Australian Government
Department of Agriculture and Water Resources

AUSTRALIAN Pork®

Low Carbon Emission Roadmap for the Australian Pork Industry

APL R&D Report

Final Report
APL Project 2020/0086

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1. Introduction

This report has been prepared as a complementary document for the Low Carbon Emission Roadmap for the Australian Pork Industry Brief and Manual (APL Project 2020/0086). The objective of this report is to provide industry recommendations that will:

- Provide guidance for the next steps in attaining 'Low Carbon Emission Pork' across the Australian pork industry.
- Outline the research gaps that may improve the knowledge base on emission reduction strategies relevant to the Australian pig industry.
- Identify opportunities/limitations associated with the target of low emission or carbon neutral status.
- Identify opportunities for extension.

Future research in this GHG emissions field has potential to provide a valuable basis for the Australian pig industry to continue consumer and government communications, both as a means of conveying the achievements made by industry, and also as a way of developing support for further advancements.

2. Baselining, Benchmarking and Setting Targets

2.1 Baselining

Baselining research exists for the pig industry for 2010 (Wiedemann et al. 2016) and trends have been studied by Watson, Wiedemann et al. (2018). Further work will be required into the future to maintain currency in these data, to enable tracking of performance (see section on data). It would also be beneficial to expand the regional specificity and stratification of these datasets by piggery size and housing type, to build an increasingly robust knowledge base of the industry.

Extension and Adoption

While there is a reasonable understanding of the emission profile at an industry level, few piggeries have a clear understanding of their emission baseline or emission reduction options. This is a key aspect of other industry programs (for example, MLA) and funding support has been provided via Federal Government grants.

We recommend APL establish a major, industry wide extension program over the next 2-4 years to baseline the industry and develop emission reduction plans for businesses. This could be supported via grant money and should be seen as a priority. It may also be possible to partner with other sectors (finance, retail) to roll this program out.

2.2 Target Setting

Progress rarely happens without measuring and setting a target to reduce impacts. Whilst the general "low carbon" emission target set by Australian Pork will provide guidance across the industry, a quantifiable target would allow progress to be tracked over time and provide an increase in promotional opportunities resulting from progress made. As noted in the Industry Reference Group Meeting 2 (25 August 2021– see presentation and minutes in Appendix A undertaken as part of this project, setting a meaningful target for an industry involves a number of steps, summarised below:

1. Setting and emission boundary.
2. How is the baseline measured – emission intensity vs total emissions?
3. What is the Baseline Year?
4. Target and timeframe.

While there are no strict rules around target setting, there are useful guidelines. The Science-Based Target (SBT) Setting Manual (SBTi 2020) provides a recognised methodology for the establishment of targets with the following recommendations applicable to the Australian pork industry:

- Target should cover a minimum of 5 years and a maximum of 15 years
- Absolute emissions reduction from Scope 1 and 2 should align with well-below 2°C or 1.5°C decarbonisation pathway
- Target should cover at least 95% of company-wide (industry wide) Scope 1 and 2 emissions
- If Scope 3 emissions are significant (over 40% of total Scope 1, 2 and 3 emissions), an absolute Scope 3 target should be set.
- Scope 3 targets should be ambitious, measurable and clearly demonstrate how a company (industry) is addressing the main source of the value chain GHG emissions in line with current best practice.

Targets are required to be set on total emissions, in formal guidance (Paris Agreement, SBTi etc). This reflects the imperative to reduce emissions to avoid climate change. Emission intensity is useful for reporting through the supply chain and for tracking improvement (benchmarking) and can be used for target setting, but if used on it's own, would not comply with guidance such as the SBTi. It is also noted that emission intensity includes scope 1, 2 and 3 emission sources.

While the pork industry has achieved a significant reduction in emission intensity of 69% between 1980 and 2020 (Watson *et al.* 2018), many of the 'easy wins' have been made and the rate of change noticeably declined in the most recent decades. Further progress will require significant action and investment to ongoing emission reduction, and counter trends need to be considered.

Preliminary consultation with industry via the Industry Working Group for this project provided useful insight into goal setting. Most group members indicated that an emission intensity target would be preferred (see Appendix A.).

Recommendation

For the industry to make serious progress towards carbon neutrality, we recommend the following process.

1. Formalise the structure of an industry target (emission intensity, absolute scope 1, 2 emissions etc).
2. Establish a series of options to deliver against emission reduction targets at 2025, 2030 and out to 2050. This should also investigate economic costs and policy settings required to achieve these ambitions.
3. Engage with industry stakeholders to establish an industry position.
4. Put the plan into action, with industry research and extension to support the program.

2.3 Industry Data

Collection of reliable production and operational data across the industry is essential to track GHG emissions across the national pig herd.

Table 1 provides a summary of the key data requirements to undertake an accurate GHG assessment.

Table 1. Important parameters to monitor for GHG assessment

Operational Factor	**Comment**
Herd composition	Breakdown of pig numbers
Pigs weaned /sow.year	Annual average
Finisher pig weight	Average weight at delivery to processing
Electricity/Diesel/LPG Usage	Usage in piggery operations
Feed composition	Key feed ingredients, crude protein, digestibility
HFC	kg feed per kg LW
Feed waste	Proportion of feed offered that is not consumed and directly enters the waste system
Use of residual or waste products for pig feed	Use of material other than manufactured pig rations. Residuals and wastes can be practically defined as products provided to the piggery with no cost
Manure management	Proportion of manure managed in different systems
Energy generation from methane	Electricity generated and exported from the site. Gas (MJ) generated and exported from the site.

Recommendation

Collection of periodic data (i.e. every 2 years) across the national herd is recommended to support GHG accounting at industry scale. Tracking emissions will allow reductions in emissions to over time to be confidently assessed and promoted. This could be co-ordinated alongside other industry initiatives (benchmarking and APL surveys). This need will be addressed in the short term through the recently commissioned LCA study.

3. Reduce Emissions

While significant research and investment has been undertaken into the two key sources of GHG emissions in piggery production, feed and manure management, gaps in the knowledge base exist. The following sections briefly outline areas the potential research and investment which may result in benefits across the Australian pig industry.

3.1 Screening of emission mitigation options

A screening assessment of potential options to reduce emissions was conducted. This screening exercise was conducted with two goals:

- A short term 2025 timeframe to reduce emissions. This largely includes mitigation options that have already been proven as viable and are ready for adoption by the industry.
- Medium to long term strategies with a 2030 plus horizon with the aim of achieving closed loop systems across the industry. This includes innovation, collaborative industry wide effort, and bringing together a range of proven strategies into a single operation.

4. All options considered are detailed in Table 1Summary

A large number of recommendations have been provided in this short report. These have been summarised and rated against a set of criteria in **Error! Not a valid bookmark self-reference.** and Table 3 to assist with prioritisation.

Table 2. Below are summaries of the options considered likely to have the best potential for mitigation presented in horizons for short term and long term.

5. Short Term Mitigation Strategies

A range of technical options exist to reduce emissions, but currently uptake of these technologies has been limited. This suggests the barriers relate to cost-effectiveness or ease of operation. We have identified strategies in this section that aim to overcome barriers to adoption, including work directed to reduce costs.

5.1 Diet

The use of sustainable diet components can significantly reduce the GHG emissions from feed. In particular, continuing to decrease reliance on imported soymeal with high levels of emissions from land use change is a priority to decrease environmental impacts from feed. There may also be ongoing opportunities to reduce crude protein levels and decrease nitrogen related manure emissions. This research area could benefit from cross-industry investment from monogastric species to investigate the opportunity for environmentally optimised diets.

5.1.1 Unlocking zero input feed sources

The expected reduction in scope 1, 2 and 3 emission intensity for replacing a standard wheat/barley diet with approximately 35% residuals and waste products (including carbohydrates, dairy and fish waste) is 10% in a conventional piggery. This is an option to reduce GHG, improve sector wide circularity, and reduce costs and is therefore a very attractive option.

We note this reduction is dependent on the digestibility and protein content of the by-products and the feed formulation. Lower digestibility ingredients and ingredients with excessive protein will increase volatile solids and nitrogen excretion rates and lead to higher manure emissions.

A number of barriers to adoption exist, including information on what products are available, what requirements exist for using these, availability of suitable feeding systems and how to develop diets that suit waste products.

Research and Development

A full survey of potential feed sources suitable for piggeries, including their location, feed value, current use/disposal, cost (if any), availability and any constraints to their availability or usability is recommended.

Research may be needed to identify better ration formulation in diets with high levels of by-products, particularly if new sources are discovered.

Extension and Adoption

Following the survey of potential feed sources, APL may be able to assist by co-ordinating offtake agreements with large companies or helping to overcome regulatory barriers with mixed waste sources. The role of APL would be warranted if the agreements that need to be sought were too large, or across multiple regions, and therefore couldn't be managed with just one piggery.

Showcasing the benefits of using by-products via case studies would be beneficial, to raise the profile of this as a viable option for piggeries.

5.1.2 Low GHG diets

Soybean meal imported from Brazil or Argentina is a high emission feed source because of dLUC emissions. Conversion from a relatively high imported soybean meal content diet (~ 9%) to a reduced soybean meal diet (no soybean meal content) can result in reductions of scope 1, 2 and 3 emission intensity of up to 24%.

There are two major options to address the high relative emissions from soymeal:

1. Investigating the cost, availability and suitability of certified soy, and whether these systems protect against loss of soil carbon in addition to deforestation.
2. Replacing soymeal. This requires consideration of different Australian grown diet ingredients (for example, canola or cotton meal) that can replace soymeal. Determining suitability, cost effectiveness and environmental outcomes from different diets would be beneficial. This could also include using higher levels of amino acids.

Research and Development

Research may be needed to identify the best Australian grown soymeal alternatives with respect to herd performance and environmental impact. This research area could benefit from cross-industry investment from monogastric species to investigate the opportunity for environmentally optimised diets.

Extension and Adoption

APL may be able to collaborate with other industry bodies that utilise soymeal to perform a review of certified soy systems, their suitability to reduce reported impacts from soymeal imported into Australia, and the availability and cost of certified soymeal in Australia.

Considering the task of reducing GHG emissions from feed grain is generally outside the remit of the pig industry, we also recommend engagement with the Grains industry (potentially via the feed grains partnership) to promote emission reduction strategies that will lower the impact from Australian feed grain into the future. This work should be done in collaboration with other like-minded feed grain users.

5.1.3 Low crude protein diets

Nitrogen (N) intake by pigs influences the N excretion in manure. In deep litter and free range piggeries, N excretion influences nitrous oxide emissions, which contribute some 10% and 31% to the emission profile from each of these piggery systems respectively. While it is noted in later sections that the emission factors for outdoor/free range have not been researched, it is reasonable to believe that the emission factors will still be reasonably high. Reducing emissions may be achieved in this situation by reducing crude protein levels in the diet, to reduce the overall amount of N excreted by the pigs. This can be influenced via diet modifications such as using higher levels of amino-acids, though that usually results in higher costs.

Research and Development

Active considerations that should be in place with this type of research include the stocking rate of pigs in the range area and the duration of stocking. Ultimately, nitrous oxide emissions are elevated by high N levels in soils over extended periods of time, particularly if these periods include frequent wetting / drying events. Research should therefore consider the multiple effects that result in high N deposition per hectare: N excretion / pig, pigs/ha and length of stocking period (pigs / ha / year).

Extension and Adoption

Pending research findings, extension to industry nutritionists and companies may be warranted, to increase awareness and consideration of environmental performance in diet formulation.

5.2 Manure Management

5.2.1 Methane mitigation

Methane mitigation is well recognised by industry as an important means of reducing impacts from GHG and energy. The increased implementation of capped aerobic ponds is a key aspect of achieving the low carbon ambitions of the industry.

We have identified a number of needs below. However, the single largest barrier in this space is the cost-effectiveness of covered ponds and the willingness of businesses to sign off on the investment.

Prior to further research, we recommend convening a forum with industry members including those who have constructed covered ponds or other methane mitigating manure management systems, and those who haven't. The aim of the forum would be to present the current knowledge and invite case studies of those who have developed projects, and also those who haven't, to discuss the barriers and solutions to expanding the uptake of covered ponds. The points below could be presented and prioritised by the group, along with new points. This forum should be carefully convened and would be most valuable if 'case studies' could be provided by 2-4 industry members in the form of a 15 min presentation covering set topics (cost-benefit, problems encountered, barriers, other benefits). Case studies should also include those who have NOT installed covered ponds, covering the business case and reasons why they have not invested, and what would need to change for them to invest. To get the most value, some producers may need assistance to prepare this case study beforehand.

Research and Development

A number of gaps exist in the existing knowledge base regarding the capture and use of methane emissions from piggery effluent, and the accurate determination of GHG emissions from pork production. These include:

1. Methane leakage from covered ponds and anaerobic digesters. Currently thought to be 10%, but no Australian research has been done to examine this. Leakage represents a loss of energy potential and ACCUs, and is also a safety hazard. It would be beneficial to understand what loss rates exist under commercial conditions.
2. Emissions originating from secondary treatment ponds. Emission rates are not known and this source is thought to contribute between 15% and 30% of the emissions from a piggery with a covered pond. This also represents a loss of methane yield and could be managed via longer Hydraulic Retention Time (HRT) in covered pond installations. This work could be done in parallel with item 1.
3. Develop and foster lower cost construction options or better funding models for industry. This may include helping to establish standard covered pond designs, and outlining itemised costs and a bill of materials for construction to reduce the barrier to farms managing the construction process themselves. Training could be established to cover the key requirements to get a project up-and-running. The industry could extend this as far as providing a 'help desk' to help assist with reviewing costings and assisting producers to manage the design and construct phase.
4. Develop the business case for the Build-Own-Operate-Maintain model (BOOM) where the capital cost of the digestor is invested by a third party, who then sells power back to the piggery and exports power to the grid. It may be possible to help co-ordinate these efforts across the industry to improve scale and attract larger investors.
5. Champion new financing options such as green loans for installation of covered ponds.
6. Additional benefits resulting from odour reduction from introduction of methane capture. Quantifying odour reduction would be useful for planning and development, and may demonstrate an additional benefit from installing a covered pond.
7. Biomethane production. Biomethane may be a higher value output than electricity in the future, as markets for green gas expand. Investigating the cost-benefit of biomethane

production compared to on-site electricity production could be warranted. Demonstrating technologies and examples of establishing green gas production may also be warranted.

8. While covered ponds are the best option for methane mitigation, where this is cost prohibitive, other options should also be investigated. Short HRT treatment systems are highly effective for reducing emissions, though other environmental problems such as poor nutrient management can emerge from using these systems because there may be inadequate wet weather storage capacity. Similarly, solids separation is effective in reducing emissions, though specific research has not quantified these benefits under Australian conditions. Further development work is warranted to investigate if emissions can be reduced in a cost-effective way via these types of alternative manure management systems and to demonstrate the type of systems that can deliver low emissions.
9. Establishing cost-effective solid separation systems that dramatically reduce GHG emissions from ponds. These could include trafficable sedimentation basins and other more traditional forms of solids separation. Research is needed to demonstrate the most effective systems, and to confirm efficacy.

Extension and Adoption

Ongoing support is required to maximise uptake, particularly among smaller producers and those with lower cost power supplies. This could take the form of:

1. Demonstration sites (e.g. Rob Bailey – 500 sow piggery in southern Australia)
2. Case studies showing costs of installation and operation. With increasing ACCU values and also increasing costs over time, these case studies should be periodically updated.
3. Produce standard designs that would allow producers to construct systems without the requirement for third parties.
4. APL to facilitate the buying of equipment in bulk (e.g. treatment trains, generators, scrubbers, flares, etc) to reduce capital costs.
5. APL investigate other opportunities to sell carbon credits (e.g. overseas markets). This may require the amalgamation of credits from several piggeries. APL could facilitate this process.
6. Service provider capacity is also an issue for the pig industry in the area of effluent management and biodigestion, with industry experts having recently retired without having been replaced.

5.2.2 Reducing nitrous oxide

In deep litter and free range piggeries, nitrous oxide emissions are understood to contribute some 10% and 31% to the emission profile from each of these piggery systems respectively. Research was conducted to determine nitrous oxide from deep litter (Phillips *et al.* 2016) but no similar research has been done in outdoor/free range systems, and current emission estimates are based on European factors.

Research and Development

Research that could benefit the industry may include:

- Improved estimation methods for N_2O emissions from outdoor production systems, including the impacts associated with stocking density and length of rotations. Experiments measuring N_2O under representative Australian conditions are required. These experiments should also assess methane and ammonia at the same time to provide a rounded analysis of GHG emissions.
- Research should also investigate mitigation opportunities from the use of lower crude protein diets (noted above), improved rotations and range area management, and potentially via the use of inhibitors to directly reduce N_2O production.

Extension and Adoption
APL could facilitate the outcomes of the research into nitrous oxide emissions from outdoor piggeries to be incorporated into the country specific emission factors in the National Inventory Report. Updated emission factors would allow improved accuracy in estimating GHG emissions for outdoor piggery operations.

5.2.3 Nutrient Recovery

Closed loop technologies to recover nutrients from manure are available but are generally not cost effective. Development of demonstration sites and markets for fertilisers (particularly for emerging organic markets) would be beneficial, particularly where this can utilise excess and low cost heat and power from CHP units. Market analysis may be warranted to help establish the business case for investment. This would reduce GHG emissions via production of new outputs from the piggery, and via reduction of emissions from current manure management systems by reducing ammonia losses and field application losses.

Research and Development
Research that could benefit the industry may include:

- Development of demonstration sites implementing nutrient removal technologies at a commercial scale.
- Business case to evaluate demand for piggery derived nutrients and determination of cost for commercial viability.

6. Blue Sky Mitigation Options

The pig industry is in the enviable position of having many proven technologies that reduce emissions, but barriers exist around cost-effectiveness. However, with a very ambitious goal the need exists to provide next generation solutions to move industry forward. Research on these initiatives must occur in the near term if such options are going to be available in 2030 and beyond.

Here we have assumed that energy efficiency will diminish in it's importance moving forward, because green energy will begin to take precedence.

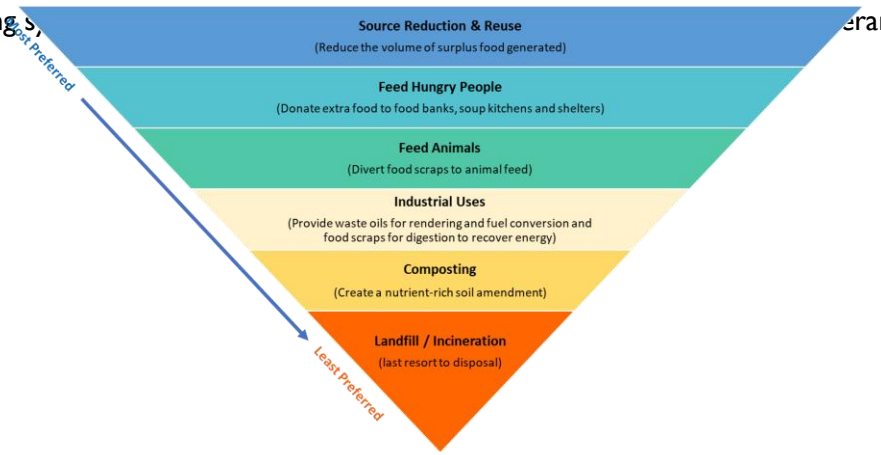
The remaining emission sources will include manure (where covered ponds can't be used, and leakage from covered ponds and secondary systems) and feed.

Blue sky options should focus on addressing these needs.

6.1 Closed loop farm

We recommend developing a wholistic and large scale demonstration site to show how food waste, pig systems and energy can be worked in tandem. This site could be established with the ambition of demonstrating positive energy production (export of energy), low-cost pork production and zero non-by-product feed requirements.

The full cascading s erarchy



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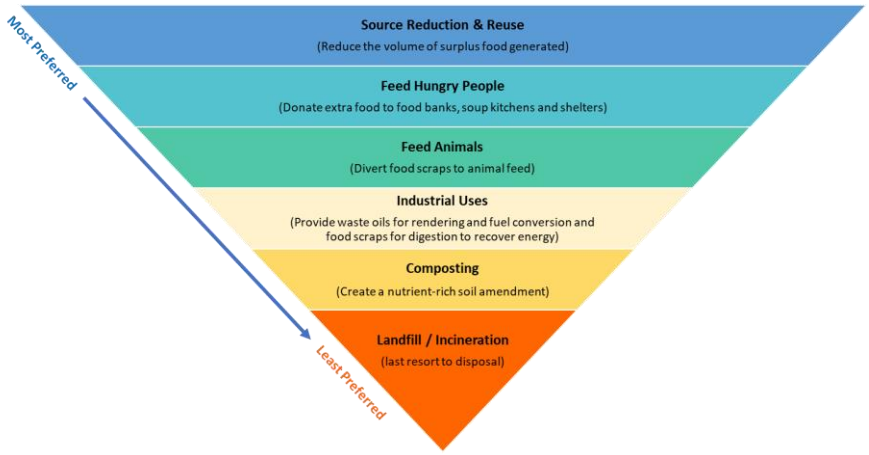

Figure 1. Food recovery hierarchy triangle (U.S. EPA 2021e)

This site would:

1. Conduct research on maximising value from waste food from manufacturers, retailers and municipalities via:
    a. Developing new processes for handling of difficult waste streams (mixed) and how to separate these to maximise value as feed.
    b. Developing heat treatment for products that currently can't be fed legally, and developing the regulatory processes to legally feed these products.
    c. Develop ideal feeding strategies and diet formulation.

2. Demonstrate alternative options for residual waste food – insect production for animal feed.
    a. This field is expanding, and the site could act as a demonstration and proof-of-concept testing ground for new options as they become available. Integrating this into a system which already maximises waste food and manure would be more insightful that operating in isolation.
3. Demonstrate energy recovery technology.
    a. Optimizing biogas yield and quality
    b. Value recovery from CO_2
    c. Biomethane generation
    d. Energy recovery from manure and mixed biomass (i.e. energy generation with all biomass not suitable for feeding to pigs)
    e. Heat recovery and utilisation (for example, rendering)

4. Demonstrate nutrient recovery technology.
    a. Bolt-on technologies for P removal (i.e. based on struvite)
    b. Bolt-on technologies for N removal (ammonia stripping).
    c. System optimisation and cost reduction of nutrient removal.

With these core aspects in place, a system to evaluate environmental and economic potential for new technologies could be established to provide guidance for research and adoption. This would be a strategic investment for the industry. Provided a suitable, existing piggery was available, development of this type of facility may require $25M funding. It would suit a university or possibly a large scale private enterprise.

6.2 Other research directions

Feed grain is likely to remain a source of emissions for pigs. Further collaborative work with the grains sector to investigate ways to reduce emissions from grain is a priority.

7. Carbon Storage

Carbon sequestration is an important factor is the assessment of carbon emissions. A number of common practices within the piggery industry have the potential to result in positive impacts on soil carbon. These impacts are not currently well understood and further research may assist in quantifying the benefits from different effluent and manure management practices.

Soil carbon is being viewed as a solution to reduce net emissions and will receive significant funding support from the Federal Government.

Soil carbon is a reasonably small opportunity to reduce net emissions on pig farms, but it is positive for soil health and should be seen as a good activity to participate in.

Research and Development

- Determine long term soil carbon sequestration in manure and effluent areas by conducting a study comparing soil carbon sequestration in paired sites.
- Outdoor piggery operations: Impact on soil carbon from the outdoor production including impacts from stocking rates and length of rotational cycle for the main outdoor piggery regions in of Victoria and Western Australia.
- Review existing soil sampling data from effluent and manure utilisation areas to determine trends over time in response to historic management interventions.
- Calibrate modelling to allow improved estimation of soil carbon change with manure/spent litter and effluent application.
- Set up long-term monitoring of soil carbon on promising sites and institute practice change to improve soil carbon.
- Spreading of effluent and spent bedding: Short and long term impacts on carbon retention within the soil profile to determine preferred soil types, climatic conditions, method of application and land use practices. Research could begin by surveying soil data in manure and effluent reuse areas and comparing with paired sites without effluent or manure application, to determine the extent of soil carbon improvement. Pending the findings, this work could be used to promote soil carbon sequestration at piggeries.
- Investigate the benefits / disbenefits of composting compared to stockpiling of manure management emissions and carbon sequestration rates.
- Soil carbon ERF: Determine the feasibility of soil carbon how the soil carbon ERF could apply to a piggery operation, including identification of potential opportunities for generating carbon credits.

Extension and Adoption

APL could prepare extension materials to instruct on pig industry specific methodology for the application of the soil carbon ERF, including recommendations for effluent, spent litter and outdoor piggery management to maximise carbon sequestration.

8. Impacts of Low Carbon or Carbon Neutral

Significant international attention has been directed toward GHG emissions across all sectors of the economy, with governments, organisation and industry sectors pursuing emission reduction or carbon neutral targets. If the Australian Pork industry sought to achieve a carbon neutral status by 2025, immediate and radical changes would have to take place. The shift towards carbon neutral will place a financial impact on the industry. The industry would need to be determined who was responsible for this financial burden, with the potential options being:

- Producers
- Retailers
- Tax Payers/Government

While the cost of carbon reduction is an issue that is larger than just the pig industry, the financial impacts of setting an attainable emission reduction target should be considered at an early stage in considerations.

Recommendation
Modelling of emission reduction (see section 2.2) should be accompanied by economic modelling.

Policy recommendation
Currently, if a piggery generates carbon credits from a covered pond and sell these to the Government, these can't be 'claimed' against the emission profile of the business from a branding perspective. This is largely a policy problem that could be overcome by effectively lobbying Government to enable sellers of ACCUs to the Federal Government to also claim these as progress to reducing their business carbon account.

We recommend APL join with other Ag industries to lobby for the Federal Government to allow double claiming of emission reduction and carbon storage.

Extension and Adoption
Demonstrating benefits from carbon market participation which could include cost-benefit analysis presented in case studies and introductory workshops for producers wanting to know the basics.

9. Summary

A large number of recommendations have been provided in this short report. These have been summarised and rated against a set of criteria in **Error! Not a valid bookmark self-reference.** and Table 3 to assist with prioritisation.

Table 2. Research Priorities for Emission Reduction

No	Mitigation opportunity	Technical mitigation potential - reduction of net emissions	Proportion of the industry where this is relevant	Industry mitigation potential	Technical - Readiness	Ease of Adoption	Other benefits/disbenefits	R&D cost*	Cost to implement	Horizon#	Chance of Success	Possible co-funding partners
1.1	Survey of potential zero GHG emission feed sources (by-products) - including location, feed value, current use/disposal, cost and availability	10%	100%	10%	H	M	aligns with zero waste	L	L	H1	H	poultry
1.2	Research to identify better ration formulation in diets with high levels of by-products	10%	100%	10%	H	M	aligns with zero waste	M	L	H1	H	poultry
1.3	Industry co-ordination of waste feed collections with major companies and municipalities	20%	100%	25%	L-M	M	aligns with zero waste	H	M	H2	M	municipalities, retailers, ARENA
1.4	Remove regulatory barriers with swill feeding				M	M	requires change in regulatory policy	H	M	H2 - H3	L	
1.5	Investigating cost, availability and suitability of certified soy and associated reduced dLUC emissions.	24%	100%	24%	H	H	improves supply chain credibility	M	Unknown (M)	H1	M	poultry
1.6	Identify viable and cost effective alternatives to imported soy.	24%	100%	24%	H	H	benefits Australian producers	M	Unknown (M)	H1	M	poultry
1.7	Impact of changing dietary nitrogen on nitrous oxide emissions from deep litter and free range	10%	26%	2.6%	H	M	benefits for water quality	H	L	H2	M	poultry
1.8	Alternative feed sources including insects	10%	75%	7.5%	L-M	M	best opportunity is to feed insects on excess biomass in an integrated zero waste system, then feed back to pigs, or to feed on manure and then render the insects. High cost, high tech required.	H	H	H3	L-M	poultry
1.9	Low GHG Grain - collaborative work with grains sector to investigate ways to reduce emissions from grain component of feed	100%	9%	9.3%	M	L	requires changes to be implemented across the grains sector	H	H	H2	H	Graingrowers

No	Mitigation opportunity	Technical mitigation potential - reduction of net emissions	Proportion of the industry where this is relevant	Industry mitigation potential	Technical - Readiness	Ease of Adoption	Other benefits/disbenefits	R&D cost*	Cost to implement	Horizon#	Chance of Success	Possible co-funding partners
2.1a	Methane leakage from covered ponds and AD - curre	10%	16%	1.6%	H	M	if leakage can be reduced this will increase energy recovery	H	L	H2	H	meat processing, ARENA, Fed. Govt.
2.1b	Methane leakage from covered ponds and AD - poten	10%	74%	7.4%	H	M		H	L	H2	H	meat processing, ARENA, Fed. Govt.
2.2	GHG emissions originating from secondary	20%	74%	15%	H	M		H	L	H1	M	meat processing,
2.3	Identifying lower costs of construction of methane capture and reuse methods and overcoming barriers to entry	53%	58%	31%	M	M	aligns with zero waste, reduced energy, lower odour	H	M	H1	H	meat processing, ARENA, Fed. Govt.
2.4	Develop business case for BOOM model for anaerobic digestion - potentially coordinated across industry to attract large investors	53%	58%	31%	M	M	aligns with zero waste, reduced energy, lower odour	H	M	H1	H	meat processing, ARENA, Fed. Govt.
2.5	Champion new financing options such as green loans for covered ponds.	53%	58%	31%	M	M	aligns with zero waste, reduced energy, lower odour	H	M	H1	H	meat processing, ARENA, Fed. Govt.
2.4	Verification of additional benefits from methane capture, including odour reduction	N/A	74%		M		supports implementation	H	M	H1	M	meat processing
2.5	Maximise efficiency of biogas production											
2.6a	Biomethane technology and examples of use in the green gas market - current	5%	16%	0.8%	M	L	new revenue stream	M	Unknown (M)	H2	M	meat processing, ARENA, Fed. Govt.
2.6b	Biomethane technology and examples of use in the green gas market - future	5%	58%		M	L	new revenue stream	M	Unknown (M)	H2	M	meat processing, ARENA, Fed. Govt.
2.7	Short HRT - investigate barriers to adoption for small/M producers including best practice management of high nutrient effluent	53%	58%	31%	H	L	maximises nutrient content in effluent but spreading operationally difficult	L	M	H1	M	
2.8	Establish cost effective solids separation systems, including sedimentation basins and traditional separators	25%	25%	6.3%	H	H		M	L	H2	M	
2.9	Improved estimation methods for N_2O emissions from outdoor production systems, including the impacts associated with stocking density and length of rotations. Experiments measuring N_2O under representative Australian conditions are	10%	6%	0.6%	H	M	could be done in parallel with water quality/soil quality research to address emerging problems	H	M	H2	M	possibly free range poultry
2.10	Mitigation opportunities from the use of low crude protein diets, improved rotations and range area management, and potentially via the use of inhibitors to directly reduce N2O production.	10%	6%	0.6%	H	M	could be done in parallel with water quality/soil quality research to address emerging problems	H	M	H2	M	poultry
2.11	Nutrient recovery - Demonstration farms - market analysis to establish business case for investment	N/A	74%	N/A	M	L	new revenue stream and less on-site water quality impacts	H	H	H2	M	meat processing, ARENA
2.12	Acidification of ponds to reduce methane	53%	58%	N/A	H	L	produces acidity in effluent which is difficult to manage.	M	M	H2	L	
2.13	Methane capture and reuse from solids	10%	21%	N/A	L	L	methane production rates have been shown to be low (Tait 2017)	H	H	H2	L	poultry
2.14	GHG impact from black solider fly fed on manure for agronomic use	unknown	5%	N/A	L	M	Unlikely to mitigate GHG based on first principles. Needs to be demonstrated that this is more effective that current practice	H	M	H2	L	

No	Mitigation opportunity	Technical mitigation potential - reduction of net emissions	Proportion of the industry where this is relevant	Industry mitigation potential	Technical - Readiness	Ease of Adoption	Other benefits/disbenefits	R&D cost*	Cost to implement	Horizon#	Chance of Success	Possible co-funding partners
3.1	Long term soil carbon sequestration in manure and effluent areas byt conduction a study comparing soil carbon sequetration in paired sites	0 - 10%	6%	0.6%	M	L	could be done in parallel with water quality/soil quality research to address emerging problems	M	M	H2	M	Fed Govt. soil carbon initiatives
3.2	Outdoor piggery operations: Impact on soil carbon from the outdoor production including impacts from stocking rates and length of rotational cycle for the main outdoor piggery regions in of Victoria	0 - 10%	6%	0.6%	M	L	could be done in parallel with water quality/soil quality research to address emerging problems	M	M	H2	M	Fed Govt. soil carbon initiatives
3.3	Review existing soil sampling date from effluent and manure utilisation areas to determine trends over time in response to historic management interventions	0 - 10%	6%	0.6%	M	L	could be done in parallel with water quality/soil quality research to address emerging problems	M	M	H2	M	Fed Govt. soil carbon initiatives
3.4	Calibrate modelling to allow improved estimation of soil carbon change with manure/spent litter and effluent application.	0 - 10%	6%	0.6%	M	L	could be done in parallel with water quality/soil quality research to address emerging problems	M	M	H2	M	Fed Govt. soil carbon initiatives
3.5	Set up long-term monitoring of soil carbon on promising sites and institute practice change to improve soil carbon.	0 - 10%	6%	0.6%	M	L	could be done in parallel with water quality/soil quality research to address emerging problems	M	M	H2	M	Fed Govt. soil carbon initiatives
3.6	Short and long term impacts on carbon retention within the soil profile to determine preferred soil types, climatic conditions, method of application and land use practices.	0 - 10%	100%	10%	M	H	may increase value of spent litter, effluent. Needs to take into account water quality (nutrient application rates) to avoid increasing problems in this area via high application	H	L	H2	M	Fed. Govt. soil carbon initiaties, grains, dairy sectors
3.7	Investigate the benefits / disbenefits of composting compared to stockpiling of manure management emissions and carbon sequestration rates.	N/A	100%	N/A	M	M	potentially saves money on unnecessary processing of manure if shown not to generate lower impacts.	H	M	H2	M	
3.8	Soil carbon ERF: Determine the feasibility of soil carbon how the soil carbon ERF could apply to a piggery operation, including identification of potential opportunities for generating carbon credits. Survey carbon levels in manure and effluent areas using monitoring data and/or paired sites	N/A	30%	N/A	M	M	new revenue stream, other soil health benefits.	M/H	H	H1	M	Fed Govt. soil carbon initiatives
4.1	Modelling of emission reduction and associated economic impact modelling for industry pathways.	N/A	100%		H	H	Research guidance and increased uptake of all options across industry	M	L	H1	H	
5.1	Full scale closed loop demonstration farm with biomass processing, feed generation, nutrient, energy and water recovery	Towards 100%	100%	100%	L	L	demonstrates the APL goal of L carbon and zero waste	V.H	V. H	H3	M	ARENA, Municipalities, State Govt, Universities, Retailers, large pork producers

Table 3. Extension, Adoption and Policy Priorities for Emission Reduction

No	Target Area	E, A or P	Extension, Adoption and Policy Priorities for Emission Reduction Description	Implementation Cost	Chance of Success
1.1	**Diet - By-product Usage**	Extension and Adoption	APL could assist by co-ordinating offtake agreements with large companies or helping to overcome regulatory barriers with mixed waste sources. The role of APL would be warranted if the agreements that need to be sought were too large, or across multiple regions, and therefore couldn't be managed with just one piggery.	M	H
1.2		Extension and Adoption	Showcasing the benefits of using by-products via case studies would be beneficial, to raise the profile of this as a viable option for piggeries.	M	H
1.3	**Diet - Low GHG Diet**	Extension and Adoption	APL may be able to collaborate with other industry bodies that utilise soymeal to perform a review of certified soy systems, their suitability to reduce reported impacts from soymeal imported into Australia, and the availability and cost of certified soymeal in Australia.	H	M
		Extension and Adoption	Engagement with the Grains industry (potentially via the feed grains partnership) to promote emission reduction strategies that will lower the impact from Australian feed grain into the future. This work should be done in collaboration with other like-minded feed grain users.	H	
1.4	**Diet - Low crude protein**	Extension and Adoption	Extension to industry nutritionists and companies to increase awareness and consideration of environmental performance in diet formulation.	M	M
1.5	**Diet - Swill Feeding**	Policy	APL to lobby government to change current regulatory barriers regarding swill feeding	H	L
2.1	**Manure - methane mitigation**	Extension and Adoption	Industry forum on barriers to adoption of biogas to identify barriers and solutions	L	H
2.2		Extension and Adoption	Covered ponds and digesters - Demonstration sites	H	M
2.3		Extension and Adoption	Covered ponds and digesters -Case studies showing costs of installation and operation of covered ponds and digesters, showing increasing ACCU values and also increasing costs over time, these case studies should be periodically updated.	M	H
2.4		Extension and Adoption	Covered ponds and digesters - Produce standard designs that would allow producers to construct systems without the requirement for third parties.	H	M
2.5		Extension and Adoption	Covered ponds and digesters - APL to facilitate the buying of equipment in bulk (e.g. treatment trains, generators, scrubbers, flares, etc) to reduce capital costs.	H	M
2.6		Extension and Adoption	Covered ponds and digesters - APL investigate other opportunities to sell carbon credits (e.g. overseas markets). This may require the amalgamation of credits from several piggeries. APL could facilitate this process.	M	M
2.7		Extension and Adoption	Covered ponds and digesters - Service provider capacity is also an issue for the pig industry in the area of effluent management and biodigestion, with industry experts having recently retired without having been replaced.	M	M
2.8	**Manure - nitrous oxide**	Extension and Adoption	APL could facilitate the outcomes of the research into nitrous oxide emissions from outdoor piggeries to be incorporated into the country specific emission factors in the National Inventory Report.	M	M
3.1	**Carbon Storage**	Extension and Adoption	APL could prepare extension materials to instruct on pig industry specific methodology for the application of the soil carbon ERF, including recommendations for effluent, spent litter and outdoor piggery management to maximise carbon sequestration.	M	M
4.1	**Low Carbon Impacts**	Policy	Currently, if a piggery generates carbon credits from a covered pond and sell these to the Government, these can't be 'claimed' against the emission profile of the business from a branding perspective. This is largely a policy problem that could be overcome by effectively lobbying Government to enable sellers of ACCUs to the Federal Government to also claim these as progress to reducing their business carbon account.	H	L
4.2		Extension and Adoption	Demonstrating benefits from carbon market participation which could include cost-benefit analysis presented in case studies and introductory workshops for producers wanting to know the basics.	M	M

Appendix A.

IRG Meeting 2: Minutes. 2nd 'Low Carbon Pork' Roadmap Project industry reference group meeting

Date: 25/08/2021

Location: Microsoft Teams, IAE Boardroom.

Attendees: Edwina Beveridge (EB), Kirsty Cooper (KC), Judy Crough (JC), Darryl D'Souza (DD), Richard Evison (RE), Ian Longfield (IL), Jarad Smith (JS), Clayton Warren (CW), Gemma Wyburn (GW).

IAE: Stephen Wiedemann (SW), Kate McCormack (KMc), Eugene McGahan (EMc), Tracy Muller (TM), Gabriel Crane (GC).

Apologies: nil

Agenda

Time	Item	Presenter/Participants
3:00pm-3:05pm	Introduction and meeting aims.	SW/All
3:05-3.35pm	Proposed "Low Carbon" Definition – review of background considerations: • What is the emission boundary? • What is the baseline? • Emission intensity and/or total emissions?	
3:35pm-4.15pm	What are the options for the reduction target and timeframes?	

Notes:

<u>Separate targets into scope 1+2 and scope 3?</u>

DD – Excluding scope 3 emissions will not be well-received. If we talk in terms of supermarkets/retail you need the carbon footprint (all scopes).

DD – we need to be clear on what the supply chain includes (farm, meat processing etc)

IL & JS – Need to include scope 3 emissions.

EB – What about increases in soil carbon from manure application? Maybe splitting Scope 3 into feed and processing?

Possible to separate scope 3 into upstream and downstream emissions and focus more on upstream (we have more control to adjust these).

CW – Can we still make a substantial reduction like the one seen between 1990 and 2020? What is the next innovation that will allow us to take this next step?

<u>Total emissions or emissions intensity?</u>

JS, DD, RE, EB – Emissions intensity makes the most sense.

JC – There needs to be more information on how to meet these targets.

Strong drive to report on EI for comparing industries such as lamb etc. and within the industry itself.

Can we have case studies which focus around: 1) improving SOC by manure application, 2) diet manipulation using by-products and waste, and 3) improving FCR and pigstay.

Baseline

SW commentary: If we look at emissions since 1980 – there's a curvilinear pattern and almost a plateau between 2010 and 2020 as we have made huge improvements in production in the past, but this is slowing. Also the expansion of adoption of covered anaerobic ponds around 2010.

So what's next? We need to think of innovations and come up with the next big change. Is it exporting energy? Soil carbon? Water recycling? Feed waste?

Note – historic total carbon emissions didn't include dLUC (direct land use change eg. soybean)

– either 2005 or 2010?

What target should be set?

CW – The big market players are aiming for net zero by 2030-40-50. Should we be so aggressive? Will there be any additional benefit?

IL – Net zero by 2025 is unachievable, this would require over 1 million t CO_2-e decrease.

RE, EB, IL,DD - would pick option 2B from slide 16 from deck.

JS – Massive change required to reach carbon neutrality in the next 3.3 years is not possible without clear guidance and means to do so.

JC – How does imported pork play into this?

KC – The focus will be on Australian pork.

EB – How far will exporting power from biogas take you towards carbon neutral? Is it achievable? What about deep litter, outdoor?

DD – These emissions targets are in the strategic plan, these should be stretch targets, but we need to have tangible ways, new innovations, big shifts to achieve this. We must select an option, but I don't see how we can reach those targets in the given timeframes.

SW – What we are hearing is that we need to know what the emissions reduction strategies are before making decisions on target options.

KC – The target in the strategic plan was intended to be a stretch target and not easy to meet.

JS – We need to be mindful of the blowback from producers that will be told to meet these targets.

Key feedback

Item	Consensus	Rationale
Scope of emissions?	Scope 3 emissions should be included in target-setting and reporting.	Scope 3 is necessary to provide a comprehensive assessment of emissions from pork production. All scopes of emissions will continue to be measured and reported.
Total emissions or emissions intensity?	Emissions intensity is the preferred metric for emissions reduction targets.	Emissions intensity measures are familiar to industry and allow for comparison between proteins.
Feedback on targets	Preference expressed for 2B (see meeting slides).	Moderate target in alignment with government and international targets for CN2050.
Further investigation/action	Investigation into emissions reduction strategies is required.	Producers have highlighted the need to understand the options for emissions reduction strategies before an informed decision on an emissions target can be made.