155	$65,111	$12,542	**$156,808**
2023-1005				$240,000	$54,875	**$294,875**
2023-1061-1062				$46,240	$87,740	**$133,980**
2023-1047				$119,400	$8,000	**$127,400**
2024-1087					$142,085	**$142,085**
2022-1127-1131, 2022-1139			$170,829	$262,474	$100,921	**$534,224**
Total	$188,000	$725,000	$836,184	$1,013,425	$601,763	$3,364,372
Total projects completed in 2023/24 Financial Year						40 projects with total AMPC investment of $6.51M
Evaluated projects as a proportion of total projects completed in 2023/24						40% of projects 52% of budget

Note: Subject to rounding error

As noted in the methodology, the AMPC components of project investment costs were all multiplied by a factor of 1.1 in the analysis to accommodate program management costs.

Of the 10 selected projects/clusters, five received additional, documented, cash or in-kind contributions, as outlined in Table 3 below. No further management costs are added as it is assumed that these are factored into the contributions received from other partners.

Table 3 Other cash and in-kind investment into evaluated projects by year ($ nominal, excluding overheads)

Project Code	2019/20	2020/21	2021/22	2022/23	2023/24	Total
2020-1040	$219,230	$1,589,420	$931,730		$109,620	**$2,850,000**
2022-1055			$113,870	$93,670	$18,040	**$225,590**
2023-1005				$174,890	$39,990	**$214,870**
2023-1061-1062				$23,120	$43,870	**$66,990**
Total	**$219,230**	**$1,589,420**	**$1,118,050**	$291,680	$211,520	**$3,357,450**

Note: Subject to rounding error

Alignment with Australian Government Research Priorities

Table 4 below outlines the Australian Government's Rural Research, Development and Extension (RD&E) priorities (Commonwealth of Australia 2016), and the more recent National Agricultural Innovation Priorities, established in the National Agricultural Innovation Policy Statement (Commonwealth of Australia 2021).

Table 4 Australian Government Research Priorities

Rural RD&E Priorities	National Agricultural Innovation Priorities
1. Advanced technology 2. Biosecurity 3. Soil, water and managing natural resources 4. Adoption of R&D	1. Australia is a trusted exporter of premium food and agricultural products by 2030 2. Australia will champion climate resilience to increase the productivity, profitability and sustainability of the agricultural sector by 2030 3. Australia is a world leader in preventing and rapidly responding to significant incursions of pests and diseases through futureproofing our biosecurity system by 2030 4. Australia is a mature adopter, developer and exporter of digital agriculture by 2030

Table 5 below outlines how the evaluated projects broadly align with the above investment priorities.

Table 5 Project alignment with Australian Government Research Priorities

		Rural RD&E Priorities	National Agricultural Innovation Priorities
2020-1040	Hot Carcass Grading: Driving Quality Assurance and Processing Efficiency	1,4	1,2,4
2021-1047	Low-cost Assessment and Arrangement of Solar PV Opportunities	1,3,4	2
2022-1055	Diverting Plastics from Landfill – Business Scenario Study	1,3,4	2
2023-1038	Beef Striploin Fat Removal – Stage 2B: Controlled Variable Thickness Robotic Fat Trimming	1,4	1,2,4
2023-1047	Beyond Border Analysis of Regulatory and Related Costs	2,3	1,2,3
2018-1050	In Plant Trial of Robotic Picking and Packing System	1,4	1,2
2023-1061-1062	Empowering Women in Maintenance Trades	4	2
2022-1128-1131, 2022-1139	Smallstock Traceability Pilots (5 plants) and Smallstock Traceability Pilot Study Evaluation	1,2,4	1,3
2023-1005	Transport Emissions, Efficiency and Sustainability Roadmap	1,3,4	2
2024-1087	Kokumi Flavour Peptide Production from Beef Offal Co-Products	1,3,4	1,2

4.0 Results

Economic impact by project

The results for the 10 individual projects assessed are presented in Table 6.

Table 6 Results from impact evaluations (Total Project Investment including overheads, 30 years)

Project Code	Project Name	PV Costs ($m)	PV Benefits ($m)	NPV ($m)	BCR
2020-1040	Hot carcass grading: driving quality assurance and processing efficiency	$4.44	$34.50	$30.05	7.8
2021-1047	Low-cost assessment & arrangement of PV opportunities	$0.27	$1.98	$1.70	7.3
2022-1055	Diverting plastics from landfill – business case scenario	$0.41	$0.65	$0.24	1.6
2023-1038	Beef striploin fat removal – stage 2B: controlled variable thickness robotic fat trimming	$0.28	$1.5	$1.22	5.3
2023-1047	Beyond border analysis of regulatory and related costs	$0.15	$0.69	$0.54	4.6
2018-1050	In Plant Trial of Robotic Picking and Packing System	$0.25	$1.03	$0.78	4.1
2023-1061-1062	Empowering Women in Maintenance Trades	$0.15	$0.45	$0.29	3.0
2022-1127-1131, 2022-1139	Smallstock Traceability Pilot (5 plants) and Smallstock Traceability Pilot Study	$0.69	$0.87	$0.18	1.3
2023-1005	Transport Emissions, Efficiency and Sustainability Roadmap	$0.57	$3.38	$2.81	5.9
2024-1087	Kokumi Flavour Peptide Production from Beef Offal Co-Products	$0.16	$1.25	$1.09	8.0

Overall economic impact

The aggregated results from the ten projects modelled over 30 years from the last year of investment (2023/24) is presented in Table 7 below. The results suggest most of the net benefits will be realised in five to ten years' time. This is typical of rural R,D&E as innovations often take up to five years to become fully developed and adopted. After 10 years many innovations are likely to be superseded, or similar outcomes achieved, under the counterfactual scenario.

Table 7 Summary of overall results from evaluated projects

Years from project investment (2023/24)	0	5	10	15	20	25	30
Present value of benefits ($m)	-$3.72	$17.83	$39.76	$45.56	$45.87	$46.14	$46.29
Present value of costs ($m)	$7.37	$7.37	$7.37	$7.37	$7.37	$7.37	$7.37
Net present value ($m)	-$11.16	$10.39	$32.32	$38.12	$38.43	$38.70	$38.85
BCR (weighted average)		2.4	5.4	6.2	6.2	6.3	6.3

Figure 1 below shows the modelled flow of (undiscounted) costs and benefits from the evaluated projects. The results indicate benefits will peak briefly in 2028/29 and again in 2031/32. It is also worth noting that negative impacts are seen through benefits in the first years due to adoption costs.

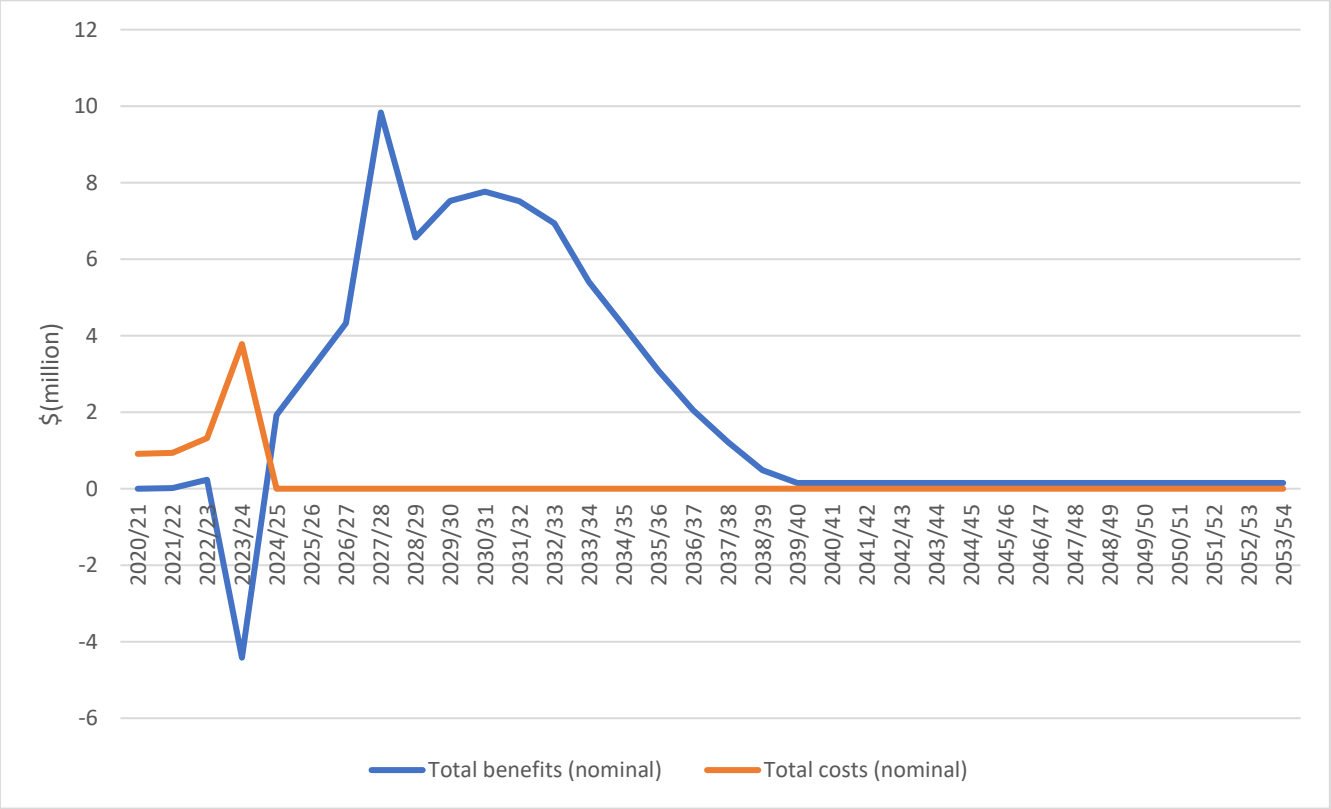

Figure 1 Flow of undiscounted costs and benefits from selected projects

Sensitivity Analysis

Table 8 shows how the overall economic impact results would change based on changes in the discount rate. The results show that even applying a discount rate of 10%, the projects would still deliver a positive NPV ($24.48M) and favourable BCR (4.4).

Additional sensitivity analysis was also undertaken for individual projects, adjusting both discount rates and assumed benefits once innovations are adopted. These results are detailed in the report appendices.

Table 8 Aggregated economic impact (total project investment, after 30 years) applying different discount rates

Discount rate	NPV ($M)	BCR
0%	$62.31	9.5
3%	$46.81	7.4
5%	**$38.85**	**6.3**
7%	$32.30	5.4
10%	$24.48	4.4

5.0 Discussion

There is a positive overall estimated economic return from the ten (10) evaluated projects (6.3 weighted average BCR over 30 years). This has been significantly impacted by the high investment, and in turn weighed average, for project 2020-1040 *Hot carcass grading: driving quality assurance and processing efficiency.* The weighted average without this project would be 4.0.

The overall estimated economic return from the ten evaluated projects (6.3 weighted average BCR over 30 years) is comparable with assessed returns from other RDC investments. An assessment of 111 RDC project cluster evaluations, between 2014 and 2019, found a slightly lower weighted average BCR of 5.5, with annual weighted average BCRs from 3.3 to 9.1 (Agtrans Research 2019).

Figure 2 below compares the weighted average BCR from this analysis with previous annual evaluations of AMPC core projects completed by GHD. This comparison shows that this year's results are close to the average over the period 2018/19 to 2023/24 of 6.5.

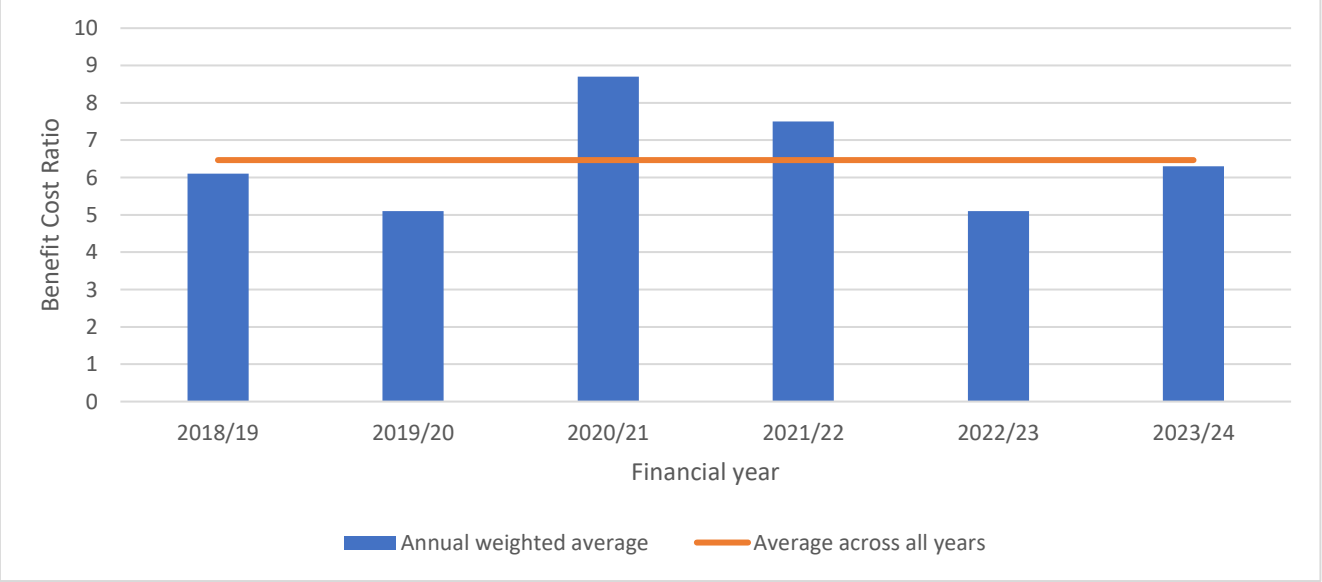

Figure 2 Weighted average BCR from annual evaluations of a sample of AMPC core projects (total investment, 30 years)

Overall, the results from the sample of evaluated projects suggests that AMPC R&D projects concluding in the 2023/24 financial year are likely to yield substantial economic benefits to processors, the larger red meat supply chain and the broader public over the coming years.

6.0 References

Agtrans Research (2019) *Cross-RDC Impact Assessment 2019*. Prepared for The Council of Rural Research and Development Corporations.

Council of Rural Research and Development Corporations (CRRDC) 2018, *Cross-RDC impact assessment program: guidelines.*

Council of Rural Research and Development Corporations (CRRDC) 2018a, *Cross-RDC Impact Assessment Program: Management Procedures*.

Additional references for each project assessment are outlined in appendices.

7.0 Appendices

Appendix	Project Code	Project Name
A	2020-1040	Hot carcass grading: driving quality assurance and processing efficiency
B	2021-1047	Low-cost assessment & arrangement of solar PV opportunities
C	2022-1055	Diverting plastics from landfill – business scenario study
D	2023-1038	Beef striploin fat removal – Stage 2B: controlled variable thickness robotic fat trimming
	2021-1077	Beef Striploin Fat Removal – Stage 2A: twin-head laser and ultrasonic 3D fat-lean boundary profiling subsystem
	2016-1032	*Technology Evaluation for Fat Removal for Beef Striploins*
E	2023-1047	Beyond border analysis of regulatory and related costs
F	2018-1050	In Plant Trial of Robotic Picking and Packing System
	2017-1065	*Integrated Robotic Picking and Packing of Primal Cuts*
	2014-1007	*Development of Primal Cut Recognition and Localisation Software for Use in Robotic Pick and Pack Systems*
G	2023-1061-1062	Empowering Women in Maintenance Trades
H	2022-1127-1131, 2022-1139	Smallstock Traceability Pilots (5 plants) and Smallstock Traceability Pilot Evaluation
I	2023-1005	Transport Emissions, Efficiency and Sustainability Roadmap
J	2024-1087	Kokumi Flavour Peptide Production from Beef Offal Co-Products

7.1 Appendix A: 2020-1040: Hot Carcass Grading: Driving Quality Assurance and Processing Efficiency

Background

The development of Meat Standards Australia (MSA) guidelines has created a comprehensive set of standards and protocols to ensure consistent eating quality in red meat. AMPC, along with other industry investors in the red meat industry have made significant investments towards the classification and measurement of objective meat grading. Suitable objective measurement technology has been identified as a key step to accessing the premiums associated with the identification and sale of high-grade meat. Projects ALMTech I and ALMTech II, funded by a diverse array of donors including AMPC, have focused on the development and implementation of suitable technologies to realise the value of premium meats and support genetic improvement.

In 2021, Intra-Muscular Fat (IMF) became part of Australia's AUS-MEAT language as a key indicator in lamb quality and is a focus of measurement. The Meat Eating Quality (MEQ) probe provides objective grading of beef and lamb carcasses on the slaughter floor by inserting prongs into the hot carcass. By providing reliable and objective meat quality assessments in real-time, this innovation aims to tackle key industry challenges such as the absence of objective quality measures for lamb meat and timely information early in the processing chain. This technology displayed accuracy in results and surpassed industry standards for IMF measures in lamb and marbling measurements in beef.

Description of the project

Through the collaborative efforts of industry, machine learning engineers and meat processing professionals the MEQ probe has been created. For model training, over 20,000 lamb IMF samples and over 100,000 beef marbling measurements were collected, and machine learning models were developed.

Table 9 *Project description and logic*

Project Details	Research organisation: MEQ Probe Pty Ltd Dates: 2020-2024 Principal researcher: Remo Carbone
Rationale	There is a demand for accurate data on meat quality early in the processing chain. Developing real-time, accurate, and objective grading tools for beef and lamb carcasses is a key step to the industry's demand for objective and reliable meat quality assessments.
Objectives	/ To develop a commercially viable, easily adoptable unit / Provide evidence of accurate and reliable grading in a use-case scenario for both lamb and beef / Develop the necessary Machine Learning algorithms / Validate according to the MSA system along with integration into industry's language
Activities and Outputs	/ Measurement of IMF on the kill floor / Collection of samples for validation / Robust process of measurement and tracking of samples to validate MEQ probe's outputs against proven standards / Statistical analysis of outcomes
Outcomes	**Lamb Outcomes**

	/ MEQ Probe successfully identified the 'premium' lamb category (IMF>4.7%) and successfully drafted lambs into low, medium, and high categories. / Maintained continuous IMF outputs with high accuracy and precision. / The Probe surpassed MSA guidelines and requirements for IMF measurements in lamb. **Beef Outcomes** / Ensured continuous MSA marble score output within AUSMEAT standards. / The Probe successfully determined high ultimate pH carcasses. / Surpassed accreditation standards as a marbling measure in beef.
Potential Impacts	/ Increased efficiency early in the processing line resulting in cost savings for chiller space and temperatures / Reliable meat grading resulting in consistent product classification / Improved accuracy of pH identification for beef carcasses / Increased value of final product at consumer level / The Probe has been commercially accredited by the Australian Meat Industry Language and Standards committee for its accurate measurement of lamb IMF / Data feedback to producers with accompanying financial rewards for higher quality meat

Project investment

AMPC invested $1,430,000 over 4 years ($110,000 in 2020, $797,500 in 2021, $467,500 in 2022 and $55,000 in 2024), in nominal terms and inclusive of project management costs. Other in-kind contributions and cash contributions totalled $2,850,000 over the course of the project.

Summary of impacts

Table 10 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 10 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/ **Increased identification of higher quality meat, creating greater premiums in the market** / Energy and operational efficiency due to the identification of meat grade early in the processing line / Feedback to producers allowing for optimisation of genetics and livestock management
Environmental	/ Through the identification of meat quality early in the processing line, freezer and chiller temperatures and space are optimised leading to less energy usage
Social	/ **A more consistent eating quality for the end consumer**

Quantification of impacts

Estimated benefits

The significant investments from the red meat industry into the quality frameworks and classification technologies has led to substantial premiums. The most significant benefit from *2020-1040: Hot Carcass Grading: Driving Quality Assurance and Processing Efficiency* is expected to be achieved through this technology allowing access to greater value.

Table 11 Benefit assumptions

Variable	Assumption		Source/ Explanation
a) Total farmgate value 2020-21 (billion)	$13.6		State of the industry report (MLA 2023a)
b) Total beef graded through MSA (billion)	$7.5		55% of total throughput (MLA, 2022)
c) Additional farm gate returns from MSA premium (million)	$204		(MLA, 2022)
d) Increased value	2.7%		c / b
	Beef	Lamb	
e) Marginal value add to premium of measurement of MEQ Probe	2%	4%	Although the type of measurement done by the Probe is high value, the marginal value is considered compared to the counterfactual scenario of other technologies likely to be developed
f) Value of applicable product (billion)	$7.5	$3.5	b, (MLA, 2023b)
g) Potential value / year (million)	4.0	3.8	d x e x f

Adoption costs

The cost to implement was assumed to be $150,000 per device, inclusive of set up costs and the present value of O&M costs.

Counterfactual

The counterfactual modelled is assumed to be a similar outcome but delayed implementation and adoption. Further, the benefit attributed to the Probe is only a marginal component of the total benefit likely to be realised from the accurate grading of meat quality that the Probe can do. This is reflective of the key competitive advantage of the MEQ Probe providing meat quality data early enough in the supply chain to optimise operations.

Attribution

Although this project builds upon previous investments by MLA, AMPC and other stakeholders to develop a quality framework and the necessary technology to assess this, the benefits quantified are assumed to be the marginal benefits attributable to this project. Hence, the attribution table below considers the benefits quantified to be attributable to this project, in proportion to the investments made.

Table 12 Attribution assumptions

Source	Attribution	Explanation
AMPC	36%	AMPC's investments (real) in this project.
Other investors in project	64%	Other investments (real) in this project.
Total	**100%**	

Note: Subject to rounding error

Adoption

Adoption is assumed to be high among processors at 80% of throughput with delayed adoption over 5 years. This is reflective of the relatively low adoption costs, high expected premiums/efficiencies and early adoption by some plants. The counterfactual adoption is assumed to be similar but delayed by 10 years. Further, under this adoption scenario, the premiums realised through this technology may decline over time as adoption increases.

Distribution of benefits

Benefits are expected to accumulate mostly in the private sector. Consumers are expected to pay a premium to receive a more consistently high grade of meat, which will lead to increased profits along the supply chain from retailers to producers.

Results

Table 13 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2023/24 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to 2023/24 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2023/24) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $30.05 million and a favourable Benefit Cost Ratio of 7.8.

Table 13 Investment criteria for total investment in Project 2020-1040 ($m)

Year	0	5	10	15	20	25	30
PV Benefits	-$0.73	$10.29	$29.13	$34.50	$34.50	$34.50	$34.50
PV Costs	$4.44	$4.44	$4.44	$4.44	$4.44	$4.44	$4.44
NPV	-$5.17	$5.85	$24.69	$30.05	$30.05	$30.05	$30.05
BCR	-0.2	2.3	6.6	7.8	7.8	7.8	7.8
IRR	NA	25%	38%	39%	39%	39%	39%
MIRR	-100%	16%	21%	17%	14%	13%	11%

The flow of total undiscounted costs and benefits from the project is presented below.

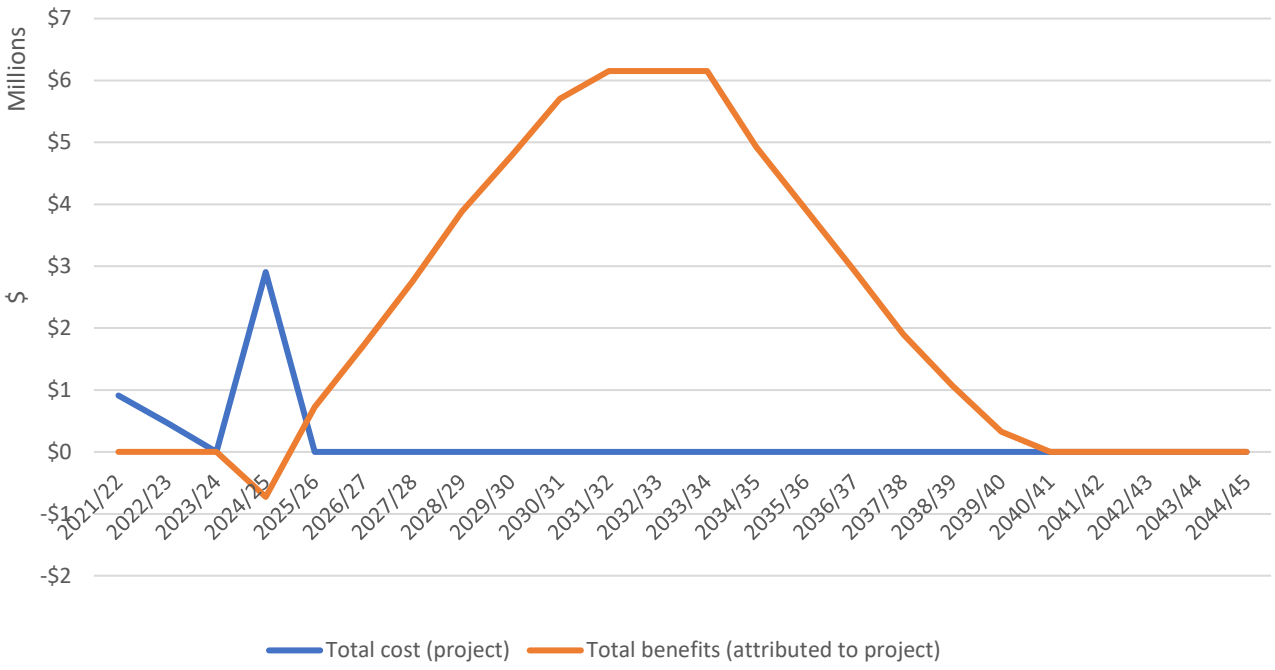

Figure 3 *Flow of undiscounted costs and benefits from project*

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 14 below.

Table 14 *Sensitivity analysis*

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		30.05	7.8	11%
Adjusted discount rate				
	0%	47.93	11.9	7%
	10%	19.14	5.3	15%
Change in marginal value add				
	50%	8.86	3.0	8%
	150%	51.24	12.5	13%
Delay in adoption under the counterfactual (years)				
	5	11.46	4.0	9%

	15	44.62	11.0	13%

The accuracy of the assessment is highly dependent on:

- The extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and
- The level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions).

An assessment of coverage and confidence ratings for this project is presented below.

Table 15 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	Medium	The modelled scenario does not include expected operational efficiencies and cost-savings through the identification of meat quality early in the processing line.
Confidence in assumptions	Medium	The approach taken in modelling is reflective of premiums given in-market. Further, the early adoption by some plants and proven advantages of this technology show it is likely to see the outcomes measured.

Conclusions

Project *2020-1040 hot carcass grading: driving quality assurance and processing efficiency* has contributed to the production of the MEQ Probe. Demand for this technology has already been proven and it is expected to be highly utilised across the industry bringing benefits for operations efficiency along with facilitating premiums in consumer markets through the accurate classification of meat quality.

Based on the adopted assumptions, the project investment will likely deliver a highly positive economic benefit (BCR 7.8) which remains positive under all scenarios modelled.

References

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Acknowledgements

GHD would like to acknowledge the time given by Remo Carbone (MEQ Probe Pty Ltd, May 24th, 2024).

7.2 Appendix B: 2021-1047: Low-cost Assessment and Arrangement of Solar PV Opportunities

Background

Solar Photovoltaics (PV), commonly referred to as solar panels, are an effective technology to support AMPC's strategic goal of achieving 100% renewable electricity use by 2030. However, prior to this project, the red meat processing sector had a relatively small portion of its energy produced from Solar PVs at 10.3 megawatt (MW). The slow uptake of solar PV in the sector can be attributed to historical issues such as correct sizing, access to appropriate contractual agreements for solar PV systems, and challenges with the acquisition and quality of equipment. These past issues have led to a low level of uptake of solar PVs, especially over the 2019 and 2020 years.

This project aimed to drive the uptake of Solar PV in the sector to achieve AMPC's strategic goals whilst supporting applicable processors moving to more efficient energy sources.

Description of the project

The project consisted of Beam Energy Labs working closely with processing sites that had shown interest in receiving information on their current solar performance along with the feasibility of adding more solar capacity. As this was independently completed, sites were able to access reliable information on how suitable solar would be for their individual situation.

Table 16 Project description and logic

Project Details	Research organisation: Beam Energy Labs Pty Ltd Date: 2020-2023 Principal investigator: Andrew Lister
Rationale	The key purpose of this project was to address the slowdown of solar implementation in the red meat processing industry. By providing access to Beam Energy Labs, plants were able to access transparent information on the applicability of their sites and in turn advance the uptake of solar PV systems.
Objectives	/ Address the slowdown of solar uptake / Allow plants to access specialists that utilise software to predict the best outcomes against site specifications / Drive uptake of renewable energy in the RMP sector in line with AMPCs goal to achieve 100% renewable energy by 2030. / Provide transparency by showing all options and discussions on how factors such as battery size affect output. / Review solar PV production for sites with existing systems and validate if the systems' performance satisfies their potential
Activities and Outputs	/ Desktop review of existing solar penetration at sites and performance reviews to assess if systems are performing as expected, 2 sites were reviewed / Solar assessments and consultations were conducted to discuss site and installation requirements, 52 sites were assessed / Procurement strategies were discussed with members proceeding with further investment in PV, 19 sites utilised Beam Energy Lab's assistance

	/	Member surveys were conducted throughout the program to assess members' attitude towards the PV system, financing preferences and further recommendations.
Outcomes	/	An additional 15 MW of solar capacity was installed, contracted, or approved indicating a 150% increase in the installed base of solar within the RMP sector.
	/	There were large increases in deployed solar across the RMP sector in Victoria, NSW, and QLD
	/	Identification of the underuse of potential space in the RMP sector for solar, with only 6% of roof capacity used and 1% of ground-mount area.
Potential Impacts	/	Difference in performance and output pre and post review from Beam Energy.
	/	Increase in PV procurements and installations after program completion
	/	Increased knowledge of contributing factors to feasibility of Solar PV
	/	Contribution to AMPC's 2030 goal and in turn reputation of the RMP sector

Project investment

AMPC was the sole investor over 3 years investing **$226,800** ($161,200 in 2022, $ 49,200 in 2023 and $16, 400 in 2024) in nominal terms and inclusive of project management costs.

Summary of impacts

Table 17 below provides a summary of the expected triple bottom line impacts (economic, environmental, and social) from the project.

*Table 17 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	**Solar panels implemented have a payback period of approximately 5.5 years**
Environmental	/	Increase in renewable energy use and capacity of the industry
	/	Likely to lead to greater uptake of Solar and other renewables in the future
	/	Approximately 13,367 tonnes of carbon emissions per annum avoided
Social	/	Achievement of 2030 goals and shifting to renewables will lead to greater social perception

Quantification of impacts

Estimated benefits

Through consultations with AMPC along with Beam Energy Labs, it was evident that this project has led to a large uptick in the adoption of solar panels by plants, estimated at an additional capacity of 153% compared to without this project. This facilitation of adoption has key benefits for the environment, however, the most material benefits for plants are likely to be reflected through energy cost savings.

Table 18 Benefit assumptions

Variable	Assumption	Source/ Explanation
a) Additional solar capacity added (MW)	15	Project report
b) Annual electricity cost savings (million)	$1.7	Consultant's estimate based on MW added and consultations conducted
c) Expected payback period (years)	5.5	Per comms Beam Energy
d) Implementation cost (million)	$9.5	b x c

Adoption costs

As above, adoption costs are expected to be $9.5 million in the 2023/24 year.

Counterfactual

The counterfactual has been defined as bringing implementation of 15MW of solar capacity forward by four years. Hence, the benefits are only expected prior to 2027/28 financial year. A discounted cost to implement is considered under the counterfactual to account for the depreciation of the solar panels, assumed to depreciate constantly over a 25 year period.

Attribution

This project is not solely attributable to the identified benefits, with significant past research along with some promotion and extension expected as outlined in Table 19 below.

Table 19 Attribution assumptions

Source	Attribution	Explanation
AMPC	45%	
Past research	40%	Past research is considered attributable to a significant component of this project's benefits.
Promotion and extension	15%	Continued extension work for implementation was expected for some sites.
Total	**100%**	

Note: Subject to rounding error

Adoption

Adoption was expected to be completed in the 2023/24 year. This is a likely scenario considering the amount of installations already completed at the time of consultations along with those contracted.

Distribution of benefits

The benefits are likely to accrue to the private sector in the form modelled, directly leading to cost savings over the medium term for plants. However, transitioning to renewables is key to Australia's emissions reduction strategy and is hence a public benefit as well through the carbon emissions avoided through continued use of the energy grid.

Results

Table 20 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2023/24 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to 2023/24 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2023/24) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $1.70 million and a favourable Benefit Cost Ratio of 7.3.

Table 20 Investment criteria for total investment in Project 2021-1047 ($m)

Year	0	5	10	15	20	25	30
PV Benefits	-$4.14	$1.98	$1.98	$1.98	$1.98	$1.98	$1.98
PV Costs	$0.27	$0.27	$0.27	$0.27	$0.27	$0.27	$0.27
NPV	-$4.41	$1.70	$1.70	$1.70	$1.70	$1.70	$1.70
BCR	-15.3	7.3	7.3	7.3	7.3	7.3	7.3
IRR	NA	18%	18%	18%	18%	18%	18%
MIRR	-100%	10%	8%	7%	7%	6%	6%

The flow of total undiscounted costs and benefits from the project is presented below.

Figure 4 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 21 below.

Table 21 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		1.70	7.3	8%
Adjusted discount rate				
	0%	3.08	12.4	8%
	10%	0.64	3.4	11%
% attribution to project				
	30%	1.09	5.0	8%
	60%	2.45	10.0	8%

The accuracy of the assessment is highly dependent on:

- The extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and
- The level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions).

An assessment of coverage and confidence ratings for this project is presented below.

Table 22 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	Low – Medium	It is recognised a key objective of AMPC's support in adopting renewable energy sources in the RMP sector is to achieve the carbon emissions targets set out by the industry, the approach taken does not reflect this overarching objective's benefits.
Confidence in assumptions	High	The modelling assumptions are well researched and advised specifically for the RMP sector.

Conclusions

Project *2021-1047 Low cost assessment and arrangement of solar PV opportunities* has successfully driven a significant increase in the RMP sector's adoption of renewable energy. This is likely to lead to cost-savings in the medium term for plants involved whilst also contributing to the sector's 2030 net-zero emissions target. There is potential much larger benefits than those modelled will occur if greater uptake is seen throughout the sector.

Based on the adopted assumptions this analysis has estimated the project investment will likely deliver positive economic benefit (BCR 7.3) which remains positive under all scenarios modelled.

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Acknowledgments

GHD would like to acknowledge the time given by Andrew Lister (Beam Energy Labs Pty Ltd, May 3rd, 2024)

7.3 Appendix C: 2022-1055: Diverting Plastics from Landfill – Business Scenario Study

Background

The red meat supply chain is dependent on plastics to maintain food safety and quality standards, making it difficult to implement circular solutions. With initiatives like Circular Economy for Flexible Packaging (CEFLEX), Australia's National Packaging Targets 2025 and the Australian Packaging Covenant Organisation (APCO) the meat processing industry is also gearing towards sustainable solutions for retail packaging. Although the food processing sector is unlikely to meet its targets for 2025, it is likely that there will be extended producer responsibility rules implemented by 2025 which means that processors must pay to manage the plastic waste generated (MLA, 2023).

This project aligns with AMPC's zero solid waste to landfill policy to achieve zero waste operations by 2030. A review of policies, regulations and the industry environment was conducted to understand the market and regulation related to waste streams for single-use plastic products. To build knowledge of scientific and technological advancement in plastics circularity, the existing evidence base was also researched.

Description of the project

Through selected case studies the project identified and analysed the types and amounts of single-use on-site plastic waste generated by Australian red meat processors annually. Consequently, the project evaluated the environmental impact of diverting single-use on-site plastics from landfill, and developed scenarios that red meat processors across the sector can consider. The project objectives were monitored through 6 milestone reports between March 2022 and July 2023.

Table 23 Project description and logic

Project Details	Research organisation: Southern Cross University (SCU) Date: 2022-2023 Principal researchers: Owen Hogan, Lachlan Yee, Pascal Scherrer
Rationale	To explore various opportunities through which red meat processors can divert on-site plastic waste from landfills. Working with specific sites to understand their baseline scenario of plastic waste.
Objectives	/ Review policy, regulations, and industry environment to understand market conditions in relation to circular economy strategies and waste streams for single-use plastic from landfill. / Build knowledge of scientific and technology advancement in plastics circularity. / Analyse the types and amounts of single-use plastics from landfill and develop scenarios for consideration. / Evaluate the impact of diverting single-use plastics from landfill
Activities and Outputs	/ **Phase 1**: Establish an industry overview through a review of literature on academic and industry best practices, online survey of AMPC member facilities and selection of case study facilities for detailed analysis. / **Phase 2**: Detailed process analysis of on-site plastic use and waste at selected case study facilities. / **Phase 3**: Developing scenarios outlining a viable pathway to reduce on-site plastic use and waste. / **Phase 4**: Testing and validation of preferred scenarios and dissemination of findings.

Potential Outcomes	/	Contribution towards strategies and initiatives such as CEFLEX and Australian National Plastics Plan for sustainable plastic management.
	/	Through a greater understanding of waste streams and sources, preparation of the industry to meet APCO's 2025 National Packaging Targets and shift from 'take-make-dispose' to more circular economies.
	/	Identification of plastic alternatives will better align the Australian meat processing industry with international practices.
	/	Decrease in use of single-use plastics throughout the red meat processing supply chain
Potential Impacts	/	Implementation of biodegradable and other plastic reducing alternatives
	/	A decrease in total plastic waste, contributing to AMPC's 2030 waste goals
	/	Increased capacity and understanding of plastic within the RMP sector leading to potentially avoided fines or pay to dispose fees

Project investment

AMPC invested **$172,489** into the project ($87,071 in 2022, $71,622 in 2023 and $13,796 in 2024) in nominal terms and inclusive of project management costs.

Summary of impacts

Table 24 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 24 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	**Reduced landfill fees**
	/	Reduction in the likely fees or fines associated with the 2025 change in rules and regulations
	/	More efficient decision making of pathways to decrease plastic waste in-plant
Environmental	/	Step towards achieving the red meat sector's environmental goals
	/	Decreased plastic to landfills
Social	/	Proactive investment into diverting plastics from landfill is likely to contribute to the red meat processing sector's positive community perception

Quantification of impacts

Estimated benefits

This project's benefits have been modelled through estimating the potential to decrease landfill fees, or similar waste disposal costs, that are currently being paid by processors. This is a conservative approach, considering that it is not reflective of likely increases in these fees along with potential impending regulatory fees associated with plastic waste. Further, there are major social and environmental benefits that have not been represented in the modelling; landfill fees are mostly reflective of the operational costs of dealing with waste and do not include the negative externalities associated with plastic waste.

Table 25 Benefit assumptions

Variable	Assumption	Source/ Explanation
a) Decrease in single use plastics identified	60%	Project report
b) On-site plastic consumables annually in industry (tonnes)	4500	Project report extrapolated site findings to total industry
c) Addressable plastic waste identified (tonnes)	2700	a x b
d) $/tonne for waste disposal	$200	Based on the higher value of this report's scenario analysis: All Energy Pty Ltd (2022).
e) Total current cost of addressable plastic waste (annual)	$542,000	c x d

Adoption costs

Although there are likely costs to be associated with adoption of low-plastic consumables, they have been assumed to be included in the conservative benefit outlined in the model.

Counterfactual

The counterfactual is assumed to be that similar projects would have been carried out by individual meat processors following the change in rules and regulations in 2025. There would be increased cost in terms of fines and/or disposal fees along with a delay in the benefits attributed to this project by an estimated 3 years.

Attribution

Although this project has summarised key findings for the industry, and more specifically for the plants included in the study, there are significant further costs expected. This is considering that the identified plastic reduction strategies are preliminary and only suggested; further work will be required by plants or an overarching project to test the feasibility.

Table 26 Attribution assumptions

Source	Attribution	Explanation
AMPC	23%	Project investment (real) as a percentage of total costs
Other investors in project	28%	Project investment (real) as a percentage of total costs
Future development	25%	$86,000, half of this project's cost is expected in future development, attribution calculated as expected cost as a percentage of total costs.
Promotion and extension	25%	$86,000, half of this project's cost is expected in promotion and extension to disseminate the findings and practice changes throughout the industry, attribution calculated as expected cost as a percentage of total costs.

Source	Attribution	Explanation
Total	**100%**	

Note: Subject to rounding error

Adoption

There is an expected fast rate of adoption considering the likely increase in regulatory and financial burdens of plastic waste. The 16% of industry included in this study are expected to be the leading adopters of practice changes followed by the rest of the industry within a 4-year period.

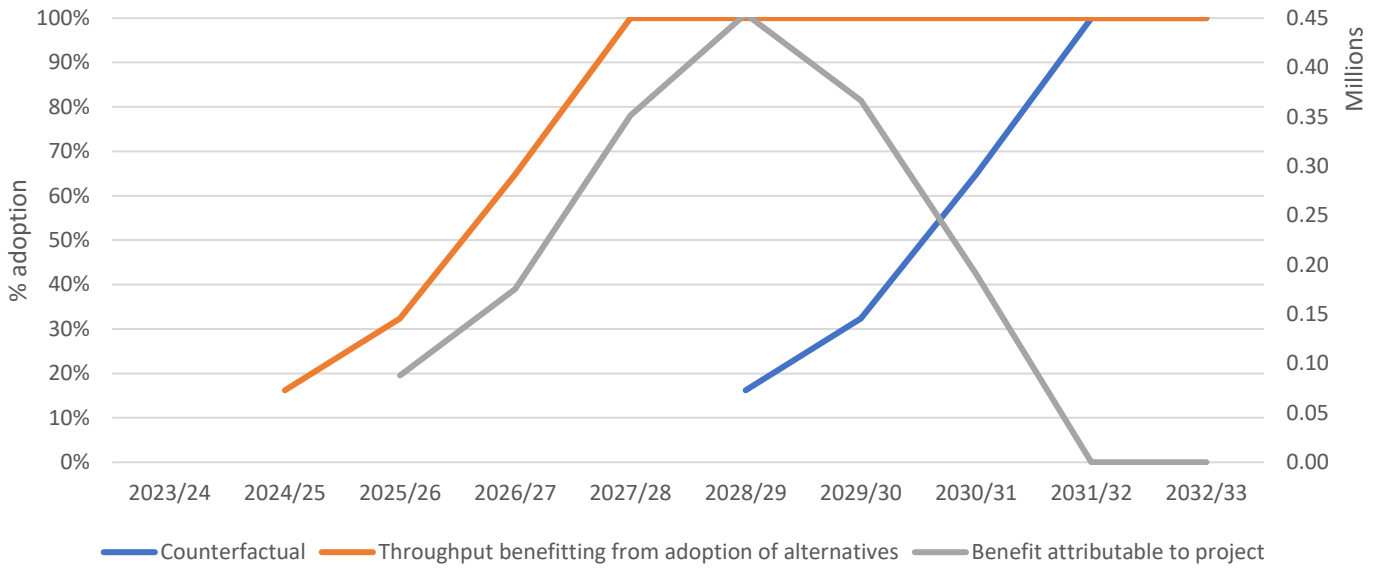

Figure 5 Flow of undiscounted costs and benefits from project

Distribution of benefits

The benefits are expected to accrue both publicly and privately. This analysis has considered the private benefits associated for plants with decreasing plastic waste, and hence the disposal fees associated. However, this acts more as a proxy to the more broad ranging issues associated with plastic waste production, which holds negative externalities to the broader public.

Results

Table 27 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2023/24 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to 2023/24 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2023/24) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $0.24 million and a favourable Benefit Cost Ratio of 1.6.

Table 27 Investment criteria for total investment in Project 2022-1055 ($m)

Year	0	5	10	15	20	25	30

PV Benefits		$0.58	$0.65	$0.65	$0.65	$0.65	$0.65
PV Costs	$0.41	$0.41	$0.41	$0.41	$0.41	$0.41	$0.41
NPV	-$0.41	$0.17	$0.24	$0.24	$0.24	$0.24	$0.24
BCR		1.4	1.6	1.6	1.6	1.6	1.6
IRR	-83%	18%	18%	18%	18%	18%	18%
MIRR	-40%	11%	9%	8%	7%	7%	7%

The flow of total undiscounted costs and benefits from the project is presented below.

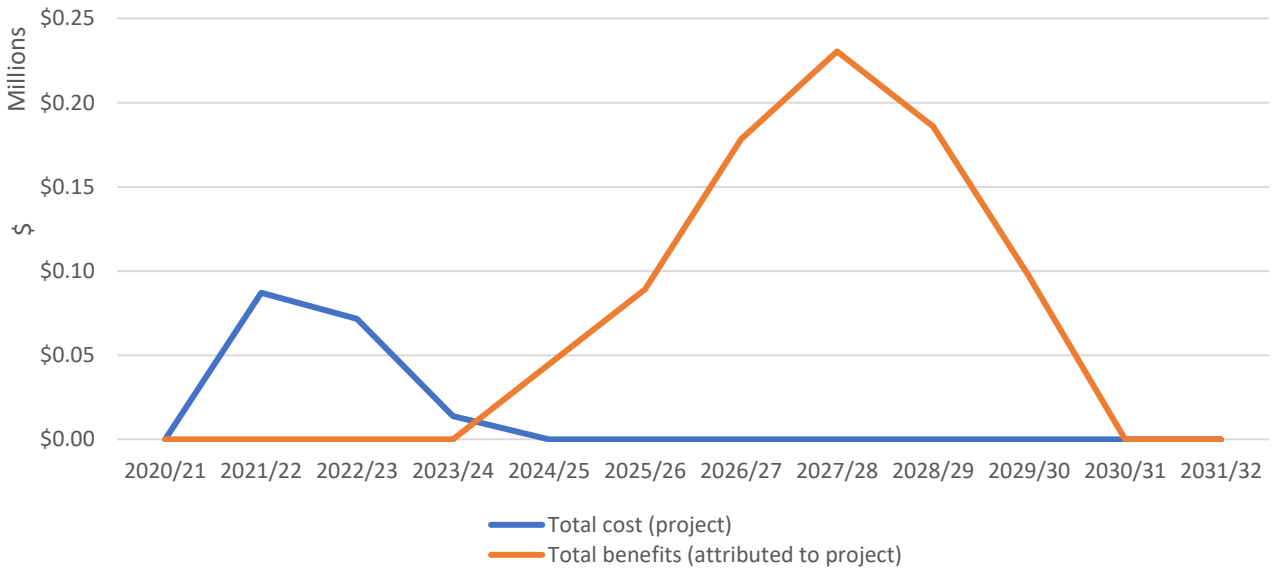

Figure 6 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 28 below.

Table 28 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		0.24	1.6	7%
Adjusted discount rate				
	0%	0.41	2.0	2%
	10%	0.11	1.3	11%
Landfill gate fee (per tonne)				
	$100	-0.04	0.8	6%

	$300	0.3	2.3	10%

The accuracy of the assessment is highly dependent on:

- The extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and
- The level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions).

An assessment of coverage and confidence ratings for this project is presented below.

Table 29 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	Medium	The modelling has considered only one component of the potential economic benefits which although the most tangible may not be the driving force towards adoption. Regulatory shifts along with progressing towards targets are also likely to be key motivation to adoption of lower plastic usage.
Confidence in assumptions	Low	The regulation and pricing surrounding plastic waste is likely to change substantially soon. There is a high degree of uncertainty in key assumptions such as adoption rate and timeframes.

Conclusions

Project *2022-1055: Diverting Plastics from Landfill – Business Scenario Study* explored opportunities for red meat processors to divert onsite plastic waste away from landfills. The recommendation of plastic alternatives emerging from this study will align the Australian meat processing industry with international practices. Based on the adopted assumptions this analysis has estimated the project investment will likely deliver a favourable economic benefit (BCR 1.6).

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Acknowledgments

GHD would like to acknowledge the time given by Owen Hogan (Southern Cross University, May 15th, 2024).

7.4 Appendix D: 2023-1038: Beef Striploin Fat Removal – Stage 2B Controlled Variable Thickness Robotic Fat Trimming

Background

Manual trimming of beef striploin fat is a time-consuming process requiring judgment, dexterity, and experience as there is a lack of guidance in understanding where the fat-lean interface is within the body of the striploin primal. Further, retailers use quality checks to determine if there is too much fat left on the primal, imposing penalties if this is found. This often leads to over-trimming and yield losses along with carrying a risk of injury to staff. To address this, AMPC has invested in a three-stage development and testing of a robotic tool that uses ultrasonic methods and laser technology to automate the fat-trimming tool. The tool is controllable and can process the striploins to customer-specified fat thickness.

Description of the project

A series of AMPC past project investments include the initial investment by AMPC into the evaluation of the technology (2016-1032), the development of a prototype (2017-1045), development of sensing technologies (2021-1077) and the project selected in this year's assessment (2023-1038). The technology successfully trimmed the top fat of 50 striploin primal pieces above the eye-muscle where uniformity of fat thickness to specification is critical. Tests were conducted adjacent to the normal production line and results were documented.

The trial achieved the desired results and continued development of this automation is likely to increase efficiencies and contribute to safer work conditions.

Table 30 Project description and logic

Project Details	Research organisation: Business and Manufacturing Consultancy UK Dates: 2023-1038 Principal investigator: Koorosh Khodabandehloo
Rationale	AMPC has invested significantly into the trimming tool in to address overtrimming and safety concerns. Although the feasibility and development stages had been completed, a trial of the trimming tool was needed to ensure the technology created was suitable in situ.
Objectives	/ Implement a controllable fat trimming tool to be used with a robot. / Using sensory data from stage 2A, integrate the tool with existing robotic cell and develop cut algorithms. / Undertake comparative trials with manual trimming to assess capability and show improvements that avoid over trimming by at least 2 mm. / Prepare a report on findings and update value proposition for a production solution.
Activities and Outputs	/ Striploin was prepared by deboning and manually removing the top fat cover and presented to the robotic tool. / Using laser and ultrasonic sensing the robot measured the striploin profile and determined slicing paths for fat removal as determined by specific coding. / The robot carrying the tool removed non-uniform fat layers.
Outcomes	/ The controlled robotic process reduced over trimming that is often akin to the manual process and proved safe in practice. / The controllable tool for robotic trimmer performed better than 2 mm reduction in over trimming.

	/	For all samples trimmed robotically there was no damage caused by the blade to the striploin. / Package and dispatch processes continued as usual.
Potential Impacts	/	Labour savings / Improvements in efficiency i.e. number of cuts per hour / Yield savings / Greater automation of the processing line

Project investment

AMPC invested **$270,270** into the project ($158,400 in 2023 and $111,870 in 2024), in nominal terms and inclusive of project management costs.

Summary of impacts

Table 31 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 31 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	**Labour savings through the automation of trimming** / **Yield savings through more precise trimming**
Environmental	/	
Social	/	Automation of a hazardous activity currently performed by personnel

Quantification of impacts

Estimated benefits

The benefits are expected to be through the automation of the manual trimming leading to labour savings, along with a more precise yield. The final report of project 2016-1032 outlined that current manual trimming is labour intensive, injury prone and over-trims leading to a lower yield.

Table 32 Net benefit assumptions

Variable	Assumption	Source/ Explanation
a) Labour savings	$80,000	Replacement of 1 FTE wage in skilled role
b) Yield increase per cut	$1.5	Based on BCA in project 2016-1032, reflects a conservative approach and potential market response to changes in the cut's composition.
c) Cuts (per hour)	120	Final report project 2016-1032
d) Savings in yield (per hour)	$180	b x c

Variable	Assumption	Source/ Explanation
e) Savings / year in yield	$720,000	d x operational time in one year with 2 shifts/day
f) Total savings/year	$800,000	a + e

Adoption costs

Adoption costs are estimated to be $250,000 per cell, with two cells required per plant at minimum, along with $150,000 per cell being the PV of O&M. Therefore, total cost of implementation to a plant is $800,000.

Counterfactual

Under the counterfactual, a similar outcome is presumed to occur but with a delay of seven years. This is reflective of the developing robotic capabilities which are likely to be applied to the RMP industry eventually without this project's support.

Attribution

This project is only expected to be attributable to a relatively small amount of the total benefits quantified, 8%. The breakdown of attribution is outlined in Table 33 below.

Table 33 Attribution assumptions

Source	Attribution	Explanation
This project 2023-1038	8%	
AMPC past costs (projects 2016-1032, 2017-1045 and 2021-1077)	53%	AMPC has contributed significantly to the development of this technology via three previously completed study. Attribution has been estimated based on total costs and proportioned accordingly.
Future development	39%	Consultations indicated there would be a remaining $1.5 million of expected future costs for some further technical developments and commercialisation.
Total	**100%**	

Note: Subject to rounding error

Adoption

Due to significant future development still expected, adoption is delayed by three years and expected to occur at a rate of 3 plants per year. Given the significant costs of implementation along with the relatively high throughput that the technology is expected to suit, the top third of plants are expected to be likely adopters. Further, only half of these plants have been modelled in adoption due to the uncertainty remaining in future development and plant demands.

Distribution of benefits

The benefits are likely to accrue to the private sector within plants that adopt this technology through increased profitability and a safer working environment for employees.

Results

Table 34 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2023/24 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to 2023/24 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2023/24) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $1.22 million and a favourable Benefit Cost Ratio of 5.3.

Table 34 Investment criteria for total investment in Project 2020-1326 ($m)

Year	0	5	10	15	20	25	30
PV Benefits	$-	$0.43	$1.45	$1.50	$1.50	$1.50	$1.50
PV Costs	$0.28	$0.28	$0.28	$0.28	$0.28	$0.28	$0.28
NPV	-$0.28	$0.14	$1.17	$1.22	$1.22	$1.22	$1.22
BCR	-	1.5	5.2	5.3	5.3	5.3	5.3
IRR	NA	14%	30%	30%	30%	30%	30%
MIRR		11%	19%	15%	13%	11%	11%

The flow of total undiscounted costs and benefits from the project is presented below.

Figure 7 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 35 below.

Table 35 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		1.22	5.3	11%
Adjusted discount rate				
	0%	1.95	7.9	7%
	10%	0.76	3.7	15%
Yield increase per cut				
	$1	0.7	3.5	9%
	$2	1.74	7.2	13%

The accuracy of the assessment is highly dependent on:

- The extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and
- The level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions).

An assessment of coverage and confidence ratings for this project is presented below.

Table 36 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	High	The benefits have been detailed in the reporting and are simple. Although improvements in safety is a potential benefit also, it is likely to be of a smaller significance compared to the labour and yield impacts which have been modelled
Confidence in assumptions	Low	The scenario considered has required high level assumptions surrounding adoption rates, costs and timeframes, leaving a low level of confidence.

Conclusions

This project trialled a robotic fat-trimming tool with advanced sensory capabilities. The tool successfully automated the fat-trimming process resulting in significant labour savings as traditionally, fat-trimming is a time-consuming manual task that demands experienced judgment and dexterity from workers. Although significant further development costs are expected, based on the adopted assumptions this analysis has estimated the project investment will likely deliver a positive economic benefit (BCR 5.3). This remained positive across all modelled scenarios.

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Acknowledgments

GHD would like to acknowledge the time given by Koorosh Khodabandehloo (Business and Manufacturing Consultancy UK, May 9th, 2024).

7.5 Appendix E: 2023-1047: Beyond Border Analysis of Regulatory and Related Costs

Background

Australian meat producers and processors face significant costs to gain market access to key trading partners. Although many of the requirements are based on country-specific regulations that suit food safety criteria, there are many cases where the requirements are misaligned, outdated or unnecessarily costly for both Australian producers and processors along with importing countries. Hence, there is potential to address these inefficiencies through their identification and formulation of solutions.

Description of the project

AMPC invested in this project to develop knowledge of costs and resources associated with technical market access requirements and inform and encourage the uptake of flexible approaches and solutions. Researchers collaborated with the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) along with industry personnel and investigated quantitative data to identify potential opportunities and solutions to determine priority issues.

Table 37 Project description and logic

Project Details	Research Organisation: SG Heilbron Pty Ltd Date: 2023-2024 Key researchers: Selwyn Helibron
Rationale	To build an understanding and awareness around the costs of market access requirements both domestically and in Australian product's destination markets. Further, to identify flexible approaches and solutions to unnecessarily costly or duplicative practices. The project is aimed at placing Australian exporters in a more competitive position internationally.
Objectives	/ Identify market access costs associated with key trade partners / Quantify costs associated with regulations and market access requirements / Develop recommendations to address excessive costs, specifically through the utilization of shared data initiatives / Identify case studies that show the potential benefits of carrying out the recommendations
Activities and Outputs	/ Utilise members of DAFF and AMPC along with red meat processors to develop a preliminary set of key interventions and markets for data gathering purposes / Gathering of data through interviews and surveys from selected exporters on key interventions and markets / Creating estimations of costs associated with foreign receival of Australian red meat, utilizing Australian equivalent practices carried out by DAFF / Formation of priorities for actions that address the key interventions and markets, including the expected benefits if achieved / Identification of indicative work timelines and institutional mechanisms for implementing the prioritised actions, including in-Australia and in-market initiatives
Potential Outcomes	/ Increased knowledge and emphasis of the significant costs surrounding current regulation and variances across different markets / Adoption of the prioritised actions by industry and DAFF

	/	Inform future Australian trade policies
Potential Impacts	/	Adoption of the identified actions by DAFF leading to decreased costs
	/	Uniform data sharing cross-border, initially for the key examples given but also if successful could lead to many more data sharing solutions
	/	Increased trust by key trading countries overcoming unnecessary trade costs

Project investment

AMPC invested **$140,140** into the project ($131,340 in 2023 and $8,800 in 2024), in nominal terms and inclusive of project management costs.

Summary of impacts

Table 38 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 38 \Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	**Reduced costs for domestic exporters and producers through the identified case studies**
	/	Greater international market share for Australian red meat
	/	Reduced regulatory costs for importing countries of Australian red meat
Environmental	/	Reduced product and resource waste
Social	/	Better international partnerships for Australia

Quantification of impacts

Estimated benefits

The primary modelled benefit from the project is that it provides a basis for decreasing the costs associated with meeting regulatory requirements, specifically for the prioritised actions. Only the domestic benefits have been quantified. This analysis assumes that the likelihood of these actions being carried out has increased due to this project.

Table 39 Benefit assumptions

Variable	Assumption		Source/ Explanation
a) Red meat exports to the US opportunity cost-savings and marginal increased chance of success	$4.75 million	5%	Value based on report estimate, % is consultant's estimate on increased chance of savings
b) Annual value attributable to project	$237,500		a (value x %)

Variable	Assumption		Source/ Explanation
c) EU regulatory cost savings case study and marginal increased chance of success	$16 million	2%	Value based on report estimate, % is consultant's estimate on increased chance of savings
d) Annual value attributable to project	$320,000		c (value x %)
e) China market access case study and marginal increased chance of success	$8 million	2%	Value based on report estimate, % is consultant's estimate on increased chance of savings
f) Annual value attributable to project	$160,000		e (value x %)
g) Benefit in synergies in other areas with data sharing	$20 million	1%	Value estimated, % is consultant's estimate on increased chance of savings
h) Annual value attributable to project	$200,000		g (value x %)
i) Total annual value	$917,500		b + d + f + h

Adoption costs

No adoption costs are modelled, the case studies provide 'win-win' scenarios for Australia and export partners.

Counterfactual

The counterfactual is no change in the current regulatory costs and processes for export of Australian red meat.

Attribution

This project is only expected to be attributable to a relatively small amount of the total benefits quantified, 8%. The breakdown of attribution is outlined in Table 40 below.

Table 40 Attribution assumptions

Source	Attribution	Explanation
AMPC	7%	This project provides key information and identifies the next steps necessary to achieve benefits
Past research	49%	Past projects have informed some costings in relation to the inefficiencies evident in regulatory implementation
Future development	44%	There are significant additional steps required to achieve the identified actions including setting up data sharing initiatives, establishing working group to

Source	Attribution	Explanation
		progress the recommendations, development of target strategies and integration into trade talks
Total	**100%**	

Note: Subject to rounding error

Any changes to regulatory requirements are likely to be delayed and happen only on an opportunity basis due to the nature of trade agreements. Hence the modelling assumes the increased likelihood of change occurring from 2029/30, 5 years delayed.

Distribution of benefits

The benefits are likely to accumulate in the private sector. The domestic red meat production sector would benefit from increased market access or market share through decreasing regulatory costs of export, this is likely to be distributed through the red meat supply chain. This project has shown that governments, both domestic and trade partners for red meat, may benefit through significantly decreasing their monitoring costs through less duplication or other validation techniques already being conducted. This may also lead to lower prices in destination countries for the consumers of Australian red meat.

Results

Table 41 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2023/24 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to 2023/24 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2023/24) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $0.54 million and a favourable Benefit Cost Ratio of 4.6.

Table 41 Investment criteria for total investment in Project 2023-1047 ($m)

Year	0	5	10	15	20	25	30
PV Benefits		$0.09	$0.28	$0.42	$0.54	$0.63	$0.69
PV Costs	$0.15	$0.15	$0.15	$0.15	$0.15	$0.15	$0.15
NPV	-$0.15	-$0.06	$0.13	$0.27	$0.39	$0.48	$0.54
BCR		0.6	1.8	2.8	3.6	4.2	4.6
IRR	NA	-2%	14%	17%	18%	18%	19%
MIRR	-100%	0%	10%	11%	11%	11%	10%

The flow of total undiscounted costs and benefits from the project is presented below.

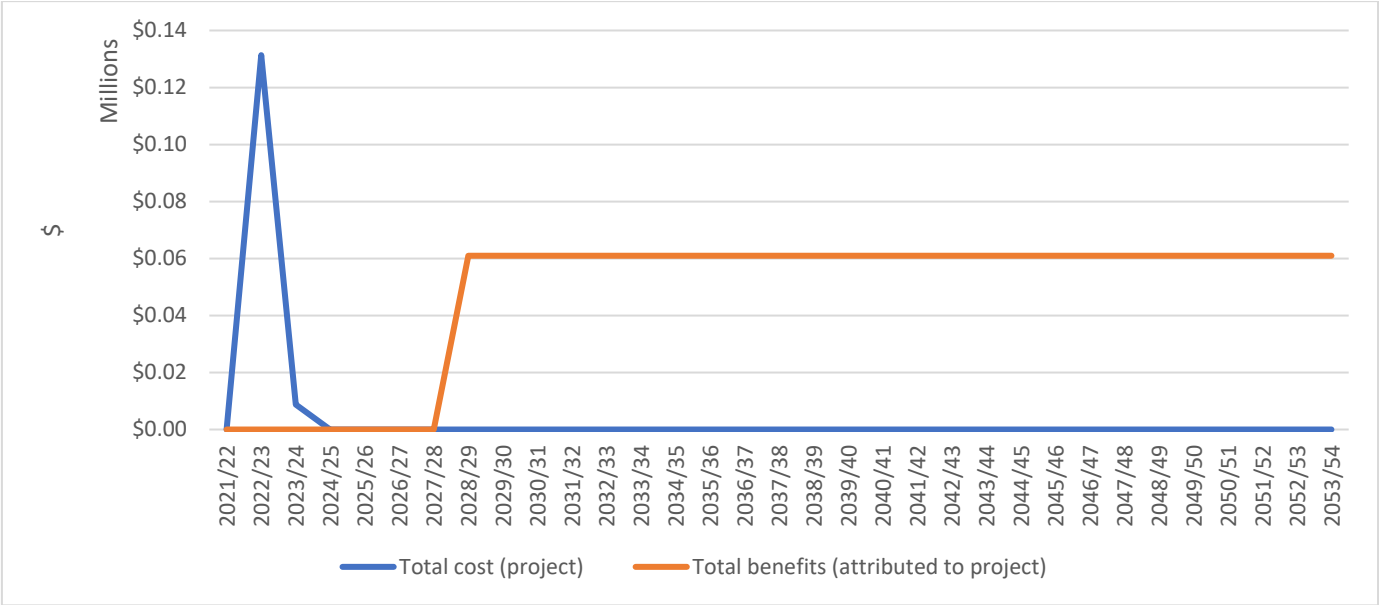

Figure 8 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 42 below.

Table 42 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		0.54	4.6	11%
Adjusted discount rate				
	0%	1.31	9.7	7%
	10%	0.22	2.5	13%
Increased chance of successful implementation				
	+1%	0.9	7.0	12%
	-1%	0.17	2.2	9%

The accuracy of the assessment is highly dependent on:

- The extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and
- The level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions).

An assessment of coverage and confidence ratings for this project is presented below.

Table 43 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	Medium	The increased understanding of regulatory costs and identification of potential areas where these can be decreased have many potential application usages. However, the most likely scenarios are captured in the modelling.
Confidence in assumptions	Low	The mechanisms of creating change in trade agreements are difficult to estimate considering they are so dependent on external factors such as politics.

Conclusions

Project *2023-1047: Beyond Border Analysis of Regulatory and Related Costs* aimed to enhance the competitiveness of Australian red meat exports in the global market by analysing the costs associated with market access requirements. The case studies and proposed solutions offer mutually beneficial scenarios for Australian processors and export partners. Based on the adopted assumptions this analysis has estimated the project investment will deliver a positive economic benefit (BCR 4.6). This remained positive across all modelled scenarios.

References

SG Heilbron Pty Ltd. (n.d.). *Beyond Border Analysis of Regulatory and Related Costs,* prepared for AMPC and provided to GHD commercial-in-confidence.

Acknowledgments

GHD would like to acknowledge the time given by Selwyn Helibron (SG Helibron Pty Ltd, May 2nd, 2024).

7.6 Appendix F: 2018-1050: In Plant Trial of Robotic Picking and Packing System

Background

Picking and packing vacuum-packed primal red meat cuts is a labour-intensive, manual process in the supply chain. It results in high labour costs and workplace health and safety risks such as stress-related injuries from lifting and packing heavy cuts.

To address this, AMPC has invested in automating this process using robotic solutions. Project 2014-1007 developed a vision-sensing software for the identification and geometric profiling of primal cuts. Project 2017-1065 developed an automated robotic system to replicate the pick and pack operations currently in place and was trialled on ten types of primal cuts in in-house system trials. Using the robotic system developed through previous works, this project incorporated modifications and conducted an in-plant trial at JBS Australia's plant in Brooklyn, Victoria.

Due to stringent food safety and hygiene standards, meat processors have been hesitant to adopt robotic picking and packing systems. Despite a need for automation use of employees is the most widely used method currently.

Description of the project

Prior to conducting the trials, several modifications to the robotic system were made. These included the manufacture of new vision frame and outfeed areas to meet the hygiene requirements of the plant. A safety guard and light curtains were also installed.

Initial testing of the system was conducted by Strategic Engineering staff. JBS operators and maintenance staff were then trained in the necessary operations over several days before a complete handover was undertaken. The system was then left with JBS staff to conduct the in-plant trial.

After initial tests, further modifications to the control system were planned to increase overall production efficiency using a specific identification algorithm for a type of primal cut. These changes were tested by Strategic Engineering before being handed over to operators at JBS.

Although initially, the trial was conducted on four different cuts it was decided to focus on two of the largest and heaviest cuts (navel-end brisket and point-end brisket).

Table 44 Project description and logic

Project Details	Research Organisation: Richard Aplin Date: 2019-2024 Key researchers: Strategic Engineering Pty Ltd
Rationale	To integrate, install and conduct an in-plant trial on real meat cuts using the robotic picking and packing system developed in previous projects with modifications to improve performance.
Objectives	/ Determine if the robotic system developed as part of Project 2017-1065 can be successfully installed and integrated into a meat processing plant / Determine if the robotic system can share workload with human operators in packing a specific subset of primal cuts (approx. 5-20% of total products) / Report on the robot's efficacy and suitability to the plant operations
Activities and Outputs	/ Packing was tested on different primal cuts to find the optimal packing strategy for this site.

	/	Initially four different cuts were trialled however to maximise the efficiency of the robot cycle the system was trialled for two weeks on navel-end brisket and point-end brisket cuts.
	/	Primal cuts were successfully picked and packed into respective containers.
	/	The robot could account for any orientation of the cut on the conveyor belt.
	/	Successful identification of navel-end brisket was demonstrated with 90% accuracy and no false positives.
Potential Outcomes	/	Demonstrated a viable robotic picking and packing system for use in-plant
	/	Labour efficiencies were achieved although an operator was still required to validate the cuts for the in-plant trial, it is expected by the adoption stage of the technology it will be fully automated.
	/	Potential for cycle times and robotic speeds to be optimised for greater efficiency on the line.
	/	Potential for multi-robotic module setup however this is limited by plant size, output and space in the facility for the setup
Potential Impacts	/	Potential labour savings in the picking and packing process line
	/	Reduced number of stress-related workplace injuries from manual picking and packing of primal cuts

Project investment

AMPC invested **$222,750** into the project ($96,800 in 2019, $95,700 in 2023, $30,250 in 2024), in nominal terms and inclusive of project management costs.

Summary of impacts

Table 45 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 45 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	**Cost saving in labour**
	/	Reduced stress-related injuries
Environmental		
Social	/	Safer working environment

Quantification of impacts

Estimated benefits

The primary modelled benefit from the project is that it provides a basis for decreasing the cost of one labour unit FTE upon adoption of the system by a meat processing plant. This analysis assumes the scenario that further labour savings from speed and cycle optimisation have not yet been achieved although it is probable there will be ongoing efficiencies established.

Benefits are only assumed to begin in 2027-28, 3 years delayed, as further R&D is required in this space for approximately another two years before commercialisation and adoption can begin.

Table 46 Benefit assumptions

Variable	Assumption	Source/ Explanation
a) FTE equivalents saved	1	Conservative estimate of the labour-saving potential, informed by the project reports.
b) Yearly wage of FTE	$70,000	Consultant's estimate considering Meat Industry Award and current wages in industry statistics (AMIC, 2022).
c) Ongoing costs	$8,500	As indicated in the feasibility assessment conducted by MLA and Strategic Engineering in 2014.

Adoption costs

Based on a feasibility assessment conducted by MLA and Strategic Engineering in 2014, the adoption costs for one robotic cell are estimated to be $296,100, however, consultations informed there are likely additional costs involved in the sensing technologies now being used, an estimate of $350,000 is hence used. Ongoing costs of $8,500 annually emerging from equipment repair and maintenance have also been modelled.

Counterfactual

The counterfactual identified considers the benefits still to occur but are delayed. There are multiple streams of automation that could produce similar types of solutions to address this task in the processing line, hence it is considered that through this project, the benefits have been realised 5 years earlier than the counterfactual.

Attribution

This project is expected to be attributable to only a portion of the total benefits identified, with significant past research having contributed significantly and future developments needed to realise the benefits as outlined in Table 47 below.

Table 47 Attribution assumptions

Source	Attribution	Explanation
AMPC	19%	This project successfully achieved its objectives, attribution has been based on proportion of total estimated investments.
Past research	45%	Significant past research has led to outcomes produced in this project as informed by consultations and a breakdown of past investments by AMPC including in projects 2014-1007 and 2017-1065, attribution has been based on proportion of total estimated investments.
Future development	36%	There are significant additional steps required to achieve the identified benefits. Future development has been estimated to consist of $500,000 over the next 2 years to address implementation issues identified within this project.

Source	Attribution	Explanation
Total	**100%**	

Note: Subject to rounding error

Adoption

Total adoption is modelled to reach 20% of total plants in this scenario as plants are likely to be seeking automation using similar competing products in shadow robots and/or collaborative robotic technology for automated picking and packing. It is assumed that there would be a delay of 2 years prior to this technology being implemented into processing lines given the large adoption costs for plants

Distribution of benefits

Benefits are likely to accrue in the private sector within plants that adopt this technology.

Results

Table 48 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2023/24-dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to 2023/24 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2023/24) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $0.78 million and a favourable Benefit Cost Ratio of 4.1.

Table 48 Investment criteria for total investment in Project 2018-1050 ($m)

Year	0	5	10	15	20	25	30
PV Benefits		$0.10	$1.03	$1.03	$1.03	$1.03	$1.03
PV Costs	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
NPV	-$0.25	-$0.15	$0.78	$0.78	$0.78	$0.78	$0.78
BCR		0.4	4.1	4.1	4.1	4.1	4.1
IRR		-2%	19%	19%	19%	19%	19%
MIRR	-100%	4%	7%	7%	7%	7%	6%

The flow of total undiscounted costs and benefits from the project is presented below.

Figure 9 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 49 below.

Table 49 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		$0.78	4.1	6%
Adjusted discount rate				
	0%	$1.20	5.7	2%
	10%	$0.49	2.9	11%
Adoption by industry				
	10%	$0.26	2.0	6%
	30%	$1.30	6.1	7%

The accuracy of the assessment is highly dependent on:

- The extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and
- The level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions).

An assessment of coverage and confidence ratings for this project is presented below.

Table 50 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	Medium	Safety-related benefits from the adoption of this technology and improvements in the efficiency of the processing line have not been considered in this evaluation.
Confidence in assumptions	Low	The modelled benefits are highly dependent upon adoption rates, adoption timelines and future development costs to commercialisation.

Conclusions

Project *2018-1050: In Plant Trial of Robotic Picking and Packing System* successfully trialled the robotic prototype at JBS Australia's plant in Brooklyn, Victoria. The system has potential to create labour savings and partially automated an otherwise labour-intensive, manual task. Based on the adopted assumptions this analysis has estimated the project investment will likely deliver a positive economic benefit (BCR 4.1). This remained positive across all modelled scenarios.

References

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Acknowledgments

GHD would like to acknowledge the time given by Richard Aplin and Daniel Hankins (Strategic Engineering Pty Ltd, August 21, 2024).

7.7 Appendix G: 2023-1061-1062: Empowering Women in Maintenance Trades

Background

The underrepresentation of women in trades is well understood. Projects 2023-1061 and 2023-1062 focused on developing awareness of roles for women in the meat processing industry. These projects were delivered as part of the NSW Connecting Women to Trades Program grant funding to deliver skills, training, and career development to support women in pursuing maintenance trades in meat processing (NSW Government, n.d.).

Description of the project

Empowered Women in Trades (EWIT) collaborated with AMPC, processors, and TAFE NSW to deliver an immersive 3-day program designed to build on knowledge, experience, and confidence. Maintenance trades in the meat processing industry such as plumbing, electrical, fabrication, fitting, and turning were the focus of the program. Participants were supported by Applied Principles of Positive Psychology – PERMA theory and were able to experience educational aspects of trades through hands-on Virtual Reality (VR) experiences at TAFE.

Table 51 Project description and logic

Project Details	Research Organisation: Empowered Women in Trades Date: 2023-2024 Key researchers: Melinda Davis
Rationale	To address the lack of women employment in meat processing trades by facilitating training workshops. The project also acted as an awareness program for meat processors to consider more inclusive operations, potential barriers and better recruitment strategies for women in roles traditionally held by men in the industry.
Objectives	/ Deliver non-accredited job readiness training through workshops in positive psychology, human skills and sessions on job search skills across all three WiMT Programs. / Provide career information through an explanation of apprenticeships and the AASN contract, Think Digital VR experience and link to current opportunities via speed interviewing, guest speakers and industry connections. / Marketing and promotion of the WiMT program through social media platforms, local newspapers, NSW RIEF Officers and schools in the region. / Work taster experiences and scope for potential employment
Activities and Outputs	/ From the initial survey, 58 women based in regional areas expressed an interest in working in a trade. / Out of the 58 interested women, 33 participants attended and successfully completed the program (completion rate of 100%). / 4 participants identified as First Nations / 5 participants reached out to EWIT post-completion of the program for assistance with resume development / 1 participant is now looking for work experience as a fitter and turner because of the interactions from this program. / A participant who had previously been rejected was able to pass their aptitude testing however were not successful at the interview stage.

	/	The program was heavily taken up by school-aged participants looking to secure career advice and guidance.
Potential Outcomes	/	Post completion of this project, industry partners indicated that they have an improved understanding of ways to connect with women for non-traditional trade roles
	/	Greater interest and awareness of trade roles amongst participants, increased confidence and navigation skills in the job market
Potential Impacts	/	**Benefits to participants from completing the training**
	/	**Potential increases in gender diversity within plants**
	/	Knowledge building for all stakeholders involved
	/	Improved understanding of required infrastructure and equipment for female employees

Project investment

AMPC leveraged the above-mentioned grants program with matched Commonwealth funding and invested **$147,378** into the project ($50,864 in 2023 and $96,514 in 2024). AMPC's investment of $147,378 is expressed in nominal terms and inclusive of project management costs.

Summary of impacts

Table 52 below is a summary of the expected triple bottom-line impacts (economic, environmental and social) from the project.

*Table 52 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	**Realised benefits through facilitating greater diversity within plants**
Environmental	/	
Social	/	**Participants equipped with job-ready skills that may be applicable beyond maintenance trade-related jobs**
	/	Improved confidence and awareness of job opportunities among participants

Quantification of impacts

Estimated benefits

There are two benefits modelled in this analysis. Firstly, the analysis assumes a small increase in the likelihood of the plants involved in the training adopting greater diversity within the workplace. Research has been completed into the benefits associated within businesses that adopt a gender-diverse environment. Further, the return on investment of similar programs have been used as a proxy to quantify the potential advantages to participants from completing the training.

Table 53 Benefit assumptions

Variable	Assumption	Source/ Explanation
a) Participation rate	55%	33 participated out of 60 available places
b) ROI of similar training	2.9	ROI estimated in TVET training (UNESCO and NCVER, 2020)
c) ROI expected of this project's training	1.2	75% x b x a
d) Training costs	$147,000	Project costs
e) Benefits to participants	$176,400	c x d (Approximately $5,000 benefit per participant)
f) Plants included in program as a % of industry value add	5%	Estimate based on listed plants
g) Profitabiltiy increase within businesses that encourage inclusivity and diversity	22%	Based on *The Business Benefits of Gender Diversity* report (Badal, 2014)
h) Profit of processing industry (million)	$300	Assumed 10% of total processing value add (MLA, 2023)
i) Marginal impact of project on plant's progress	1.5%	Consultant's estimate
j) Profitability increase across participating plants	$50,000	f x g x h x i

Adoption costs

There are no significant adoption costs associated with this project.

Counterfactual

The counterfactual is that participants would not receive any training and hosting plants would not increase their current rate of diversity.

Attribution

The modelled benefits are considered to be entirely attributed to this project as outlined in Table 54 below.

Table 54 Attribution assumptions

Source	Attribution	Explanation
This project	100%	This project provides key training and spreads awareness of job opportunities among the participants that otherwise likely would not have occurred.
Total	**100%**	

Note: Subject to rounding error

Adoption

It is assumed that the adoption of benefits from completing the training will occur immediately from 2023/24 onwards for all participating plants and all attendees who completed the training.

Distribution of benefits

Benefits are expected to accrue both publicly and privately. The training provided is likely to increase the employability of participants along with contributing to a more equitable society. Private benefits are expected in the plants benefiting from greater diversity and attractiveness to a greater range of employees, which is a specifically poignant issue in the RMP sector.

Results

Table 55 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2023/24 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to 2023/24 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2023/24) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $0.29 million and a favourable Benefit Cost Ratio of 3.0.

Table 55 Investment criteria for total investment in Project 2023-1061-1062 ($m)

Year	0	5	10	15	20	25	30
PV Benefits		$0.28	$0.45	$0.45	$0.45	$0.45	$0.45
PV Costs	$0.15	$0.15	$0.15	$0.15	$0.15	$0.15	$0.15
NPV	$0.12	$0.29	$0.29	$0.29	$0.29	$0.29	$0.29
BCR	1.8	3.0	3.0	3.0	3.0	3.0	3.0
IRR	158%	206%	206%	206%	206%	206%	206%
MIRR	9%	13%	11%	10%	10%	9%	9%

The flow of total undiscounted costs and benefits from the project is presented below.

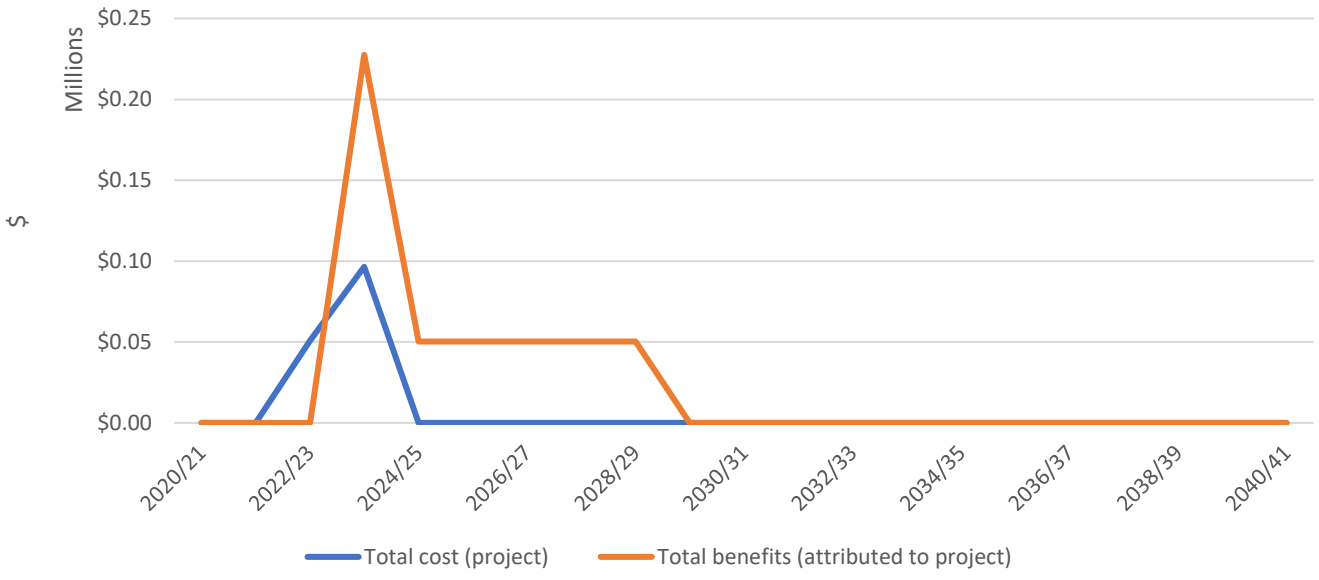

Figure 10 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 56 below.

Table 56 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		$0.29	3.0	9%
Adjusted discount rate				
	0%	$0.33	3.2	4%
	10%	$0.27	2.8	14%
Attribution of diversity benefits in plant to this project				
	0.5%	$0.12	1.8	7%
	2.5%	$0.47	4.1	10%

The accuracy of the assessment is highly dependent on:

- The extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and
- The level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions).

An assessment of coverage and confidence ratings for this project is presented below.

Table 57 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	High	Benefits have been assessed for both the plants and participants for this training program.
Confidence in assumptions	Low	It is difficult to estimate the level of impact of creating greater diversity within plants. The ROI utilised in this modelling does not consider further benefits that are associated with training of this type including better health outcomes, civic participation and well-being (UNESCO and NCVER, 2020)

Conclusions

Project *2023-1061-1062: Empowering Women in Maintenance Trades* aimed to develop awareness of employment opportunities for women in maintenance trades in the meat processing industry. The three-day program was delivered as part of the NSW Connecting Women to Trades Program grant that provided participants with skills training and career development support to pursue employment opportunities. Based on the adopted assumptions this analysis has estimated the project investment will likely deliver a positive economic benefit (BCR 3.0). This remained positive across all modelled scenarios.

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Acknowledgments

GHD would like to acknowledge the time given by Melinda Davis (Chief Operating Officer, Empowered Women in Trades, 8 August 2024).

7.8 Appendix H: 2022-1127-1131, 2022-1139: Smallstock Traceability Pilots (5 plants) and Smallstock Traceability Pilot Study Evaluation

Background

The May 2022 outbreak of foot-and-mouth disease (FMD) in Indonesia and its spread to Bali in July 2022 has reinforced the importance of biosecurity to the sustainability of Australian livestock. The importance of traceability to improve Australia's biosecurity against outbreaks like FMD is recognised as a key focus by industry bodies.

Radio Frequency Identification Devices (RFIDs) have been in use in Victoria since 2016 for stock traceability. In September 2022, Australia mandated the implementation of individual electronic identification devices (EIDs). All sheep and goat meat processors in NSW were required to have EID scanning systems in place by 30th June 2024 and 1st January 2025 for Western Australian and Northern Territory processors. Currently, there is ongoing engagement amongst key industry stakeholders, producers, agents, processors, saleyards, and equipment manufacturers to meet this deadline (DAFF, n.d.)

A previous study conducted by O'Halloran in 2021 highlighted the value of EID systems to processors through consultations with Victorian meat processors. The Australian Meat Industry Council (AMIC) collaborated with AMPC on this project which aimed to provide processors with vital knowledge and access to funding to implement the EIDs and support a smooth transition.

Description of the project

AMIC received Commonwealth funding in 2021 through the Traceability Grants Program. The grant was leveraged by industry co-funding and administered by AMPC. Pilot studies were conducted in five meat processing plants from NSW, SA, and WA. Initially, a sixth plant was involved however was unable to complete the pilot study due to issues in the availability and installation of EID hardware in the required timelines of the project. In addition to the pilot studies, a final evaluation report that presented learnings from pilot studies was also published by AMPC.

Table 58 Project description and logic

Project Details	Research Organisation: Tracy Lamb Date: 2022-2024 Key researchers: NSW Department of Primary Industries
Rationale	The pilot studies aimed to examine the benefits of RFID readers in five sheep processing plants across NSW, SA, and WA. A final evaluation report highlighted key learnings from the pilot studies and recommendations for each state body, industry group, and processing plant to support the implementation of RFID readers.
Objectives	/ Engage with meat processors as part of the pilot studies. / Monitor and evaluate the installation of RFID technology and related software. / Enhance industry knowledge and understanding of the technology.
Activities and Outputs	/ Processors were consulted via phone or site visits and the key objectives they were working towards by installing RFIDs were consolidated. / Processors were engaged via phone meetings and email correspondence during system installation and throughout the project. A site visit was conducted once the installation of the technology was completed. / Individual reports highlighting challenges encountered and lessons learned at each plant were documented.

	/ Results from interviews conducted with each processor were consolidated in the final report with recommendations for the industry. / Hardware and software providers were also consulted on their view of the implementation process, the merit of their products, and any developments in their technology since its first use in Victoria. / NSW DPI published one-page summaries consisting of learnings from each pilot study. A summary of recommendations for the industry was distributed to industry stakeholders.
Potential Outcomes	/ RFIDs provide a pathway to full carcass tracking / Improve data collection from objective measurements along the chain. The data can be used to inform decision-making in the boning room. / Improve the accuracy of animal counts and the ability to record animal health and defect status. / Reduce human error when manually entering data and improve the accuracy of mob-based traceability systems. / Improve feedback systems for producers and improve carcass compliance in meeting market specifications. / Individual carcass feedback can be linked to producers
Potential Impacts	/ Reduction in implementation costs for participating plants / Reduction in costs from uptake in learnings and recommendations from pilot studies / Improved traceability along the supply chain and efficient detection and handling of stock in the event of an outbreak. / Over the long-term, animal health feedback can improve product, reduce wastage resulting in cost savings and better returns.

Project investment

AMPC invested **$639,697** into the project ($200,228 in 2022, $322,957 in 2023, and $116,513 in 2024), in nominal terms and inclusive of project management costs.

Summary of impacts

Table 59 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 59 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	**Supplemented costs of implementation of systems for participating plants**
	/	**Reduction in costs from uptake of lessons learned from pilot studies**
	/	Improved mob-traceability and better detection and handling of stock during a disease outbreak.
Environmental	/	
Social	/	

Quantification of impacts

Estimated benefits

The primary modelled benefit of the project is that it provides a basis for decreasing the costs associated with the mandatory implementation of RFIDs across the smallstock processors. Further, the grant provided direct funding for the costs of implementation.

Benefits are assumed to begin immediately from 2023/2024 until 2024/2025 due to mandatory implementation of RFIDs in Australia by 1st January 2025 at the latest.

Table 60 Benefit assumptions

Variable	Assumption	Source/ Explanation
a) Estimated costs of system installation	$135,000	Based on previous BCA conducted by O'Halloran (2021)
b) Reduction in costs from uptake of learnings to other plants	5%	Based on previous BCA conducted by O'Halloran (2021)
c) Number of plants	40	Consultant's estimate informed by O'Halloran's study and industry statistics.
d) Adoption rate	35 plants over two years	Consultant's estimate; c – 5 participating plants
e) Future costs	$20,000	Consultant's estimate informed by consultation with researcher
f) Reduction in implementation costs across 5 plants included in project	$617,000	(1 + b) x cost of five plants' project costs

Adoption costs

Due to the modelling looking at the marginal cost-savings in adoption costs, there are no adoption costs identified for these decision changes.

Counterfactual

The counterfactual is that the plants manage the installation of RFID systems and software themselves. This is assumed to lead to greater costs along with some plants not being able to leverage the available grants utilised through this project.

Attribution

Attribution of benefits from the project considered any past inputs and expected future development costs required to realise beneficial outcomes, as outlined in Table 61 below.

Table 61 Attribution assumptions

Source	Attribution	Explanation
This project	97%	This project provides key learnings from each pilot study and consolidates recommended next steps to achieve benefits.
Future development	3%	A small additional project (estimated to be worth $20,000) is being undertaken currently that will help extend this project's findings and impacts.
Total	**100%**	

Note: Subject to rounding error

Adoption

Adoption of the RFID system is assumed to be high, reaching 100% adoption across all 35 sheep and goal processing facilities (outside of Victoria) over two years from 2023/2024 to 2024/2025 with 20 plants adopting in the first year followed by 15 plants in the second. A key factor driving the adoption is mandatory EID tagging for all sheep and goat meat processors in NSW by 30th June 2024 and by 1st January 2025 for all processors in WA.

NSW DPI has also delivered extension work post-completion of the project. This has involved consolidating learnings from each pilot study and distributing lessons and recommendations amongst industry stakeholders to support RFID implementation in other

Distribution of benefits

Benefits are expected to accrue directly to the private sector, and specifically to the smallstock processing plants that are required to implement RFID systems.

Results

Table 62 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2023/24-dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to 2023/24 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2023/24) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $0.18 million and a favourable Benefit Cost Ratio of 1.3.

Table 62 Investment criteria for total investment in Project 2022-1128-1132, 2022-1139 ($m)

Year	0	5	10	15	20	25	30
PV Benefits	$0.87	$0.87	$0.87	$0.87	$0.87	$0.87	$0.87
PV Costs	$0.69	$0.69	$0.69	$0.69	$0.69	$0.69	$0.69
NPV	$0.18	$0.18	$0.18	$0.18	$0.18	$0.18	$0.18
BCR	1.3	1.3	1.3	1.3	1.3	1.3	1.3
IRR	NA	NA	NA	NA	NA	NA	NA
MIRR	13%	12%	11%	10%	9%	9%	9%

The flow of total undiscounted costs and benefits from the project is presented below.

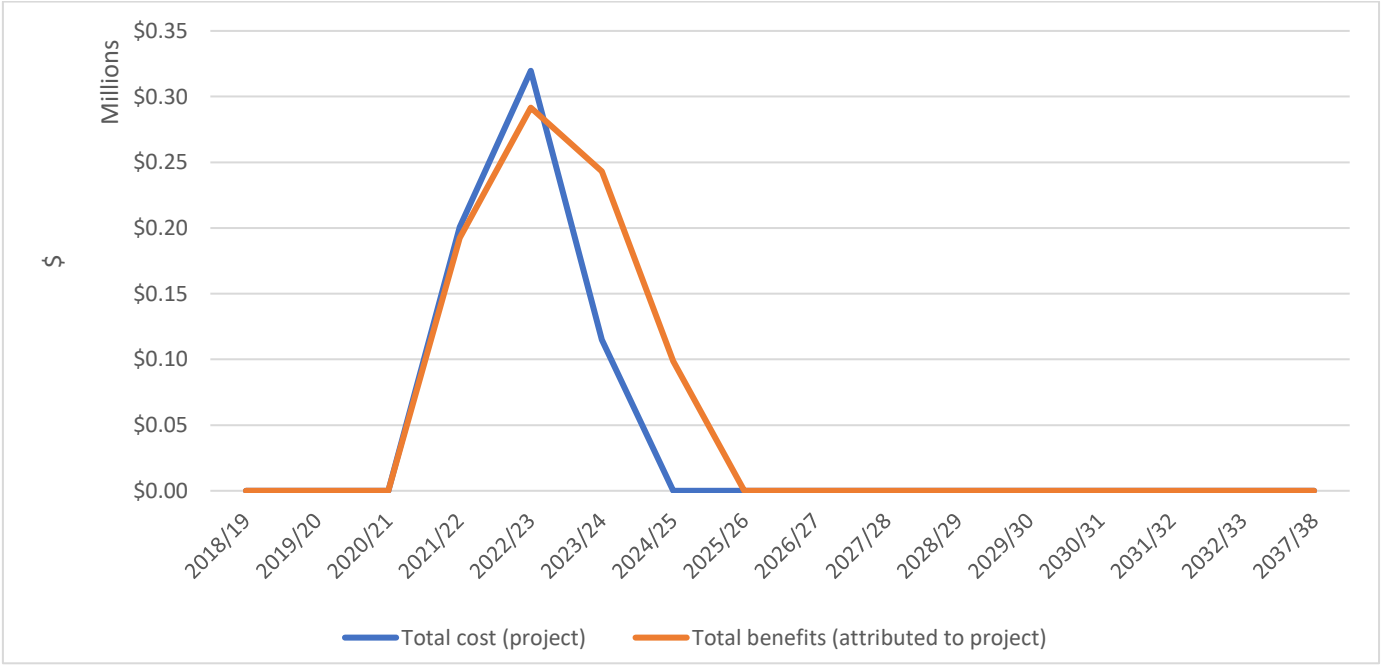

Figure 11 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 63 below.

Table 63 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		$0.18	1.3	9%
Adjusted discount rate				
	0%	$0.19	1.3	4%

	10%	$0.18	1.3	14%
Reduction in costs from uptake of learnings to other plants				
	2.5%	$0.07	1.1	7%
	7.5%	$0.30	1.4	9%

The accuracy of the assessment is highly dependent on:

- The extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and
- The level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions).

An assessment of coverage and confidence ratings for this project is presented below.

Table 64 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	Medium	There are potential additional benefits related to improved traceability and accuracy of data emerging from this project's findings that have not been included.
Confidence in assumptions	Medium	The benefits are highly dependent on difficult to determine variables as outlined in the sensitivity analysis.

Conclusions

Project *2022-1127 to 1131 and 2022-1139: Smallstock Traceability Pilots (5 plants) and Smallstock Traceability Pilot Study Evaluation* successfully supported five sheep and goat meat processing plants across NSW, SA and WA with the mandatory implementation of software and hardware associated with EID systems. The final report also published challenges encountered and lessons learned to assist other plants in their installations. Based on the adopted assumptions this analysis has estimated the project investment will likely deliver a positive economic benefit (BCR 1.3). This remained positive across all modelled scenarios.

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Acknowledgments

GHD would like to acknowledge the time given by Tracy Lamb (Development Officer at NSW Department of Primary Industries and Regional Development, 1 August 2024).

7.9 Appendix I: 2023-1005: Transport Emissions, Efficiency and Sustainability Roadmap

Background

Transport and logistics are a key element of the Australian red meat processing sector; however, outbound and inbound logistics of heavy vehicles contributes to the production of emissions. With industries increasingly expected to decarbonise, the meat processing sector has been exploring alternative energy sources and various vehicle upgrades and/or modifications. Tools to accurately measure vehicle emissions are needed to generate baseline data and support the industry transition and meet its 2030 carbon neutral target (MLA, 2023).

Description of the project

Two AMPC member companies who were operating large heavy vehicle fleets took part in online workshop consultations to determine the nature of their heavy-duty logistics operations and what vehicle types were in the fleets. Investigations were undertaken to explore the range of commercially available Internet of Things (IoT) sensors to identify potential hardware that could be utilised to collect GPS, vehicle dynamics, and truck operational data. A shortlist of products from Arduino and CSS Electronics that were commercially available and capable of measuring vehicle emissions from Arduino and CSS Electronics was compiled.

Table 65 Project description and logic

Project Details	Research Org: IMOVE Australia-Ann Breger Date: 2023-2024 Key researcher: Hadi Ghaderi
Rationale	To develop tools for AMPC member companies to be able to accurately measure and determine Scope 1 Greenhouse Gas (GHG) emissions for vehicles being utilised as part of their logistics fleet that they either own or have control of for their operations.
Objectives	/ Develop tools for determining an accurate representative baseline environmental footprint for red meat processor owned heavy transport tasks. / Identify and assess opportunities to improve environmental, social, and economic outcomes for red meat processor owned heavy transport tasks, including recent technological advancement in vehicle and fuel systems. / Identify and suggest use cases and pilot studies for future actions.
Activities and Outputs	/ The Data-integrated Visualisation and Analytics (DiVA) Platform was successfully developed and tested to investigate vehicle emissions (developed from commercially available measurement modules from CSS Electronics) / Testing showed that the DiVA Platform was effective in determining the vehicle location (via an IoT box equipped with GPS) and the vehicle's fuel consumption (collected in l/h, l/s, l/100km, and km/l). The DiVA Platform was also effective at uploading the data to the cloud for storage and providing a Dashboard interface for assessing daily reports and trip information. / A portable emission measurement system (PEMS) was successfully designed and tested to measure real-world emission data of heavy vehicles. / AI modelling was undertaken using collected vehicle data to model average CO_2 value across an entire trip being assessed.

	/	A survey and assessment of the available alternate low carbon transport options was undertaken and reported on.
Potential Outcome	/	Using renewable diesel fuel was identified as a possible approach to support a net-zero transition. However, this is likely a long-term prospect due to the lack of local supply and higher cost of renewable diesel compared to mineral diesel.
	/	The tools can be further refined to model CO_2 results for other vehicles with input of other parameters.
Potential Impacts	/	Access to tools and pathways for processors to track emissions from their transportation
	/	Leading transport emissions reduction may help improve the meat processing industry's social licence
	/	Broader impacts to any industry using heavy-duty vehicles
	/	Emissions data can provide an improved understanding of scope 1 emissions being generated from transport and set a pathway to work towards net-zero.
	/	Create opportunities for access to ACCUs or equivalent carbon abatement pricing mechanisms.

Project investment

AMPC invested **$324,363** into the project ($264,000 in 2023 and $60,363 in 2024), in nominal terms and inclusive of project management costs.

Summary of impacts

Table 66 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 66 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	Vehicle efficiency gains through increased trip and performance optimization
Environmental	/	**Total value of carbon emissions reduced from red meat heavy vehicle transport**
	/	**Total value of carbon emissions reduced from other Australian industries with heavy vehicles that adopt technology**
	/	Ongoing environmental benefits from reducing carbon emissions
Social	/	Emissions monitoring and reductions improve the social licence of the meat processing industry

Quantification of impacts

Estimated benefits

The primary modelled benefit from the project is that it provides greater certainty around energy usage from heavy vehicle logistics, and therefore improves efficiencies in abatement strategies to reduce Scope 1 Greenhouse Gas (GHG) emissions (understand, measure, improve). This benefit was quantified for Australia's red meat industry –

where transport logistics are a key part of the value chain. This benefit was also quantified for all other Australian industries that use heavy vehicles. Only domestic benefits have been quantified. This analysis assumes that the process of reducing emissions from heavy vehicles has been optimised due to this project.

Benefits are assumed to begin in 2025/26, as targets for emissions reductions are likely to be timely and require immediate action.

Table 67 Benefit assumptions

Variable	Assumption	Source/ Explanation
a) Carbon price (per tonne)	$33	ACCU average pricing (Energy Action, 2024) (Clean energy regulator, 2024)
b) Emissions attributable to transport in the red meat supply chain	0.5%	(Ritchie, 2020)
c) Total Mt of C02e from the red meat industry	51.3	(MLA, 2023)
d) Potential impact of this project to facilitate annual emissions reductions from red meat transport	0.25%	Consultant's estimate
e) Value of technology implementation in Australia's red meat supply chain sector	$21,000	a x b x c x d
f) Total Mt C02e from transport in Australia	90	(Climate Change Authority, n.d.)
g) Percent of transport emissions in Australia caused by heavy vehicles	20%	(Climate Change Authority, n.d.)
h) Potential impact of this project to facilitate annual emissions reductions from Australia's heavy vehicle transport	0.13%	Consultant's estimates: considered that it will facilitate emissions reductions in all Australian heavy vehicle industries (but reductions will be to a lesser extent than in the red meat industry, as red meat industry is at the forefront of adopting this technology).
i) Value of technology implementation in Australia's transport sector	$800,000	a x f x g x h
j) Total annual benefit	$820,000	e + i

Adoption costs

Adoption costs have not been considered in the analysis considering it is too early to estimate costs of technology. However, due to the conservative nature of the estimates the costs have been broadly absorbed into net benefits.

Counterfactual

The counterfactual is that a transition to less carbon intensive transport will occur, however in a less optimised way. The key difference that this technology is seen to provide is accurate measurement of emissions which can inform abatement strategies.

Attribution

The benefits quantified are considered entirely attributable to this project, as outlined in Table 68 below.

Table 68 Attribution assumptions

Variable	Attribution	Source/ Explanation
This project	100%	This project provides the ability for the heavy trucking industry to generate baseline transport emissions data and subsequently develop and monitor progress towards targets.
Total	**100%**	

Note: Subject to rounding error

Adoption

It is assumed that there would be little delay in this technology being implemented (benefits are assumed to begin in 2025/26) in heavy vehicle logistics as reducing emissions is a priority for many industries in Australia due to increased government regulation and maintaining a social licence to operate. Specifically, the meat industry has indicated that they intend to be net-zero by 2030 (MLA, 2023.).

Results

Table 69 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2023/24 dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to 2023/24 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2023/24) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $2.81 million and a favourable Benefit Cost Ratio of 5.9.

Table 69 Investment criteria for total investment in Project 2023-1005 ($m)

Year	0	5	10	15	20	25	30
PV Benefits		$2.82	$3.38	$3.38	$3.38	$3.38	$3.38
PV Costs	$0.57	$0.57	$0.57	$0.57	$0.57	$0.57	$0.57
NPV	-$0.57	$2.25	$2.81	$2.81	$2.81	$2.81	$2.81
BCR		4.9	5.9	5.9	5.9	5.9	5.9

IRR		47%	49%	49%	49%	49%	49%
MIRR	-100%	11%	11%	10%	9%	9%	9%

The flow of total undiscounted costs and benefits from the project is presented below.

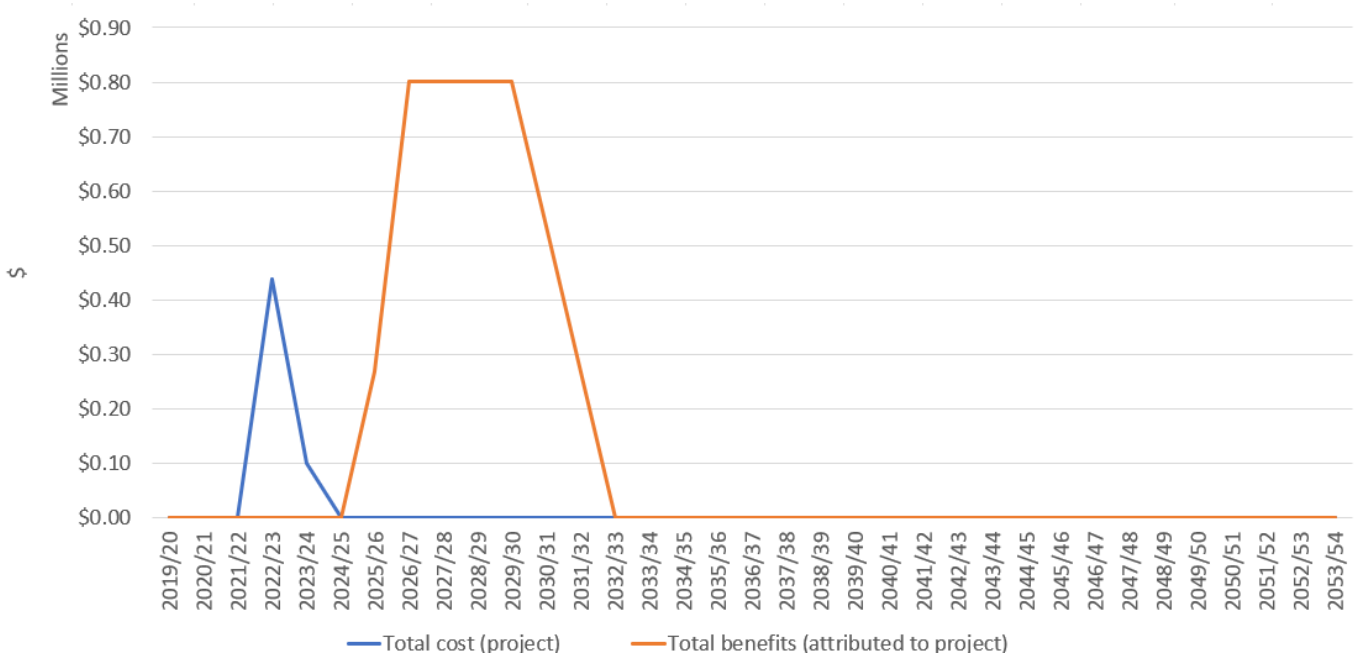

Figure 12 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 70 below.

Table 70 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		$2.81	5.9	9%
Adjusted discount rate				
	0%	$3.71	7.5	4%
	10%	$2.15	4.8	13%
Impact on total heavy transport industry				
	0.25%	$5.07	9.9	10%
	0.05%	$0.56	2.0	6%

The accuracy of the assessment is highly dependent on:

- The extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and

- The level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions).

An assessment of coverage and confidence ratings for this project is presented below.

Table 71 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	Low-Medium	The benefits of this technology are unclear and there are multiple areas where it may prove beneficial to different sectors.
Confidence in assumptions	Medium	Most assumptions used are based on reliable sources, however the impact this technology could have is a large uncertainty.

Conclusions

Project *2023-1005: Transport Emissions, Efficiency and Sustainability* successfully developed the DiVA system to measure scope 1 carbon emissions from heavy-duty vehicles under various conditions. Based on the adopted assumptions this analysis has estimated the project investment will likely deliver a positive economic benefit (BCR 5.9). This remained positive across all modelled scenarios.

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7.10 Appendix J: 2024-1087: Kokumi Flavour Peptide Production from Beef Offal Co-Products

Background

About 54-56% of live cattle weight is transferred to offal co-products in meat processing. Despite making a substantial amount of the animal and offering high nutritional value, the current utilisation of offal co-products is a market of relatively low-value to the industry. Co-products are often considered low-value and generally uses include animal feed or fertiliser despite being fit for human consumption. Offal co-products are rich in essential amino acids, collagen, minerals and vitamins and can be utilised to contribute to alleviating the increasing global demand for protein.

Converting offal into a high-value product is also challenged through overcoming public perception and making it palatable to drive consumer desirability and acceptability.

Kokumi is recognised as a sixth taste in culinary science and is derived from the Japanese words 'Koku' (rich) and 'mi' (taste) describing rich, complex flavours associated with a buttery heartiness or mouthfulness. The kokumi flavour is activated by amino acids or peptides enhancing the perception of other basic tastes such as sweet, salty and umami (NBR, 2020). This proof-of-concept study focused on assessing and quantifying kokumi flavour peptides in bovine liver and lung co-products.

Description of the project

An enzymatic method developed as part of an AgResearch-funded project was used to produce liver and lung kokumi extract. Kokumi intensity was tested using an in-vitro taste receptor assay. A flash profiling sensory trial was used to test the flavour potential of oven-dried kokumi-rich extract produced from bovine liver and lung.

Table 72 Project description and logic

Project Details	Research Organisation: Raise Ahmad Date: 2024 Key researchers: Ag Research Limited (NZ)
Rationale	A proof-of-concept study to determine the suitability of two bovine offal co-products (liver and lung) to produce food-grade kokumi extract for human consumption and add significant value to an otherwise low-value co-product in meat processing.
Objectives	/ Prepare oven-dried extract from bovine liver and lungs and conduct a yield assessment of the extract / Quantify kokumi taste peptides and relevant amino acid in kokumi extract / Determine kokumi flavour activity through in vitro taste receptor assay. / Conduct an in-house sensory test to identify sensory attributes of kokumi extracts incorporated into meat patties
Activities and Outputs	/ Enzymatic treatment of bovine liver and lung resulted in a significant increase in kokumi peptides / Lung samples contained tripeptide EVG which is reported as the most potent kokumi peptide. / Enrichment of beef patties with kokumi extract was detected in a dose-dependent manner i.e. the larger the amount of extract applied the more enhanced taste.

	/	Lung-supplemented beef patties have more desirable flavour attributes and indicated a strong effect of kokumi enrichment producing strong kokumi flavour at lower doses of enrichment than liver-supplemented patties
Potential Outcomes	/	Offal products can be enriched to improve palatability and desirability
	/	This is the first report in the industry showcasing the potential use of bovine lung as an effective substrate to produce kokumi flavour extracts to impart desirable sensory attributes in a processed meat product
Potential Impacts	/	Improved sale value of beef lung for human consumption contributing to improved revenue for meat processors.
	/	Reduced generated waste and co-products in meat processing

Project investment

AMPC invested **$156,294.50** into the project in 2023/2024, in nominal terms and inclusive of project management costs.

Summary of impacts

Table 73 below provides a summary of the expected triple bottom line impacts (economic, environmental and social) from the project.

*Table 73 Triple bottom line impacts, including those valued as part of this evaluation (**bold**)*

Economic	/	**Increasing the value of beef lung from a low-value offal co-product often used in pet food to a high-value product fit for human consumption**
Environmental	/	Reduced waste generated from offal co-products in meat processing
Social	/	Improved consumer acceptance of meat products enriched with offal co-products

Quantification of impacts

Estimated benefits

The primary modelled benefit is that this project's findings provide a basis for increasing the market value of beef lung from a low-value offal co-product often used in pet food to a high-value product fit for human consumption. This analysis assumes that the likelihood of these actions being carried out has increased due to this project. This analysis has focussed on lungs considering the hurdles in kidney taste identified through this project.

Benefits are assumed to begin in 2026/2027 after a two-year delay as significant future research and development is required in commercialising this product.

Table 74 Benefit assumptions

Variable	Assumption	Source/ Explanation
a) Throughput per year of beef (million head)	8.03	Industry Projections 2024 (MLA, 2024)
b) Amount of lung offal per cow	2 kg	Co-products compendium (MLA 2009)
c) Price of lung offal per kilogram	$1.13	Co-product market report (MLA 2019)
d) Total annual value of lungs (million)	$9.1	a x b x c
e) Potential value added per kilogram	$1.5	Consultant's estimate
f) Potential value add of lung per year (million)	$24.1	a x b x e
g) Probability of success/potential market penetration	10%	Consultant's estimate
h) Adjusted annual value add of lung per year (million)	$2.4	f x g

Adoption costs

There are no adoption costs identified at this stage of development associated with this project, benefits are considered inclusive of additional costs of processing.

Counterfactual

The counterfactual is a scenario where there is no change in the market value of lung offal.

Attribution

Attribution of benefits from the project considered any past inputs and expected future development costs required to realise beneficial outcomes. Considering the significant past costs and future development of this project, the overall attribution of benefits to this project is relatively low despite the overall BCR being high, as outlined in Table 75 below.

Table 75 Attribution assumptions

Source	Attribution	Explanation
This project	4%	This project used the enzymatic testing methods developed by AgResearch previously to extract and quantify kokumi extract.
Past research	27%	Enzymatic methods used to quantify the kokumi extract were developed as part of past research by AgResearch.
Future development	69%	There are significant future research steps to achieve commercialisation of the product. AgResearch estimated up to $3 million additional investment into making this a viable market.
Total	**100%**	

Note: Subject to rounding error

Adoption

As there are significant future developments to follow in the upcoming years, it is assumed there will be a 2-year delay in the adoption of this product. The probability of success is assumed to be 10% given that this will be a novel product in a future market where demand is uncertain and barriers to consumer acceptance of offal co-products still exist.

Distribution of benefits

Benefits are expected to accrue privately. The red meat supply is expected to see increased value associated with the successful creation of this market would create additional demand and value for otherwise low-value products. Further, there would need to be development and processing of the product which is likely to create new value and products within the food processing sector. Further, given the successful creation of a consumer-friendly product, there is potential for co-products on a global scale to realise these additional benefits.

Results

Table 76 below presents the modelled investment performance from the project. All past costs and benefits were expressed in 2023/24-dollar terms using the Implicit Price Deflator for GDP, while all future costs and benefits were discounted to 2023/24 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the modified internal rate of return (MIRR). The analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2023/24) to the final year of benefits assumed.

The results show the investment returning a net present value (NPV) of $1.09 million and a favourable Benefit Cost Ratio of 8.0.

Table 76 Investment criteria for total investment in Project 2024-1087 ($m)

Year	0	5	10	15	20	25	30
PV Benefits		$0.23	$0.54	$0.79	$0.98	$1.16	$1.25
PV Costs	$0.16	$0.16	$0.16	$0.16	$0.16	$0.16	$0.16
NPV	-$0.16	$0.07	$0.38	$0.63	$0.82	$1.00	$1.09
BCR		1.5	3.5	5.0	6.3	7.4	8.0
IRR		16%	31%	33%	33%	33%	33%
MIRR	-100%	6%	9%	10%	10%	10%	9%

The flow of total undiscounted costs and benefits from the project is presented below.

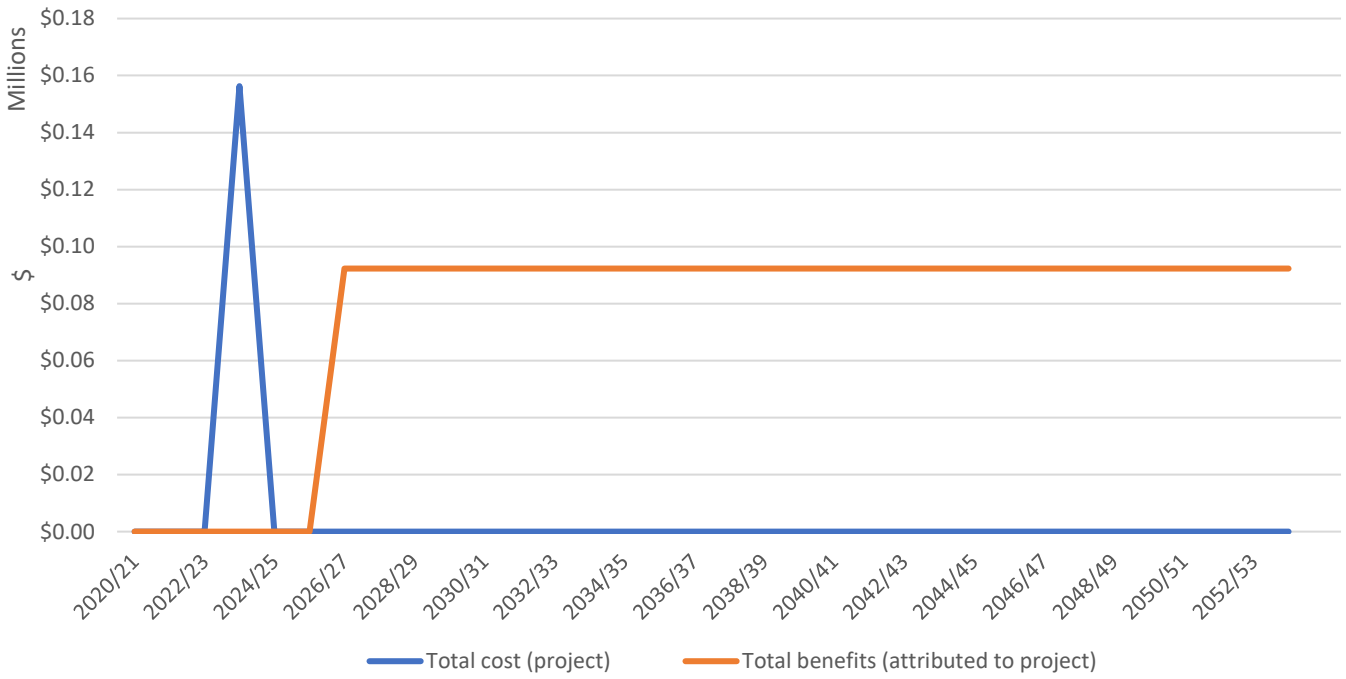

Figure 13 Flow of undiscounted costs and benefits from project

Sensitivity analysis and confidence

A sensitivity analysis was carried out to determine how the investment performance (NPV, BCR and MIRR after 30 years) would change based on changes to the discount rate and other key variables. The results are presented in Table 77 below.

Table 77 Sensitivity analysis

Changes to Key Variables		NPV ($M)	BCR	MIRR
Standard assumption		$1.09	8.0	9%
Adjusted discount rate				
	0%	$2.31	15.8	5%
	10%	$0.58	4.7	13%
Value add per kg				
	$2	$1.51	10.6	10%
	$1	$0.68	5.3	8%

The accuracy of the assessment is highly dependent on:

- The extent to which the analysis captures and quantifies the various benefits from the project, including non-market benefits (i.e. coverage of benefits), and
- The level of confidence in the accuracy of assumptions used (i.e. confidence in assumptions).

An assessment of coverage and confidence ratings for this project is presented below.

Table 78 Coverage and confidence ratings

Factor	Rating	Comment
Coverage of benefits	High	The benefits of this product, if successful in commercialisation, will directly impact the market value of beef lung converting it from a low-value product to a high-value product fit for human consumption.
Confidence in assumptions	Low	The benefits of this product are reliant on significant future development costs as well external factors such as market conditions and consumer behaviour towards offal co-products.

Conclusions

Project *2024-1087: Kokumi Flavour Peptide Production from Beef Offal Co-Products* successfully extracted and quantified kokumi flavour peptides from beef offal co-products such as liver and lung. Beef lungs were found to be a better substrate than beef liver as lung-supplemented beef patties had more desirable flavour attributes. The findings from this study have the potential to convert beef lung from a low-value product to a high-value product fit for human consumption. However, this is dependent on significant future development costs, market conditions and consumer behaviour. Based on the adopted assumptions this analysis has estimated the project investment will likely deliver a positive economic benefit (BCR 8.0). This remained positive across all modelled scenarios.

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