Australian Government
Department of Agriculture and Water Resources

AUSTRALIAN Pork

Low Carbon Emission Roadmap for the Australian Pork Industry

Final Report
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Integrity Ag and Environment

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Glossary

Business emissions	Scope 1 and Scope 2 emissions that are the most relevant emission sources to piggery operators, as these sources are within operational control of the farm
Carbon accounting	The process used to quantify greenhouse gas (GHG) emissions from an enterprise.
Carbon footprint	The process of quantifying GHG emissions emitted directly or indirectly by an individual, company or product (i.e. the sum of scope one, two and three emissions). A carbon footprint is more commonly used for products (i.e. dressed weight) than enterprises, but it can be applied at either scale. Several standards exist to define a carbon footprint, such as ISO 14067.
Emission intensity	Emissions relative to output (i.e. CO_2-e per kg of LW sold). Emission intensity values allow for comparison and benchmarking between farms of different sizes. They are the standard unit for a product carbon footprint.
Product carbon footprint	Examines the impact of only emissions produced for a product
Scope 1 emissions	Direct GHG emissions occur from sources that are owned or controlled by a company
Scope 2 emissions	GHG emissions from the generation of purchased electricity consumed by a company
Scope 3 emissions	GHG emissions that are the consequence of the activities of the company but occur from sources not owned or controlled by the company. Some examples of Scope 3 activities are emissions from purchased grain production for feed, breeders or and use of services. These emissions can relate to the supply chain prior to the business (i.e. purchased gilts) or after the business in the supply chain (i.e. meat processing).

ACCU	Australian Carbon Credit Unit
APL	Australian Pork Limited
CER	Clean Energy Regulator
CH_4	Methane
CHP	Combined heat and power
CN	Carbon neutral
CO_2	Carbon dioxide
dLUC	Direct land use change
ERF	Emission Reduction Fund
FCR	Feed conversion ratio
GHG	Greenhouse gas
HFC	Herd Feed Conversion
HRT	Hydraulic Retention Time
LCA	Life cycle assessment
LGC	Large-scale renewable energy certificate
LU	Land use
LW	Liveweight
N_2O	Nitrous oxide
SPU	Standard pig units
STC	Small-scale technology certificate

Table of Contents

List of Tables

List of Figures

1. Introduction

There is growing pressure in Australia on industries to reduce Greenhouse gas (GHG) emissions from livestock production to maintain community and consumer trust. The Australian Government has a target to reduce emissions towards a net-zero goal, and retailers have already moved to benchmark and reduce emissions from pork supply chains. The Australian pork industry has responded by developing a low carbon target by 2025, and while there is prior research available, it is difficult for producers to make progress with no "roadmap" or suggested pathway to get there. This guide provides that roadmap.

This document is a roadmap that will:

- Provide knowledge and confidence for pork producers to assist with quantifying their GHG emissions.
- Identify what is required to reduce emissions, store carbon and achieve low carbon or carbon neutral pork.
- Outline how to access funding and support to achieve the goal of low carbon pork.

This document is a first reference for the pork industry reflecting producers of all scales and production methods as the industry moves towards a low GHG emissions future. The roadmap is focused strongly on pig production at the farm level and is based around the five steps outlined in Figure 1 .

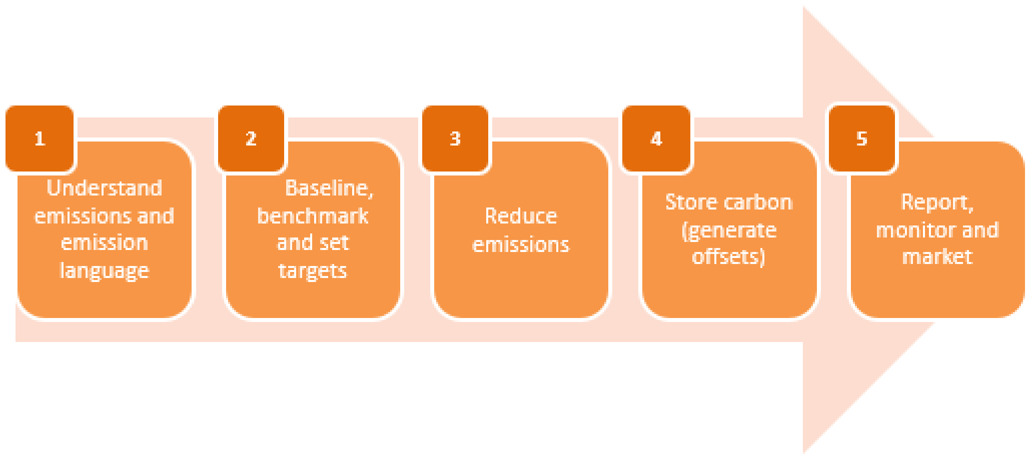


Figure 1. The five steps to low GHG or carbon neutral production systems

2. Understanding and Defining Greenhouse Gas Emissions

2.1 Greenhouse Gas Emissions

Greenhouse gases are defined as atmospheric gases responsible for causing global warming and climate change (UN Climate change glossary - UNFCC, 2021). GHGs in the atmosphere increase the retention of the Earth's outgoing energy, thus holding heat in the atmosphere. This heat trapping causes changes in the radiative balance of the Earth; the balance between energy received from the sun and emitted from Earth, and as a result alters the climate and weather patterns at global and regional scales.

GHGs are reported in the Australian Government's National Inventory Report (NIR) (Commonwealth of Australia, 2019), also known as the National GHG Inventory or NGGI, and include:

- Carbon dioxide (CO_2),
- Methane (CH_4),
- Nitrous oxide (N_2O),
- Sulphur hexafluoride (SF_6).
- Other hydrofluorocarbons and perfluorocarbons.

Not all GHGs are equal, methane and nitrous oxide have much higher warming effects than carbon dioxide. The main GHG emissions from pig production are carbon dioxide, methane and nitrous oxide, with the key contributing major sources being feed production, manure management, enteric emission, energy and purchased inputs (Figure 2). Any process, activity or mechanism which removes GHG, or a precursor of a GHG from the atmosphere is termed a sink. Trees and other vegetation are considered sinks because they remove carbon dioxide through photosynthesis, and well as soil which can store organic carbon through cultivation of certain crops or the addition of soil amendments, such as manure.

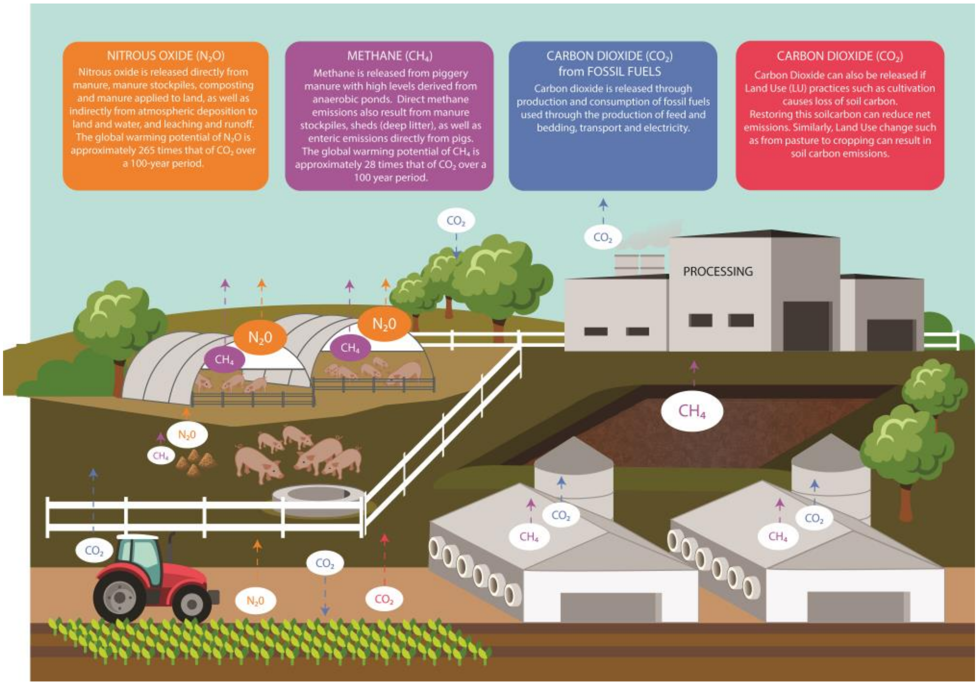


Figure 2. Sources and sinks of major greenhouse gas emissions on a pig farm

2.2 Carbon Account and Carbon Footprint – What's the Difference?

The GHG emissions generated by a piggery operation and other farm-related activities can be estimated by developing a 'carbon account'. A carbon account allows producers to calculate their current GHG emissions and helps them to understand the main drivers of emissions. It is both difficult and expensive to objectively measure the quantity of GHG emissions or the carbon storage on a piggery. For this reason, carbon accounting is done through modelled calculations based on farm inputs, to produce an estimate of emissions and carbon storage.

Standard practice is to report emissions using different classification depending on where the emissions arise and how they relate to the business. Based on the international GHG Protocol (Ranganathan *et al.*, 2004), emissions are defined into three scopes:

- **Scope 1**: "Direct GHG emissions occur from sources that are owned or controlled by the company".
- **Scope 2**: "Accounts for GHG emissions from the generation of purchased electricity consumed by the company."
- **Scope 3**: "Are a consequence of the activities of the company but occur from sources not owned or controlled by the company. Some examples of Scope 3 activities are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services." These can be further broken down into two sources:
    - **Upstream emissions:** from sources such as the production of purchased feed, and manufacture of chemicals.
    - **Downstream emissions:** from sources such as those associated with the transportation and processing of pigs.

The key sources of emissions for a piggery (pre-farm, on-farm and post-farm), separated by scope, are outlined in

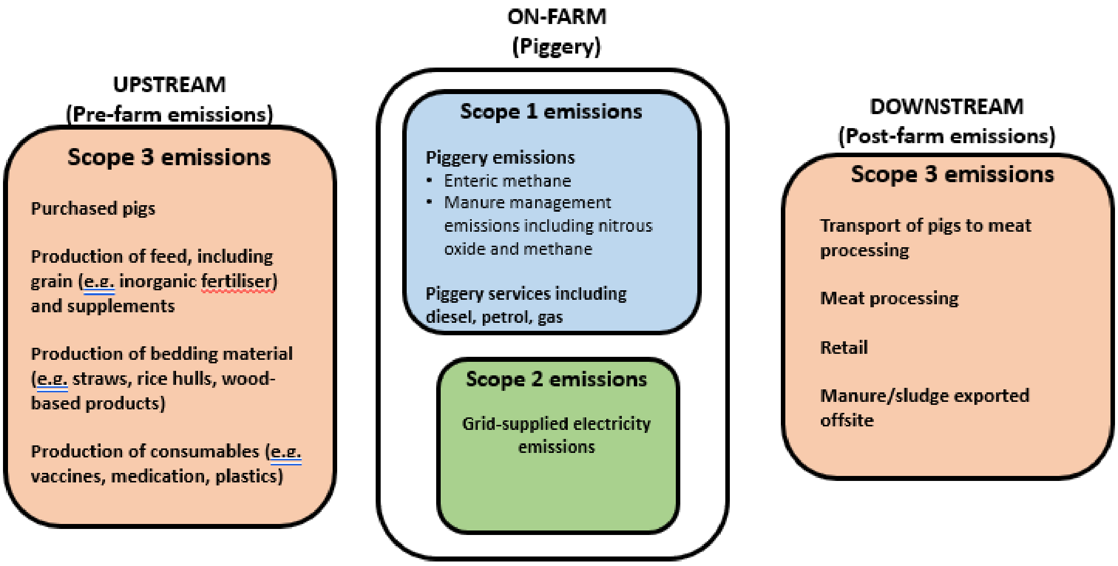


Figure 3.

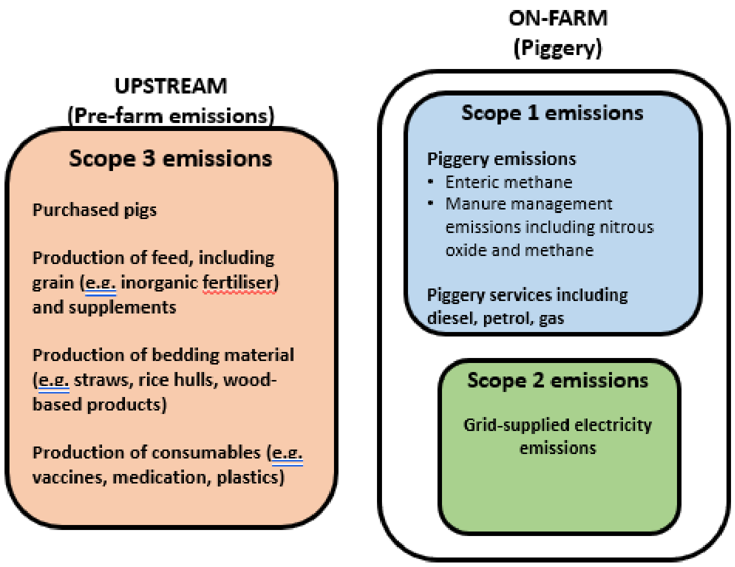


Figure 3. The breakdown of greenhouse gas emissions from a piggery into Scope 1, 2 and 3 emissions

The terms carbon accounting and carbon footprint are often used interchangeably; however, there are some clear differences, which are summarised below:

1. **Carbon accounting** is typically focused on business emissions and carbon storage and may be limited to Scope 1 and Scope 2 sources only. Inclusion of Scope 3 emissions is optional. Scope 1 and Scope 2 emissions are the most relevant emission sources to piggery operators, as these sources are within operational control of the farm and are also referred to as **business emissions**.
2. **Carbon footprint** includes Scope 1, Scope 2 and Scope 3 emission sources as mandatory for a carbon footprint assessment. It should be noted that the further a business is up the supply chain (i.e. retail supermarket), the larger their upstream Scope 3 emissions. When all businesses account for their Scope 1 and 2 emissions, the result is the total global GHG emissions, as such, undertaking a business level assessment avoids 'double-accounting' emissions.

A carbon footprint examines the combined impact of all emissions produced from a product, and is most commonly reported as emissions per unit of product (e.g. kilograms of CO_2-e per kilogram of liveweight, carcass weight or retail meat) and is commonly referred to as the **emission intensity**. A carbon footprint allows 'like for like' comparison between different production systems and even different products altogether, provided they provide the same function.

Emissions from agri-food supply chains also differentiate the contribution from **land use (LU)** and **direct land use change** (dLUC). Emissions associated with LU relate to soil carbon losses from cultivation for crop production which leads to CO_2 emissions from soil. In some cases better management practices could result in carbon storage, in which case this would represent a "negative" emission (for example, conversion of forest to cropland, resulting in the loss of carbon stored in trees and potentially soil, or planting trees, which changes LU from a pasture or crop back to a forest). These sources are often reported separately from a carbon footprint because there is an acknowledged higher level of uncertainty in these emission sources.

2.3 What is Low Carbon Pork?

Australian Pork Limited (APL) in consultation with the pork industry and community stakeholders have developed goals relating to carbon, with this document providing the roadmap to achieve industry 'low carbon emission' pork by 2025. This definition includes the aspiration that the industry becomes carbon neutral in the future.

The trends in total emissions and emissions intensity from the Australian pork industry over the last forty years is shown in Figure 4. A 69% reduction in emissions intensity was achieved from 1980 to 2020, with a 44% reduction in total emissions (Watson *et al.*, 2018). The 1990 data shows that the total emission for the industry as a whole may increase, even if the emissions intensity decreases. This is a result of an increase in the size of the national herd. In the last decade, a relatively low reduction in emissions has been achieved whilst the national herd size has remained relatively stable, and there will need to be substantial effort to lower emissions from all sectors of the industry to reduce emissions further from this point.

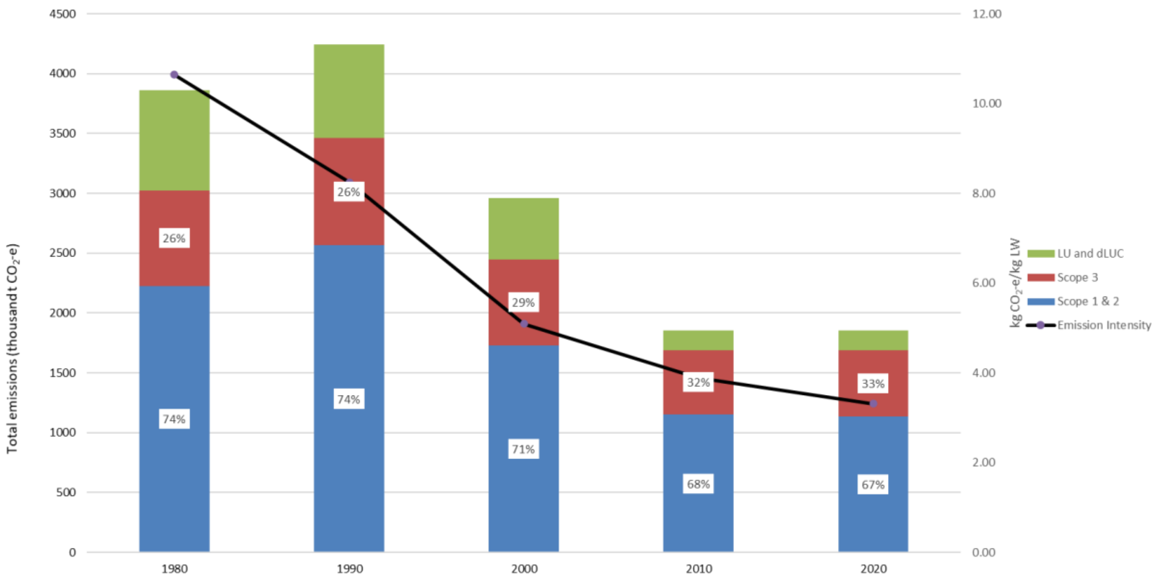


Figure 4. Changes in Scope 1, 2 & 3 total emissions and emission intensity over the period 1980 to 2020 for Australian pork production (adapted from Watson *et al.*, 2018)

3. Baseline, Benchmark and Set Target

Progress rarely happens without measuring and setting a target to reduce impacts. To baseline your operation, you can follow the process outlined in APL Project 2020/00086 – Manual, using methods that are based on the National Greenhouse Gas Inventory for scope 1 and 2 emissions. Scope 3 emissions require access to databases of emissions from purchased products, which can be sourced from the Australian Life Cycle Inventory (AusLCI) database. At present, there are no freely available and up-to-date calculators to estimate GHG emissions from piggeries. However, APL are currently working with producers to determine the emissions profile across the Australian herd, and developing processes to streamline GHG reporting.

Once you have baselined your operation, you can compare with benchmarks and track performance over time. Benchmarks are provided below. It is also important to set targets to improve performance. This will be based on the types of reduction strategies you can use and the rate of improvement you can achieve. Setting a target over a defined time period will make change possible.

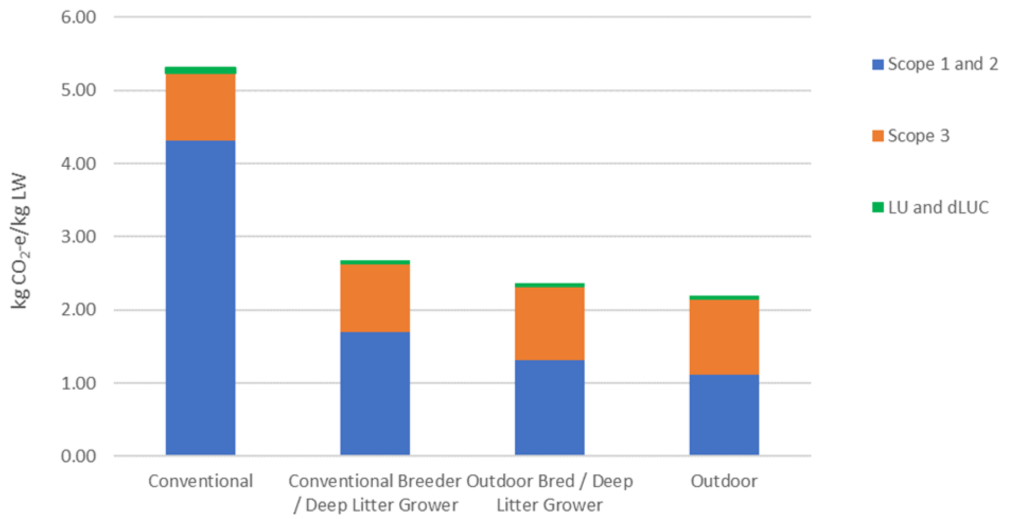
GHG emission benchmarks are important as they provide a basis to compare different production systems, as well as to assess the efficacy of different emission mitigation strategies. The four benchmark production systems[1] for this roadmap include:

- Conventional farrow to finish.
- Conventional breeding and deep litter grower/finishers.
- Outdoor breeding and deep litter grower/finishers.
- Outdoor breeding and grower/finishers.

This roadmap defines the system boundary for the assessment of GHG emissions as including all Scope 1 and 2 emissions (i.e. on-farm), all upstream Scope 3 emissions (i.e. feed production, purchases) and downstream Scope 3 emissions to the point of delivery to meat processing. The assessment includes Scope 3 impacts from LU and dLUC associated with feed production. Based on the proposed boundary, emissions intensity will be reported in kilograms of CO_2-e per kilogram of live weight (LW) as per APLs sustainability framework delivered to the point of processing (see

Figure 5). The LU and dLUC emissions associated with feed production are reported separately for each benchmark case.

[1] All scenarios are based on typical values for a 1,000 sow farrow to finish operation for each production. Key input parameters of the benchmark production systems are provided in Appendix A.



	Conventional	Conventional Breeder / Deep Litter Grower	Outdoor Bred / Deep Litter Grower	Outdoor
Scope 1 and 2	4.31	1.75	1.31	1.11
Scope 3	0.92	0.91	0.99	1.03
LU and dLUC	0.063	0.063	0.061	0.06
Total	**5.30**	**2.73**	**2.36**	**2.20**

Figure 5. Emission intensity benchmarks for four Australian pork production systems

Notes: LU = Land Use. dLUC = direct Land Use Change. These refer to losses or sequestration associated with using or changing land management.

A summary of total emissions for each 1,000 sow farrow to finish piggery benchmark production system is provided in Table 1. Note that these are total emissions from a piggery operation, rather than emissions intensity which is standardised by live weight (Figure 5).

Table 1. Total GHG Emissions from 1,000 Sow Farrow to Finish Benchmark Production Systems

	Conventional with uncovered ponds	**Conv. bred and deep litter grower/finisher**	**Outdoor bred and deep litter grower/finisher**	**Outdoor breeding and grower/finisher**
Scope 1 and 2 (t CO_2-e)	9,935	4,046	2,381	2,018
Scope 3 (t CO_2-e)	2,130	2,106	1,805	1,864
LU and dLUC (t CO_2-e)	146	146	111	100
Total Emissions (t CO_2-e)	12,210	6,298	4,268	3,981

Conventional production has a significantly higher GHG emissions than other methods of production (Table 1). This is largely due to the methane emissions associated with effluent treatment ponds from uncovered anaerobic ponds. The relative contribution from LU and dLUC are small for the benchmark scenarios due to the selection of an Australian wheat/barley based diet and low imported soybean meal inclusion, but with higher inclusion rates of imported soymeal, this can increase and become a major emission source (up to 30% of the total emission profile). Figure 6 provides a breakdown of emission intensity by source.

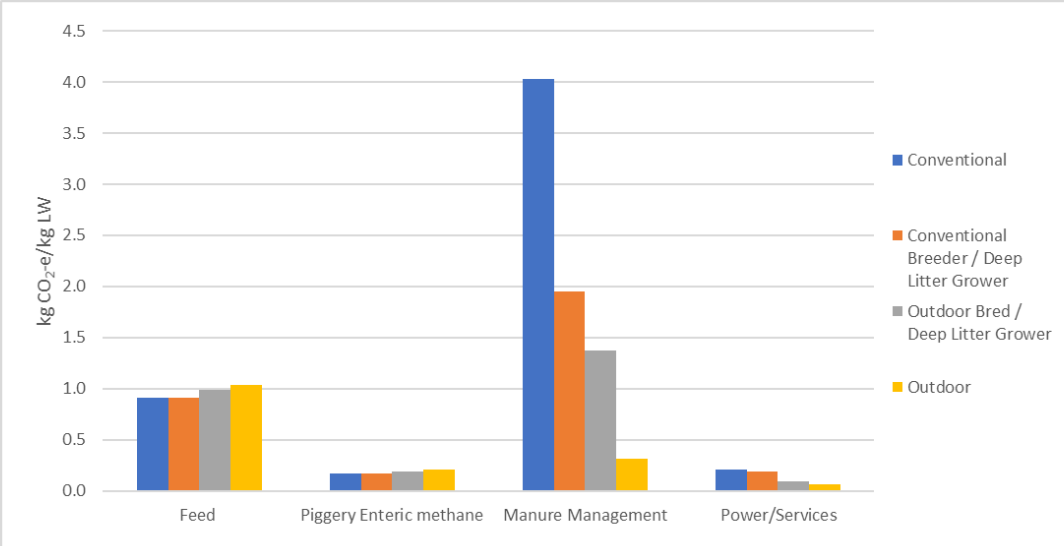


Figure 6. Sources of greenhouse gas contribution to emissions intensity for four Australian pig production systems

4. Reduce Emissions

4.1 Emission Reduction Strategies

Delivering lower emissions or carbon neutrality over time requires a plan. This section highlights a range of targeted emission mitigation strategies, primarily aimed at the two main GHG sources in piggery production: feed and manure management (Figure 7). Each emission mitigation strategy is applied to the relevant benchmark cases to demonstrate the total emission reduction that could be expected, with brief details for each mitigation strategy provided below.

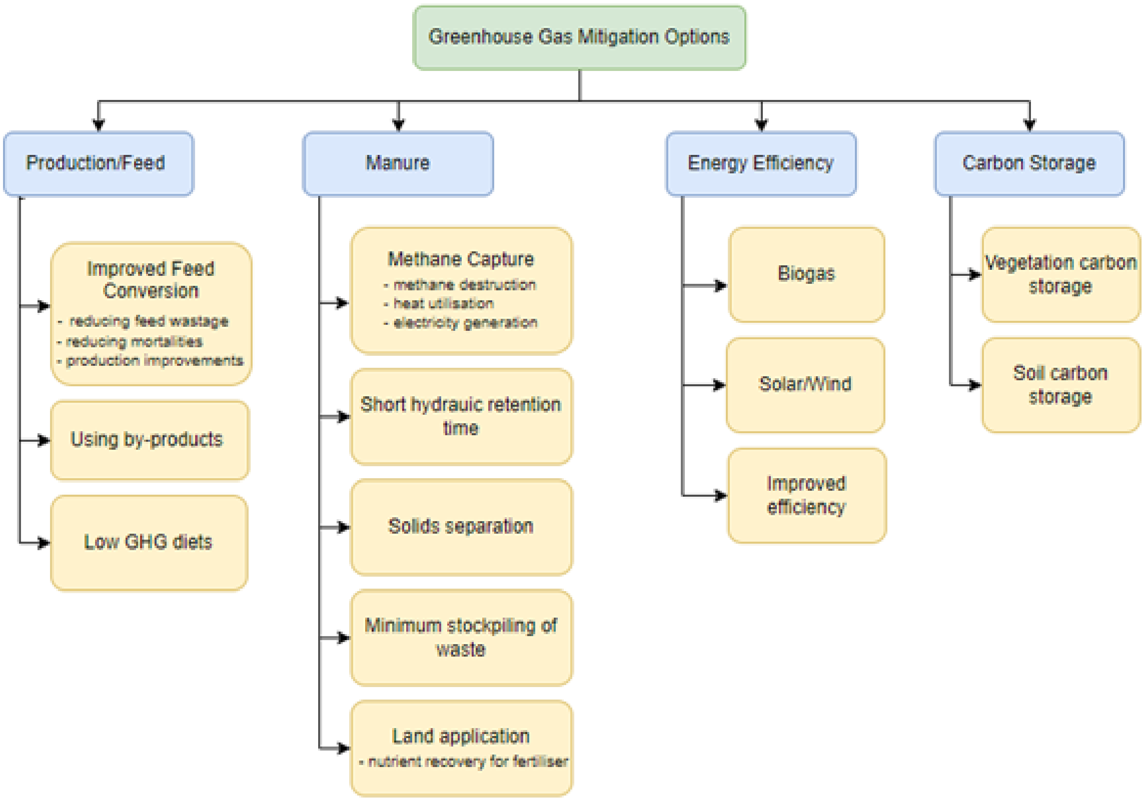


Figure 7. Greenhouse gas emission mitigation options for Australian piggeries

4.1.1 Production and Feed Emissions

- **Improved HFC**

GHG emissions may be reduced by improving feed efficiency, for example via improved growth rates, improved breeding rates, lower feed waste or improved herd health. This roadmap uses the production parameter of live weight herd feed conversion (HFC), representing the whole herd feed conversion per kilogram of live weight delivered to the point of processing. Improved HFC contributes to a lower emissions intensity by reducing the requirement for grain production, transport and milling, and reducing manure outputs, which generate GHG emissions. A 25% improvement in HFC for a 1000 sow farrow to finish conventional system, via achievable reductions in feed wastage and production improvements, can decrease scope 1, 2 and 3 GHG emissions for a conventional piggery operation with the expected reduction in emission intensity of 25%, while for a conventional breeder/deep litter grower operation the expected reduction in emission intensity is 22%. As a rule of thumb, this shows that a 1% improvement in HFC delivers about a 1% decrease in GHG emission intensity.

- **Using by-products**

The expected reduction in scope 1, 2 and 3 emission intensity for replacing a standard wheat/barley diet with approximately 35% by-products and waste products (carbohydrates, dairy and fish waste) is 10% in a conventional piggery. This reduction, however, is dependent on the digestibility and protein content of the by-products. Lower digestibility ingredients and ingredients with excessive protein will increase volatile solids and nitrogen excretion rates and lead to higher manure emissions.

- **Low GHG diet**

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%.

4.1.2 Manure Emissions

- **Methane capture**

The expected reduction in GHG emissions from including a covered anerobic pond (or anaerobic digestor) and combined heat and power system to a conventional farrow to finish piggery operation is 53% of scope 1, 2 and 3 emission intensity. It is assumed the power generated offsets 100% of the Scope 2 electricity requirements.

Methane is the major source of scope 1 emissions for conventional piggeries. Installing a covered anerobic pond (or anaerobic digestor) and combined heat and power system will reduce scope 1 and 2 emissions by 65%.

- **Short Hydraulic Retention Time (HRT)**

Short HRT systems consist of a pond, or tank, sized and designed to retain liquid effluent onsite for less than 30 days. This short HRT reduces methane generation by decreasing the opportunity for the development of anaerobic conditions, and as a result can reduce GHG emission by up to 53% compared with a conventional pond system.

- **Solids separation**

The inclusion of a solids separation process to an effluent stream, such as a sedimentation basin or screen has the potential to reduce the GHG emissions. A 31% reduction in scope 1 and 2, and a 25% reduction in scope 1, 2 and 3 emission intensity would be expected from the installation of a screw press separator (37% volatile solids removal) into a conventional piggery treatment process.

- **Minimum solids stockpiling**

For a conventional breeder and deep litter grower operation, the contribution to the carbon footprint from both methane and nitrous oxide emissions from stockpiles is typically about 12% of Scope 1 and 2 emissions, and 8% of the total emissions. If a producer converts to a no stockpile or litter off farm system, it is expected scope 1, 2 and 3 emission intensity reduction would be 8%.

4.2 Mitigation Potential Summary

Different mitigation strategies are suitable for the three main production systems in Australia. Table 2 provides a summary and qualitative assessment of the GHG mitigation strategies applicable for each production type, including details in the total mitigation potential, commercial opportunities and applicability to different scales of operations.

Table 2. Qualitative assessment of greenhouse gas (GHG) mitigation strategies for Australian piggery operations

Mitigation Strategy	Mitigation Potential[1]	Capital Cost	Operating Cost	Ease of Applying Commercially	Applicable to Small and Medium Sized	Applicable to Large Sized Operations[2]
Conventional						
Improved HFC	Medium	Low	Low	High	Yes	Yes
Use of By-Products and Co-products as Feed	Low	Low	Medium	Medium	Yes	Yes
Low GHG Diet	Medium	Low	Medium	Medium	Yes	Yes
Covered Pond	Very High	High	Medium	Low	No	Yes
Short HRT	High	Medium	Medium	Medium	Yes	No
Solids Separation – screw press	Medium	Medium	Medium	High	Yes	Yes
Deep Litter						
Improved HFC	Medium	Low	Low	High	Yes	Yes
Use of By-Products and Co-products as Feed	Low	Low	Medium	Medium	Yes	Yes
Low GHG Diet	Medium	Low	Medium	Medium	Yes	Yes
Minimum Stockpile of Solid Waste	Low	Low	Medium	Medium	Yes	Yes
Covered Stockpiles	Low	Medium	Medium	Medium	Yes	No
Outdoor						
Improved HFC	Medium	Low	Low	High	Yes	Yes
Low GHG Diet	Medium	Low	Medium	Medium	Yes	Yes

[1] Very High = ≥ 50% mitigating effect; High = 50 to 30 percent mitigating effect; Medium = 10 to 30 percent mitigating effect; Low = ≤ 10 percent mitigating effect. [2] Small/Medium operation classified as less than – 1000 sow farrow to finish (approx. 11,000 SPU)

5. Carbon Storage

The storage of carbon, also known as carbon sequestration, is the process of removing carbon from the atmosphere and depositing it in a reservoir. The two key reservoirs that provide opportunities for the sequestration of carbon for a piggery operation are vegetation and soils. The following sections detail the main principles behind carbon sequestration and how they may play an important role in the carbon accounts for a piggery operation.

5.1 Vegetation Carbon

Carbon sequestration through tree planting is a long-term strategy as it requires several years of establishment to receive carbon benefits. The age of the tree, species, environmental conditions (soil type, rainfall) and management influences the rate of carbon sequestration. Although higher rates of carbon sequestration occur in new plantations, mature plantations will continue to sequester carbon over their lifetime at a slow rate as they reach maturity (Unwin and Kriedemann, 2000). The two main factors that control total potential carbon storage in tree planting are area availability, and carbon sequestration rate. Sequestration rates vary between a low of about 2.5 t CO_2-e /ha.yr and a maximum of 30 t CO_2-e/ha.yr for very high growth rate species in high rainfall regions. A mid-point level of 7-10 t CO_2-e/ha.yr is reasonable to help estimate carbon potential.

5.2 Soil Carbon

Soil carbon (C) storage results from the movement of carbon dioxide from the atmosphere into the soil via plant biomass processes. Due to the large masses involved in soil carbon storage, small variations in soil organic carbon (SOC) can lead to large impacts on the carbon cycle. Figure 8 shows the impact different management practices have on soil carbon levels. Compost, manure and effluent application promote soil carbon storage in two ways: firstly by directly adding carbon to the soil, and secondly by increasing nutrient levels to promote plant growth, resulting in more carbon inputs.

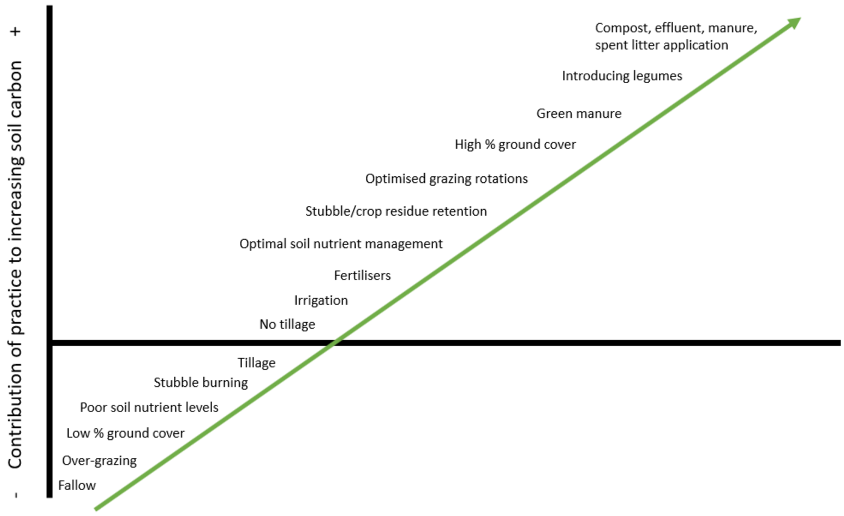


Figure 8. The effect of different management practices on soil carbon levels (adapted from Cotching, 2009)

The pig industry is in a unique position because it has manure and effluent that is available for reuse, which can promote an increase in soil carbon. In outdoor systems, the manure deposited by the pig phase has also been shown to contribute to short term increases in soil carbon (Wiedemann 2016). However, application rates should take into account nutrient levels as well, to ensure other environmental priorities are not overlooked.

6. Report, Monitor and Market

Recently, significant market attention has been directed toward GHG emissions associated with food, with retailers and brand owners pursuing emission reduction or carbon neutral targets. To achieve carbon neutral, the Australian Government Climate Active certification process has seven steps shown in Figure 9.

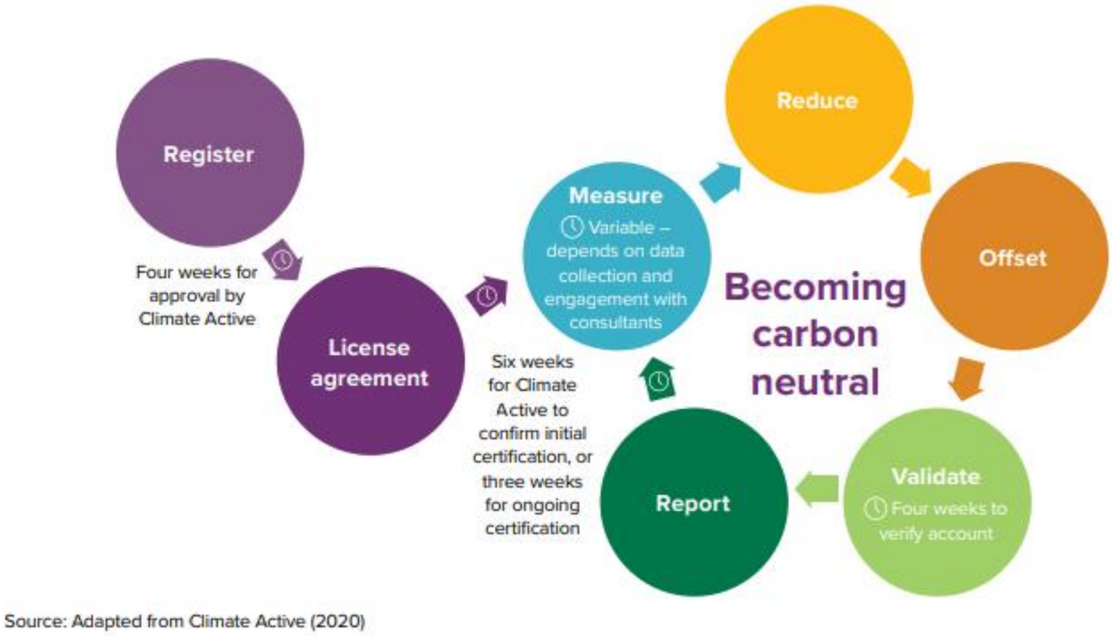


Figure 9. Steps toward carbon neutrality (Department of Industry Science Energy and Resources, 2021)

Carbon offsetting can be achieved by purchasing approved carbon credits or retiring existing carbon offset credits owned by the entity. There are multiple types of carbon credits that can be generated or purchased. Eligible carbon credits for the Climate Active program currently include:

- **Australian Carbon Credit Units** (ACCUs) are regulated financial products under the Carbon Credits (Carbon Farming Initiative, CFI) Act 2011 administered by the Clean Energy Regulator through the ERF.
- **Non-ACCU Offsets** allowed under the Australian Government Climate Active Carbon Neutral Standard.

Climate Active's certification requires independent third-party to verify the carbon footprint and offset strategies. Businesses are required to meet ongoing certification and reporting requirements (e.g. annual reporting) to use the Climate Active trademark on their products.

The carbon market is regulated by the Clean Energy Regulator (CER) which administers national carbon markets for the Emission Reduction Fund and the Renewable Energy Targets.

- **Emissions Reduction Fund**

The Emissions Reduction Fund (ERF) supplies Australian carbon credit units (ACCUs) and is a voluntary program that provides financial incentives for companies to adopt approved methodologies to reduce emissions, or by removing carbon dioxide from the atmosphere and sequestering carbon in soil or vegetation. Further details about the application of methods can be found at:

http://www.cleanenergyregulator.gov.au/ERF/Choosing-a-project-type/Opportunities-for-the-land-sector/Agricultural-methods

- **Renewable Energy Target**

The Renewable Energy Target, which creates tradable large-scale renewable energy certificates (LGCs) and small-scale technology certificates (STCs). Within a piggery operation power generation from an anerobic digestor would, in most cases, be eligible for LGCs. Further information can be found at:

http://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target/How-the-scheme-works/Large-scale-Renewable-Energy-Target

Note: Carbon credits generated through an ERF project on-farm and sold into the carbon market, cannot then be used to also offset emissions from the enterprise. The GHG Protocol Agricultural Guidance (Greenhouse Gas Protocol, 2014) states that if a company sells an offset that has been generated within its organisational boundaries, then the company must remove the emission reductions from its carbon account to avoid double counting and to conform to the GHG Protocol Corporate Accounting and Reporting Standard. This avoids 'double counting' of carbon credits.

Monitoring of inputs and outputs from a production system is key to tracking GHG emissions, and determining changes or trends in emissions over time. For a piggery operator, the key parameters to monitor are included in Table 3.

Table 3. Important parameters to monitor for GHG assessment

Operational Factor	**Comment**
Herd composition	Breakdown of pig numbers and housing
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
HFC	kg feed across whole herd per kg LW delivered for processing
Soymeal Content in Feed	% content in feed and origin
Distance to services (feed, fuel, processing)	Distance for delivery
Feed substitutes	Use of material other than manufactured pig rations
Manure management	Details of how manure is managed across the site

Collection of reliable production and operational data is an important factor in the determining the total scope 1, 2 and 3 emissions, as well as the emissions intensity of the pigs delivered to processing. A high level of input accuracy translates to more valuable GHG emission data, and allows reductions in emissions over time to be monitored and reported.

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Appendix A. Benchmark Scenario Activity Data

Key Parameters	Conventional	Conventional breeding and deep litter grower/finisher	Outdoor breeding and deep litter grower/finishers	Outdoor
Location	New South Wales			
Herd Composition	1000 sow farrow to finish			
Pigs weaned/sow.year	23.2	23.2	18.3	18.2
Live weight HFC	3.3	3.3	3.7	4.0
Finisher pig weight	100 kg			
Feed	Australian wheat/barley dominant (2% imported soybean meal)*			
Feed Milling	onsite			
Electricity	grid supplied			
Transport distance for feed	100 km			
Transport distance for fuel	100 km			
Transport distance to processing	200 km			
Manure Management System	Anaerobic Pond	Anaerobic Pond and Stockpiled Litter	Direct to Land and Stockpiled Litter	Direct to Land

*Reference: PigBal v4