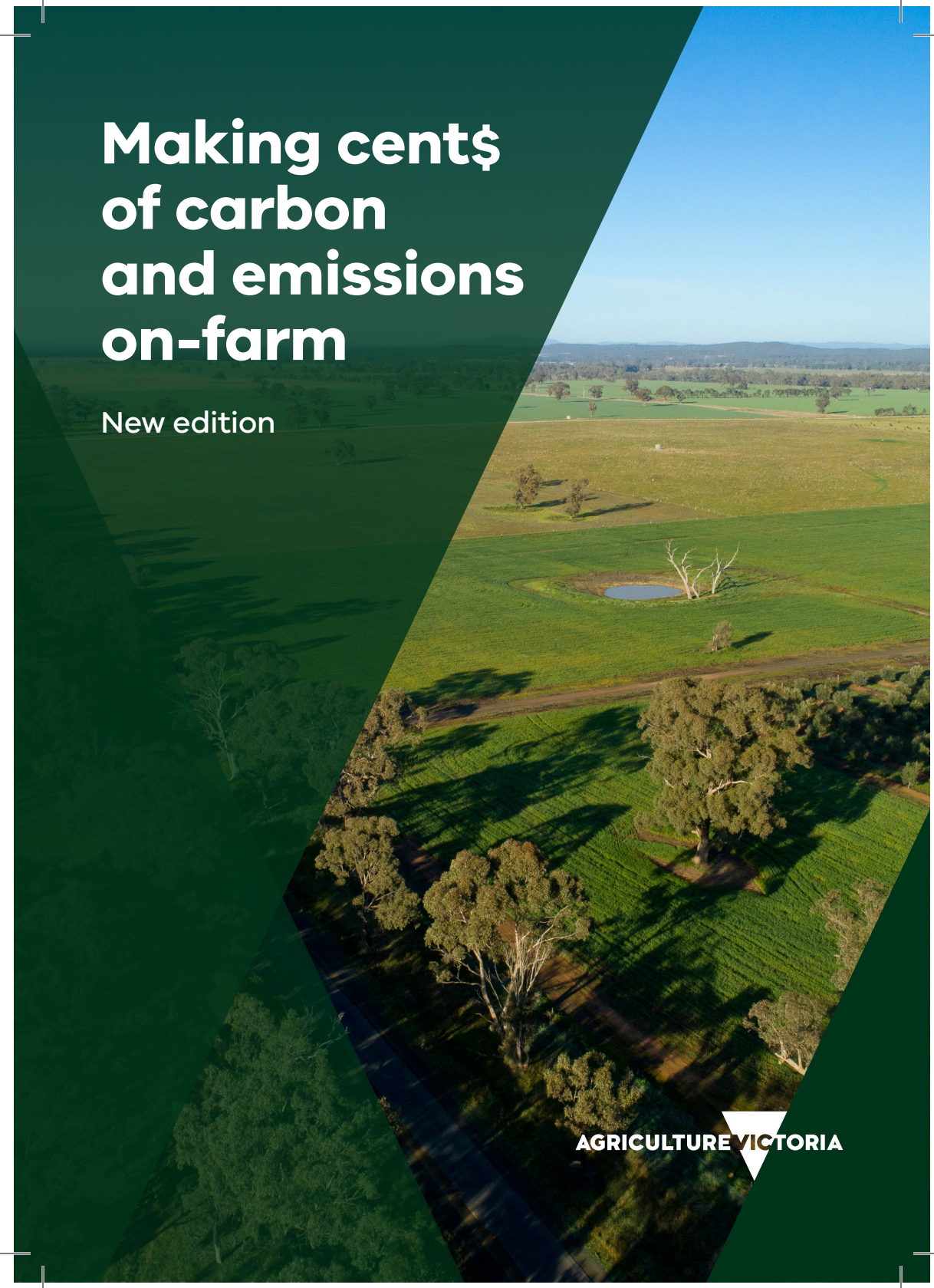
Making cent$ of carbon and emissions on-farm

New edition



AGRICULTURE VICTORIA

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Making cents of carbon and emissions on-farm

Good business management is good emissions management. Victorian farm businesses are getting on with the job of growing more food and fibre, while dealing with changeable seasons and weather patterns.

All food and fibre systems produce some form of greenhouse gas emissions, mostly in the form of:

- **Methane (CH_4)** mainly caused by ruminant digestion, manure stockpiles and effluent ponds
- **Nitrous Oxide (N_2O)** mainly from nitrogen fertilisers, animal urine, manure and denitrification, and
- **Carbon Dioxide (CO_2)** from fossil fuel-based electricity, liquid fuels, urea and lime applications.

Farms also purchase and use inputs that have embedded emissions (emissions produced in the production and supply of inputs). However, our farms also contain trees, plants, grasses and soils that absorb carbon dioxide from the atmosphere and use it to grow.

It may seem surprising but, in general, farming produces more greenhouse gas than it removes, which contributes to an increased concentration of greenhouse gases in the atmosphere. These additional heat trapping gases are increasing global temperatures and causing other changes in local (and global) climates. This will mean an increase in average daily temperatures in Victoria over time and less predictable seasonal rainfall patterns.

See figure 1 on the following page to learn more about these gases.

We know we must grow more food and fibre as the demand for food steadily increases. Farmers are constantly looking for efficiencies to improve farm productivity and resilience, while maintaining profitability.

So why is there a need to reduce emissions in agriculture?

For agriculture, markets and investors are pricing in emissions reduction to their activities – climate change is a material risk to businesses, so resources and effort are being directed to reducing this risk. Either through changes in financing criteria and/or purchasing power. Large businesses are now required to report on their efforts to reduce emissions and adapt to climate change.

In addition, continued warming of our planet will increase the frequency and severity of extreme weather events which affect agricultural production. Farmers therefore have direct interest in supporting actions to reduce warming and increasingly consumers and exporters will expect to see 'low-emissions' products.

Greenhouse gas emissions are losses from a system. Knowing your emissions and understanding the inefficiencies that release

greenhouse gases provides the opportunity to identify greater efficiency across your farming system. There is potential to reduce emissions while improving productivity and reducing costs.

This booklet aims to introduce management options to lower farm emissions that may also reduce operational costs and improve profits along the way.

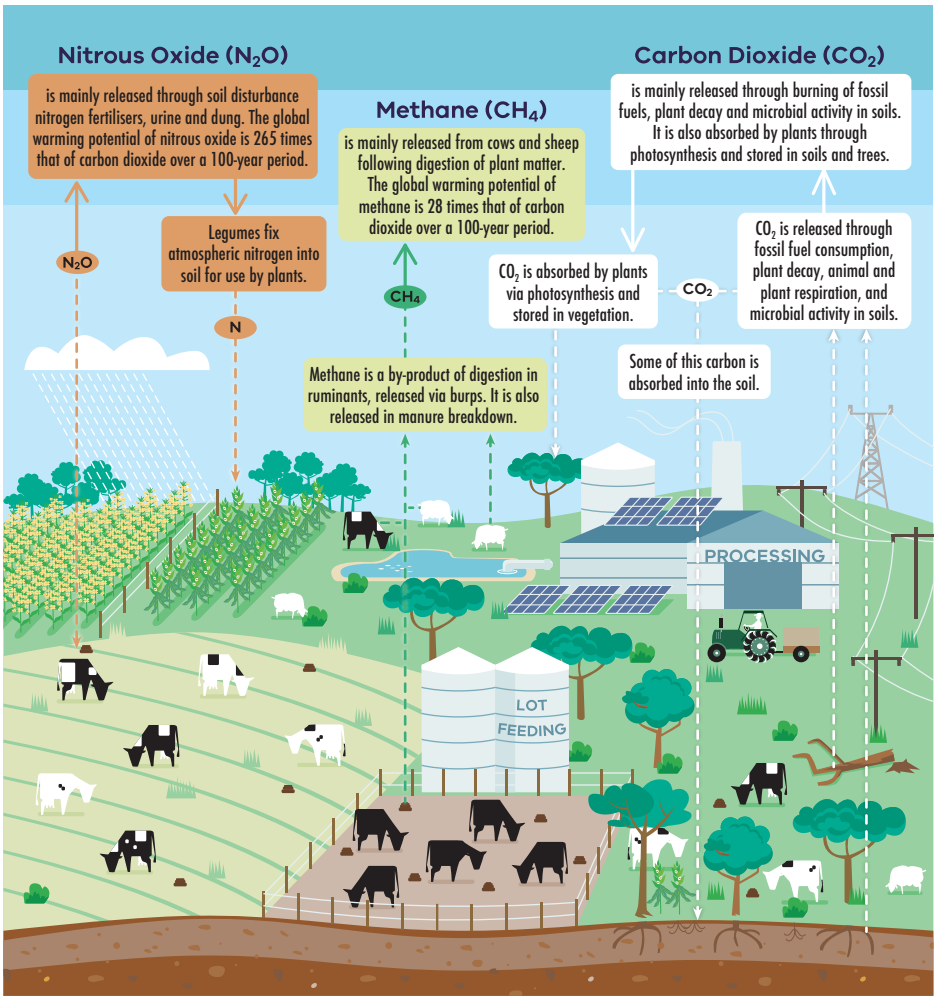


Figure 1. Greenhouse gas cycles on farm.

Taking action on-farm

Farmers are proving there are ways to increase on-farm productivity while also reducing greenhouse gas emissions on-farm. Refer to these online case studies for examples of how farmers are addressing their emissions:

In many cases, actions to reduce emissions or increase carbon on farms have multiple benefits for farm businesses, such as increasing farm health and profitability. Most farmers have already made great resource efficiency improvements, helped by new technologies, new skills and practices. Such improvements can also result in reduced overall emissions.

The following pages provide examples of actions that farm businesses can take to improve their emissions performance on-farm under the key action areas identified below.

The key actions aim to assist farm businesses take control of their situation and consider options to improve the resource efficiency of their operations. Research and development will identify additional options and solutions over time.

To stay updated, go to Agriculture Victoria's carbon and emissions webpages

Read on for some practical tips on how you can continue to manage carbon and emissions on your farm. You might be surprised at how much you are already doing.

Use the tick boxes to check what you already do and/or to plan your future actions

When thinking about how to manage carbon and emissions on farms, it is useful to think of a farm as having the following key action areas:

- ☐ **Understanding emissions:** understand your farm emissions footprint and emissions intensity
- ☐ **Know your emissions number:** Data collection and record keeping
- ☐ **Energy:** increasing efficiency, renewable energy and emissions reduction
- ☐ **Livestock:** improving performance and reducing energy loss
- ☐ **Nitrogen use efficiency and fertilisers:** improving efficiency and saving money
- ☐ **Effluent and manure management:** reducing emissions from their storage and breakdown
- ☐ **Trees:** for farm health
- ☐ **Healthy soils:** to grow food and store carbon
- ☐ **Embedded emissions:** understanding the emissions footprint of purchased inputs
- ☐ **Action planning:** pulling it all together
- ☐ **Where to next?** Being prepared for what others are doing

Understanding emissions:

Understand your farm emissions footprint and emissions intensity

A good first step to reducing farm emissions is to identify the key sources of emissions on your farm. Farmers can 'know their number' by undertaking an emissions assessment to estimate the greenhouse gas emissions coming from the farm using tools like the Greenhouse Accounting Framework (GAF) calculators or the online AIA Environmental Accounting Platform:

These calculators utilise farm data to estimate the emissions from different farming activities. Different calculators cover different farming systems. These tools provide an estimate of the total amount of carbon dioxide equivalents (CO_2-e) produced by the farm each year and provides a breakdown of these emissions by the different activities on farm.

Farm emissions are broken into three types of emissions, called Scopes:

- Scope 1: Emissions from livestock (like enteric methane from sheep and cows), nitrous oxide from nitrogen fertiliser application, urine and dung, and carbon dioxide from fossil fuel use.
- Scope 2: Emissions resulting from the electricity the farm uses.
- Scope 3: Emissions created in manufacturing products the farm buys (embedded emissions).

Farms can also capture and store carbon in trees and soils, a process known as carbon sequestration, carbon removal or carbon sink. By considering both the greenhouse gas emissions sources and sinks, tools can estimate the net farm annual emissions (footprint).

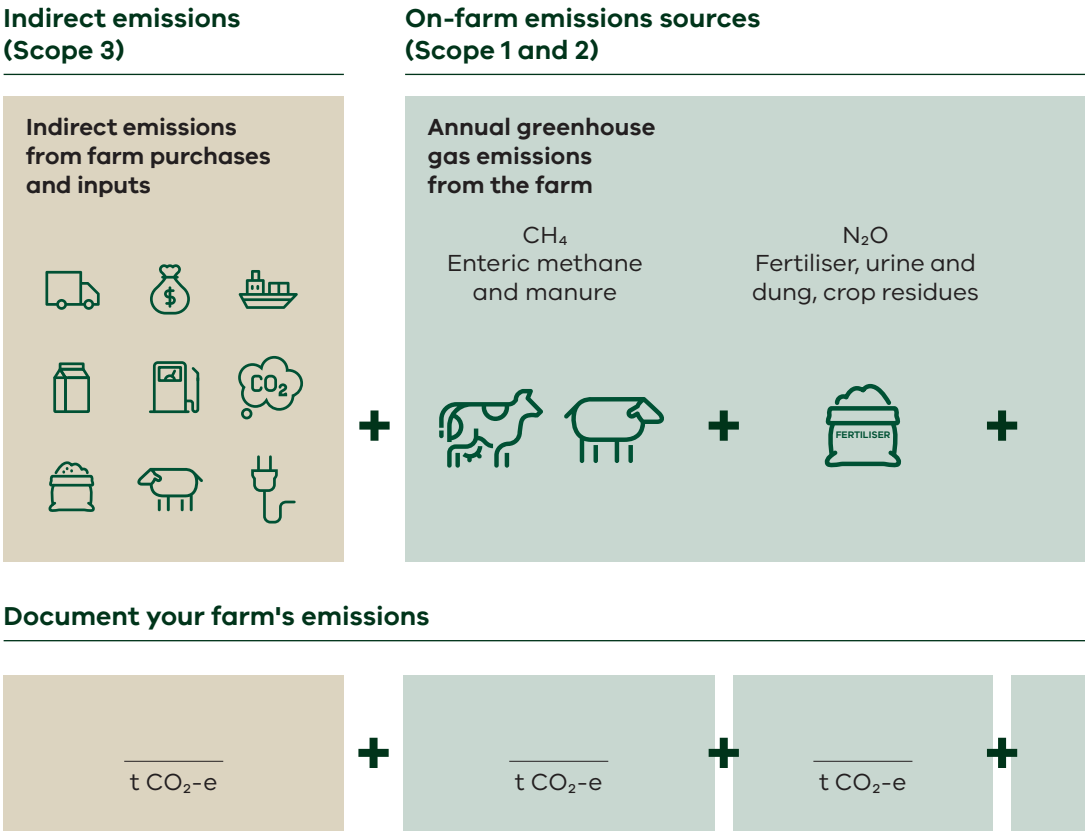
Figure 2 shows emission scopes, sources and sinks in an emissions profile for a typical livestock farm. It includes space to enter emissions information by source.

Emissions intensity

Emissions intensity measures the emissions (as CO_2-e) per unit of product, reflecting production efficiency. It helps compare farms of different sizes and can be used to benchmark your emissions efficiency to other farms. The aim is to lower emissions intensity and total emissions from a farm.
Supply chains and exporters can also use emissions intensity information when seeking lower emissions suppliers.

Figure 2. Example farm emissions profile

Figure 2 shows emission scopes, sources and sinks in an emissions profile for a typical livestock farm. It includes space to enter emissions information by source.



Carbon stocks

Net farm annual emissions (footprint/estimate)

CO_2
Energy, lime, urea

Annual change in farm carbon stocks (new sequestration)

Trees Soil

Represented in tonnes of carbon dioxide equivalents (t CO_2-e)

t CO_2-e

t CO_2-e

t CO_2-e

t CO_2-e

Know your emissions number:

Data collection and record keeping

There are several calculators or tools available to estimate your farm emissions. Farm emissions calculators are based on peer reviewed science and aligned to national and international greenhouse gas accounting standards. They are robust and as new emissions research is published, the calculators are updated to ensure calculation methods and emission factors are improved and align with the latest accepted emissions science and accounting guidance.

Some calculators can provide a modelled estimate of annual carbon sequestration from trees, based on location, age and area of tree cover (hectares). However, they are not yet able to provide an estimate of the annual soil carbon sequestration. If required, third party auditing of tree carbon sequestration is available, but would involve either site visits and/or remote estimation of tree cover over time. There are also methods for determining annual soil carbon sequestration through specific methods of measurement and modelling.

Emissions calculation is underpinned by farm data. These are usually farm records that you already collect, but there may be additional data or measurements that you need to undertake for increased accuracy. The more accurate the farm data entered into the calculators, the higher quality the emissions estimates will be. Good record keeping of the key data sources required is important.

For a list of emissions calculators see:

Management options

Select an appropriate greenhouse gas accounting tool

- [ ] investigate which tool / calculators best suit your business and the purpose for which you are estimating your emissions.
- [ ] consider which tool is endorsed by your industry body and/or ask your supply chain partners which tool / calculators is most relevant for sustainability reporting.
- [ ] undertake training in the use of emissions calculators or seek support or advisory services that can provide your emissions footprint.
- [ ] ensure the tool meets Australian greenhouse gas accounting requirements and guidelines.

Keep accurate records on the inputs and outputs of your production system

- [ ] understand the data and records needed for your farm enterprise/s to estimate emissions using the calculators.
- [ ] consider equipment needs, record keeping systems and software for collecting and organising farm data over time.

Once you know your number

- [ ] benchmark your emissions intensity over time, as well as against other similar farm systems.
- [ ] continue to collect data and estimate emissions over time to determine changes in emissions due to management and seasons.
- [ ] keep across market news and trends in order to capitalise on new and emerging markets and how supply chain emissions reduction efforts might affect your farm business over time.

Energy:

Increasing efficiency, renewable energy and emissions reduction

Energy efficiency both on-farm and along the supply chain will help minimise impacts of rising energy costs for heat, electricity, gas and liquid fuels. Additionally, there is a range of cost-effective alternatives to fossil fuels for energy generation either currently available or in development. For example, renewable energy sources now supply significant amounts of power to the electricity grid and over time the emissions from electricity use are likely to decrease as fossil fuel based electricity is replaced with renewable energy.

Energy efficiency in farming is about **achieving equal or better productivity with reduced energy input**, directly cutting operational expenses and environmental impact.

Greenhouse gas calculators often show that farm energy use is a small portion of overall farm emissions. However, for many farmers (such as those involved in cropping and more intensive agriculture such as dairy and horticulture) energy is a significant source of emissions and growing cost. Finding alternative energy sources and improving energy efficiency can save money and reduce emissions.

Management options

Farmers who increase their energy efficiency and find alternative, low cost sources of fuel, heat and electricity may become more resilient, energy efficient and profitable.

Understand your energy use:

- get an energy assessment or audit to the national standard (AS/NZS 3598.2:2014) to measure your current energy use and highlight areas for improvement. Be sure to engage an auditor with demonstrated experience in agriculture, as they can provide recommendations tailored to farm systems (e.g. irrigation, variable speed drives, refrigeration, etc).
- compare your energy bills to other offers available in your area by visiting the independent Victorian Government energy price comparison website (https://compare.energy.vic.gov.au/).
- check your tariff and your off-peak rates to make sure you are getting the best deal.
- take time to understand how to interpret your energy bills, usage and costs. The way you are charged for electricity use depends on a number of factors including your electricity distributor, the type of meter you have and the size of your business which is determined by your network demand (kVA) and consumption (kWh).
- energy meters may assist in working out where and when you are using the most power as well as how much energy different appliances use.
- identify if it is possible to be flexible about when you use your energy and consider opportunities to shift the time you use energy to off-peak periods to reduce energy costs.

Consider your options to maximise the efficiency of equipment and machinery:

- for existing equipment – develop and follow a regular maintenance schedule for machinery, equipment and vehicles to ensure optimal fuel/energy use efficiency and ensure modifications do not affect their efficiency.

- [ ] when purchasing new equipment – consider energy efficiency as a factor when making changes to farm management or investing in new equipment or infrastructure.
- [ ] when thinking long–term – develop a plan to replace inefficient equipment over time.

Make efficiency gains:

- [ ] use energy-efficient engines and maintain equipment well to avoid unnecessary fuel and electricity use.
- [ ] choose the right equipment and machinery for the task, e.g. fuel type, consumption, conditions, tyre size and drive functionality (2, 4 or all-wheel needs). Ensure all staff have appropriate training in efficient use of vehicles.
- [ ] minimise tractor passes, for example move from conventional tillage to minimum tillage. This can create savings of around 10 percent of fuel on farm.
- [ ] consider opportunities for precision agriculture, for example technologies that can optimise use and application of inputs, reducing both inputs and energy consumption during application.
- [ ] consider automation, robotics, control systems and other emerging technologies (e.g. autonomous vehicles) that can support control and monitoring of energy use and identify opportunities for further efficiencies.

Consider buildings, heating and cool room facilities:

- [ ] insulate buildings, storage and refrigeration devices, and heating and cooling pipes.
- [ ] use light coloured, heat reflective paint on roofs and walls.
- [ ] invest in energy efficient cool rooms and refrigeration. Quick cool-down of meat products and pre-cooling of fruit and vegetables will provide energy savings along the 'cold chain' while maintaining product quality and food safety standards.
- [ ] consider the application of waste heat recovery systems, heat pumps and exchangers. Recovering / reusing heat in buildings can reduce overall use.
- [ ] consider efficient home heating using efficient split systems (heat pumps) combined with solar power to reduce winter heating costs.
- [ ] install energy efficient lighting and equipment sensors making sure you always turn the lights off when they are no longer needed.

Generate your own energy, optimise storage and use of energy and source from renewables:

- [ ] choose the most efficient and cost-effective fuel source such as renewables rather than fossil fuels.
- [ ] consider production of bioenergy to generate heat and/or electricity from agriculture or plantation waste and residues (wood chips to run heaters/ hot water, biogas from effluent, straw for pellets or energy/heat/hydronic systems etc).
- [ ] obtain energy from renewable sources such as solar panels and accessories including inverters and batteries, wind and ground source heat pumps, where possible.
- [ ] explore options for renewable energy and energy efficiency retrofit grants and incentives such as the Victorian Energy Up-grades program (VEU) and the small-scale renewable energy scheme.
- [ ] consider options for energy storage on farm, either via fuel cells, thermal, or batteries.

Optimise energy used for irrigation:

- [ ] carefully match engine power to the requirements of irrigation pumps. Three phase motors are often more energy efficient. Consider installing variable speed drives (VSDs) onto pumps on the farm to match flows to requirements.
- [ ] improve the efficiency of irrigation practices. For example, schedule irrigation based on soil moisture monitoring devices, use solar power for electricity-based irrigation pumps and set irrigation schedules to minimise use of peak tariff rates.
- [ ] perform a pump test to identify how efficiently pumps are operating. Installing an hour metre on a pump is a low-cost strategy that can provide valuable information on how to prioritise pump improvements.
- [ ] optimise irrigation pump performance to reduce diesel consumption and increase water flow rates.
- [ ] measurement tools such as infield sensors, soil moisture probes and flowmeters, should be used to match water to plant/crop requirements and soil water holding capacity.

Further information

https://extensionaus.com.au/energysmartfarming/home

Livestock:

Improving performance and reducing energy loss

Methane is the main greenhouse gas produced in grazing systems. Ruminant livestock (cattle, sheep, and goats) have microbes in their rumen called methanogens. These microbes produce methane (from the fermentation of feed) that is then belched out. Feed with lower digestibility produces more methane than higher quality feeds. Belched methane represents energy lost from your production system that might otherwise be converted to the milk, meat or fibre that generates income.

Methane is an inefficiency in animal production with 6 to 12 percent of gross energy consumed from the diet lost as methane. This energy loss has been calculated as the equivalent of up to 55 to 60 days grazing intake for ewes and steers, and 40 days for dairy cows.

Management options

Management changes that improve livestock performance and efficiency can lead to **lower emissions and/or emissions intensity***.

Manage the flock or herd to optimise growth and reproductive efficiency:

- actively monitor livestock growth and condition to ensure timely management and reduce setbacks.
- ensure that stock are managed according to their nutritional requirements.
- optimise fertility and reproductive performance through good health and by meeting body condition score and liveweight targets.
- minimise young stock losses through good husbandry and provision of adequate shelter.
- optimise the proportion of young, growing or lactating stock.
- cull unproductive stock that fail to grow well or reproduce successfully.
- monitor and manage animal health to reduce impacts of diseases and parasites.

Improve the quality of the feed that livestock eat to reduce methane emissions:

- improve the quality of pasture or forage by optimising grazing management, growing high quality forage crops (e.g. forages which contain tannins, reduce methane and urinary nitrogen losses) or supplementing the diets of grazing livestock when necessary with grain or other high oil, energy-rich, low fibre feeds (e.g. during summer and autumn) while optimising protein intake.

** Actions in this list such as reducing the time animals are on the farm by turning them off earlier at the same or higher weights, by feeding feed additives or by selecting animals to produce less methane will reduce total emissions and lower emissions intensity. However, other actions that promote a healthier, more productive flock or herd will tend to lower emissions intensity but may not reduce total farm emissions.*

- finish prime stock in feedlots on high quality optimum diets or with high quality pastures to reduce finishing times and meet market specifications.
- use feeding systems that reduce spillage and spoiling to maximise feed usage which may reduce total purchased feed.
- optimise silage and hay quality by harvesting when appropriate and when quality is high using short lockup periods and good storage practices.
- use feed testing to assess the feed value of grain, hay or silage and ensure diets meet nutritional requirements of stock.
- stay tuned to industry research as methane reducing feed additives become more widely available and cost effective.

Consider ram/bull selection and breeding to achieve increased reproductive rates and shorter finishing times:

- utilise Australian Sheep Breeding Values (ASBV's) when selecting rams, Estimated Breeding Values (EBVs) for beef cattle and Australian Breeding Values (ABV's) for dairy cattle.
- include breeding values for productivity traits such as fecundity, growth rate, reproduction, feed conversion efficiency, feed intake and parasite/disease resistance in your ram and bull selection criteria. When available, consider breeding values for reduced methane emissions.
- consider the use of genomic technologies to improve the selection of breeding stock.
- identify, and cull less productive stock.

Further information
www.agriculture.vic.gov.au/carbon-emissions

Nitrogen use efficiency and fertilisers:

Improving efficiency and saving money

Nitrogen is critical to plant growth and reproduction. Pasture and crop growth will often respond to an increased availability of soil nitrogen. This situation is often managed through the addition of nitrogen fertilisers.

Nitrous oxide is a powerful greenhouse gas and accounts for 5 percent of global greenhouse gas emissions with over 70 percent of these derived from agricultural sources. Nitrogen containing fertilisers and amendments (including organic), and livestock manure (urine and dung) are the key sources of nitrous oxide emissions on farms.

When nitrogen is applied efficiently (e.g., split applications, precision placement), less is lost through leaching or votalilisation, meaning potentially lower environmental impact while more nutrients are available for crops. Nitrogen use efficiency (NUE) is the ratio between the amounts of fertiliser nitrogen (N) applied to a crop and the amount of N removed from the paddock by the crop or product. Improved NUE consequently has both productivity and profitability benefits.

Nitrous oxide is released from warm, waterlogged soils where there is excess nitrogen in the form of nitrate. Volatilisation of nitrogen as ammonia can also lead to indirect nitrous oxide emissions through redeposition contributing to excess nitrate elsewhere in the landscape.

Farmers can save money, boost pasture and crop production and reduce nitrous oxide losses by carefully planning and implementing best management practices with regards to the 4 Rs - the 'right' product, rate, timing and placement of nitrogen fertilisers to match plant needs. Maximising the use of nitrogen fixing plants in crops and pastures can reduce input costs and emissions.

Follow the 4 **R**s

- **R**ight product
- **R**ight rate
- **R**ight time and
- **R**ight place

Further information

www.fertilizer.org.au/Fertcare/Nutrients-And-Fertilizer-Information

Management options

Research has estimated that 20 percent to 60 percent of nitrogen inputs into cropping and grazing systems can be potentially lost to the environment. By improving agricultural practices we can reduce these losses, improve productivity and save money.

Right Product – Choose the best type of nitrogen:

- avoid nitrate-based fertilisers which are more prone to losses.
- consider use of enhanced efficiency fertilisers, e.g. coated for slow release, or nitrification inhibitors that may better match the fertiliser supply with plant demand for soil nitrogen.
- Inhibitors can be added to fertiliser which can reduce nitrate leaching and ammonium volatilisation. However, it is recommended to seek expert advice when choosing inhibitors.

Right Rate – Match nitrogen supply to crop/pasture demand:

- use soil or plant testing to assess plant available nitrogen supply. This helps to apply nitrogen fertiliser rates based on target yield and crop or pasture nitrogen requirements over the growing season.
- account for soil moisture availability and seasonal forecasts for more timely and calibrated fertiliser decisions.
- use industry-relevant decision support tools (e.g. Yield Prophet in Grains; Dairy nitrogen fertiliser guidelines; GrazFert for beef and sheep).
- avoid high application rates of nitrogen in any single application (i.e. never exceed recommended rates, split applications may be more effective and adjust rates according to rainfall and temperature).
- consider adopting Variable Rate Technology (VRT) for targeted application.
- use fertigation where applicable for efficient nutrient delivery.
- use sensors/drones to monitor crop health.

Right Time – Time fertiliser and amendment application to minimise nitrogen loss:

- where possible, align nitrogen fertiliser and amendment applications with crop and pasture demand. Crop/pasture demand is highest when growth rates are highest.
- avoid applying nitrogen fertiliser and amendments to warm (>10°C) and waterlogged soils.
- avoid tillage under wet conditions.
- consult a 7-day weather forecast to identify risks of soil saturation and if likely, delay nitrogen fertiliser application.
- in summer, avoid applying urea fertiliser after irrigation as this is likely to increase volatilisation losses.
- minimise the length of fallow when converting long-term pasture to crops, especially in high rainfall zones and irrigated crops.

Right Place – Appropriate application:

- apply or inject nitrogen near plant roots.
- avoid surface broadcasting to reduce losses.
- incorporate fertiliser at the top of raised beds or ridges to avoid concentration and losses in furrows and wet areas.
- determine and improve plant access to nitrogen by improving soil health and nutrient status – see section on 'Soils'. Adding nitrogen to soils that have inherent limitations to plant growth is unlikely to result in higher productivity and/or financial gain.

Further information

https://agriculture.vic.gov.au/climate-and-weather/understanding-carbon-and-emissions/nitrogen-fertilisers-improving-efficiency-and-saving-money

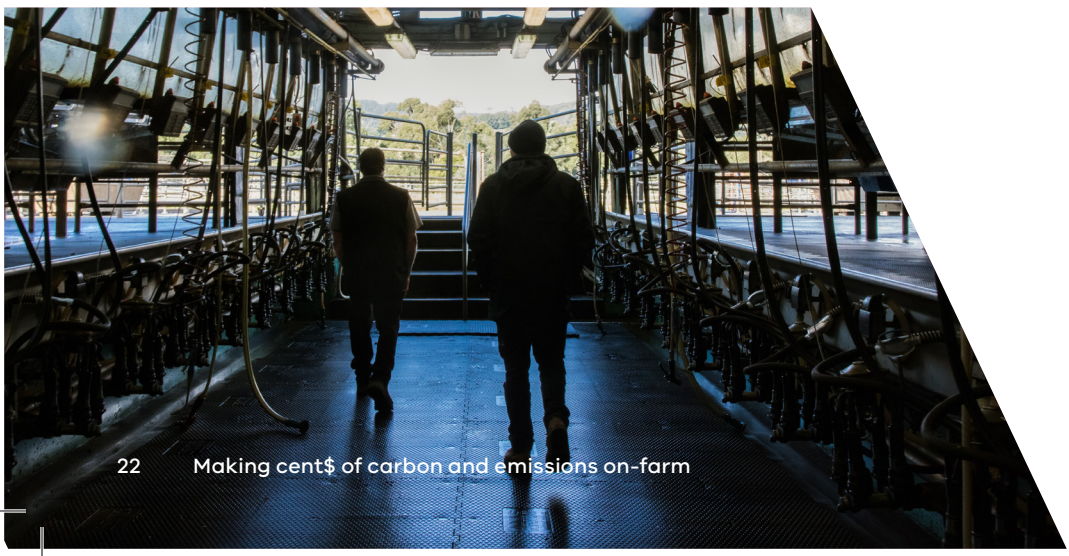
Effluent and manure management:

Reducing emissions from their storage and breakdown

Effluent and manure can be sources of both methane and nitrous oxide emissions - through biological processes during storage and application.

When manure or effluent is stored in lagoons, ponds, or tanks without oxygen, microbes break down organic matter and produce methane. Liquid systems (slurry, effluent ponds) create ideal anaerobic conditions for methane generation. The longer manure sits in anaerobic conditions, the more methane is emitted.

Livestock urine and dung deposition, nitrogen fertiliser and amendment applications and atmospheric nitrogen fixed by legumes are the largest inputs of reactive nitrogen to soil for grazing enterprises. Livestock manure (i.e. dung and urine) contains a high concentration of nitrogen. Around 80 percent of all nitrogen consumed by ruminants is excreted in dung and urine. Both directly deposited animal manure and collected manure which is land applied, should be used efficiently to improve pasture or crop growth.



Management options

Managing storage (e.g., covers, aeration) and applying manure at the right time and rate can reduce emissions. Some options include:

Consider effluent system design – ensure that the system is appropriate for the volume of effluent and manure:

- avoid holding effluent in anaerobic conditions for extended periods or use agitation in liquid systems to limit anaerobic conditions. Aeration may also be considered in some instances, so long as there are no perverse odour and/or energy use trade offs that negate their benefit.
- keep records of manure volumes, application timing, and storage conditions. Monitor system performance and consider upgrades when/if required.
- agitate or aerate effluent regularly to maintain oxygen levels and reduce methane generation.
- use solid–liquid separation to remove volatile solids, reducing methane potential in liquid effluent.
- consider the applicability of installing biogas systems to capture methane from effluent ponds. Consider use of renewable energy from this source on farm.
- consider the emergence of microbial or mineral additives that can reduce methane from effluent systems.
- cover effluent ponds or lagoons to reduce methane emissions, where appropriate and feasible to install.

Use manure efficiently:

- empty storage ponds (approximately yearly or as appropriate for the system design) and anaerobic ponds (timing dependant on the system design) by irrigating to crops or pastures.
- match application rates to crop nutrient needs.

- [ ] apply manure to paddocks as soon as practical rather than long-term storage.
- [ ] avoid application before heavy rain or on waterlogged soils (reduces denitrification risk).
- [ ] incorporate manure into soil quickly after spreading to reduce Nitrous Oxide (N_2O) and ammonia losses.
- [ ] manage manure stockpiles to avoid anaerobic conditions. Consider adding adsorbents (such as clays, zeolites, biochar) to the manure or alternatively composting and pelletising the manure instead of stockpiling it.

Reduce the loss of nitrogen from animal manure (dung and urine) to minimise nitrous oxide emissions:

- [ ] avoid applying slurries or manure to land in wet conditions, such as wet winter soils.
- [ ] avoid causing conditions that lead to poorly aerated soils (e.g. pasture pugging and compaction).
- [ ] when using manure as fertiliser, test for its nitrogen content and apply at a rate based on crop or pasture requirements.
- [ ] where possible, manage the timing of application of liquid effluent to reduce nitrogen fertiliser use.
- [ ] consider nitrification inhibitors when applying manure to reduce Nitrous Oxide (N_2O) emissions (seek expert advice first).
- [ ] balance animal diets - adjust protein:energy ratios to reduce urinary N hotspots, cutting direct Nitrous Oxide (N_2O) from paddocks.

Further information

https://agriculture.vic.gov.au/livestock-and-animals/dairy/managing-effluent

Trees:

For farm health

Trees on farms have benefits of improving productivity and land health, as well as capturing and storing carbon.

Trees store carbon in their branches, stems, leaves, bark and roots. As trees grow, they remove carbon dioxide from the atmosphere through photosynthesis and convert this into carbon to make wood. When wood rots or is destroyed (e.g. by fire) the carbon is returned to the air.

When carefully integrated into farms, trees can improve soil, water and biodiversity conservation, provide shade and shelter to livestock, rehabilitate unproductive land and improve the look and feel of a property. Carbon stored in trees on farm can also be offset against a farm business's greenhouse gas emissions. Farm productivity will increase as a result, with improved farms often having a percentage of land planted to trees which can complement agricultural production.

Good planning for strategic planting of trees ensures they become an asset not a liability. Well managed trees may provide extra income if well managed for timber and harvested following appropriate approval processes.

Management options

Many farmers have revegetated degraded or unproductive sections of their farms or waterways. Farmers have shown that they can revegetate from 5 percent to 20 percent of their farm without loss of food or fibre production.

Consider opportunity for new tree plantings on your farm:

- [ ] identify on your farm plan areas that might be suited for shelterbelts, woodlots or wildlife areas, or for managing problem areas (unproductive or erosion prone areas) - most farms have some parcels of land that are less productive and make sensible locations for plantings.
- [ ] ensure tree species match the site conditions (e.g. soils and climate) and the farm objectives.
- [ ] establish new tree plantations and ensure species selection and site preparation are geared towards optimal survival and growth – find out from a local expert suitable tree species, establishment techniques for your site, suitable nurseries and revegetation contractors.
- [ ] consider growing some woodlots with tree species that can be used on-farm (e.g. for fodder, fence posts, poles or firewood), ensuring not to use species classified as weeds.

Maintain and protect existing areas of vegetation on farm:

- [ ] encourage regeneration of native trees and shrubs, (e.g. by fencing out established native vegetation), according to a well-designed farm plan.
- [ ] protect and manage existing native trees and shrubs from loss or damage by fire, land clearing or animals.
- [ ] consider if there are programs or incentive schemes that support the protection of biodiversity and native plants or farm forestry.

Consider the carbon sequestration potential of new or existing tree plantings:

- [ ] use an appropriate carbon calculator to estimate how much carbon is being stored in your farm woodlot (go to www.agriculture.vic.gov.au/carbon-emissions for links to appropriate tools).

You could also consider participating in carbon credit or incentive schemes, noting that:

- the rate of carbon sequestration of farm trees is directly related to the type of trees, their age and location. Note the annual rate of carbon sequestration by trees typically peaks in the first few decades and then reduces over time.
- carbon credit schemes are subject to ongoing conditions and contracts, which should be thoroughly investigated before proceeding.
- or maybe you might just want to measure and record your farm carbon to balance against your own farm emissions for use in trade, market or low emissions food-fibre verification schemes (such as carbon neutral wine, milk or meat).

Further information

https://agriculture.vic.gov.au/climate-and-weather/understanding-carbon-and-emissions/trees-for-farm-health

https://agriculture.vic.gov.au/climate-and-weather/understanding-carbon-and-emissions/selling-carbon-from-trees-and-soils

Healthy soils:

To grow food and store carbon

A healthy soil is productive, sustainable and resilient to withstand the impacts of farm management practices and changing climatic conditions. Healthy soils undertake many functions for healthy plant growth, including storing and providing water and nutrients, maintaining biological activity, maintaining good soil structure and the ability to resist erosion.

Soil carbon is strongly linked to soil quality and primary productivity. Soil carbon varies depending on factors such as soil texture (the clay and fine silt fraction), climate - temperature and annual rainfall (amount and distribution over the year), soil moisture and farm management practices.

Soil organic matter makes up a small component of the soil mass, yet it has an important role in the functioning of the physical, chemical, and biological properties of the soil. Soil organic carbon is a measure of the carbon contained within soil organic matter. Soil organic matter provides a source of nutrients through mineralisation, helps to aggregate soil particles (structure) to provide resilience to physical degradation, increases microbial activity, increases water storage and availability to plants, and protects soil from erosion. Ultimately, increasing soil carbon levels can lead to better plant establishment and growth. While increasing soil carbon is highly desirable, it is also easily lost, so maintaining what you have is important. Climate is a strong driver, affecting accumulation and decomposition of soil organic matter in soils.

The following management options aim to improve soil condition by improving soil structure, reducing losses of carbon and nitrogen from the soil and building soil organic matter. Improving soil condition will enhance a plant's ability to access the nutrients it needs, capture and retain soil moisture for longer and reduce losses of carbon and nitrogen to the atmosphere, groundwater and waterways.

Management options

There are ways to increase soil carbon while also increasing productivity, water holding capacity and nutrient cycling. This can reduce input costs and produce wider natural resource management benefits.

Monitor soil nutrient levels:

- test your soil to check the nutrient status and structure of your soil and develop a plan to reduce constraints to nutrient and water access, e.g. physical (structure, compaction, drainage), chemical (pH, salinity, toxicities/deficiencies), biological (micro-organisms). Identify erosion risks and compaction areas that require careful management.
- monitor soil organic matter/soil organic carbon content over time via appropriate testing for the desired purpose. For example, standard measures of soil organic carbon usually included in nutrient soil testing by most laboratories can provide the percentage content of carbon in a soil sample. However, measurement of soil carbon stocks and carbon sequestration over time requires a different testing method, accounting for bulk density, consistent sampling depths (typically 0–30 cm), and specifically designed sample collection protocols.

Consider application of fertilisers and amendments:

- complete a nutrient balance/budget to match fertiliser and amendment applications to crop/pasture demand, and to nutrient losses in product exports (e.g. grain, hay and livestock sold from the farm).
- addition of organic amendments (e.g. manure, crop residues) where practical and economically viable. Know the quality and nutrient content of any products, have them tested and ensure any claimed benefits are supported by sound evidence and research. Ensure there are no unwanted contaminants – always know what you are adding to your soil.
- consider application of lime to improve pH on acidic soils.
- manage application of gypsum on sodic soils to maintain/improve soil structure.
- manage livestock manure (dung and urine) to minimise nitrous oxide emissions – see ‘Effluent and Manure Management’ section for further details.

Manage the soil resource:

- manage groundcover and protect soil structure to maximise water infiltration and retention for plant uptake and aeration.
- use direct drill, minimum/conservation tillage and controlled traffic techniques in cropping operations to avoid compacting soils and losing carbon and nutrients through soil cultivation and erosion.
- avoid burning crop residues and retain where possible.
- cultivate soils at an appropriate moisture content – not too moist for soils to smear, or too dry that the soil is pulverised.
- avoid bare fallows and have continuous plant cover where possible, e.g. green/brown manure crops between seasons and crops can maintain groundcover, provide active root material and organic matter as well as utilise available nitrogen and avoid losses by leaching.
- manage irrigation and soil drainage to avoid waterlogging. Use irrigation scheduling and soil moisture monitoring.
- rotate crops and include perennial pastures and legumes phases in rotations. In general, perennial pastures will improve or stabilise soil carbon more than annuals.
- do not overgraze pastures. Ensure there is sufficient groundcover throughout the year (minimum 70 percent cover). Consider stock containment areas to provide improved pasture and groundcover management options.
- manage livestock movement and paddock rotations to distribute animal deposited dung and urine evenly and reduce compaction.

Keep an eye on potential incentive programs for carbon stored in soil:

- remember that soils have a maximum limit for carbon storage. Always seek legal and financial advice before entering into long term carbon agreements.

Further information

https://agriculture.vic.gov.au/climate-and-weather/understanding-carbon-and-emissions/soils-and-carbon-for-reduced-emissions

https://agriculture.vic.gov.au/climate-and-weather/understanding-carbon-and-emissions/selling-carbon-from-trees-and-soils

Embedded emissions:

Understanding the footprint of purchased inputs

All prior sources of emissions mentioned within this booklet relate to those emissions generated from activities within the physical boundary of your farm. Within formal greenhouse gas accounting frameworks these emissions are known as 'Scope 1' and 'Scope 2' emissions. There is a further category of emissions from within a farm's carbon footprint that also needs to be considered – these are the embedded emissions from any purchased inputs utilised on the farm, or 'Scope 3' emissions.

In agriculture, Scope 3 emissions are indirect greenhouse gas emissions that occur in the value chain but are not owned or controlled by the farm. They come from activities before and after farm operations. Examples include production, supply and transport of fertilisers, chemicals, electricity and fuel, and fodder and/or livestock purchases.

Management options

While Scope 3 emissions, are not in your direct control to reduce, they still need to be considered, as informed purchase choices could reduce your farm's wider warming impact. There may be potential to select products with lower embedded emissions or reduce quantities of purchased inputs (where suitable) that can reduce this source of emissions for your business.

To understand what your Scope 3 emissions are:

- [ ] keep accurate records on the inputs coming into the production system.
- [ ] identify the largest source of Scope 3 emissions. For cropping businesses, this may be fertilisers, chemicals and fuel, whereas for livestock enterprises this could be purchased fodder or livestock (for example).
- [ ] use an on-farm greenhouse gas accounting calculator to estimate the pre-farm emissions. These are available across a range of industries including grains, sheep, beef, dairy, viticulture, vegetables and other horticultural enterprises.

Maximise input use efficiencies to reduce the quantity/volume of purchased inputs required by:

- [ ] using technology solutions for reduced chemical, fertiliser and lime use.
- [ ] maximising home-grown fodder to reduce purchased feed required.
- [ ] replacing electricity and fossil fuel use with farm generated renewable options.
- [ ] recycling organic materials.
- [ ] optimising use of effluent for nutrient use on the farm.

Where practical and feasible, select inputs with lower embedded emissions (i.e. a lower footprint):

- [ ] source lower emissions alternatives for existing inputs (examples may include green or blue urea which have lower embedded footprints than standard urea).
- [ ] consider seeking emissions footprint information from your suppliers (for example when purchasing livestock or feed, when available) to inform your selections*.
- [ ] collect data from any alternative products sourced, so they can be captured within any future emissions estimate to reduce Scope 3 emissions.

** As agricultural suppliers also begin to reduce their emissions, more low emissions products will become available. Maintaining relationships with your suppliers and requesting the emissions intensity (or footprint information) on the products they supply, may be a good first step to understanding and reducing emissions from this source.*

Action Planning:

Pulling it all together

While it is important that agriculture reduces its emissions, there is no expectation that all agricultural enterprises can reach net zero emissions. All sectors of the economy will be expected to reduce emissions and as other areas of the economy such as the energy and transport sectors become increasingly based on low emissions technologies, emissions from the use of energy and transport in farming will also reduce.

The land sector also has an important role to play in removing carbon from the atmosphere. Adoption of lower emissions practices will need be undertaken gradually over time as new innovations become available. Agriculture also has the dual challenge of needing to adapt to the changing climate whilst also reducing emissions, remaining sustainable, resilient, productive and profitable.

We know that good business management is good carbon and emissions management. This takes the form of documenting actions, tracking progress and recognising good practice.

Management options

When planning to reduce emissions or increase carbon sequestration it is an ideal time to revisit business aims and objectives, noting that farm emissions are but one part of a complex farming system.

- take a wholistic view of the business and consider your industry's sustainability frameworks in future planning.
- revisit the whole farm plan to consider productive areas, water infrastructure, conservation and environmental areas and what information and records will be needed for carbon accounting (e.g. area of trees, species and ages).
- look to tackle those emissions sources which also save you money in the short to medium term.
- understand likely future climate scenarios and plan for adaptation and long-term resilience.
- identify and prioritise the key actions for emissions reduction that will make the most difference for your farming system but also consider stepwise actions that can steadily drive down emissions intensity.
- keep a watching brief on the outcomes of research and development in your industry and assess opportunities for further emission reduction as they arise.

Where to next?

Being prepared for what others are doing

Farm businesses that understand their emissions profile and have a plan for reducing net emissions over time will be better equipped to capitalise on new market opportunities and respond to emerging supply chain and consumer demands.

Retailers, food processors, exporters and financial institutions are already looking to reduce emissions along their value chain to meet mandatory sustainability reporting requirements, improve market access, adopt sustainability or net zero credentials, meet new trading requirements or manage the risks of climate change.

Increasingly, the value chain is seeking to quantify emissions and provide evidence of their action towards lowering emissions over time. Monitoring, reporting and verification approaches require data and evidence, with some already requesting this from their suppliers or clients.

So what does that mean for farm businesses? Knowing, understanding and acting to respond to these emerging pressures is a start.

Into the future,

- keep up-to-date with what your supply chains, financiers and insurers are doing to reduce net emissions.
- consider opportunities for how your on-farm actions can improve market access within different supply chains over time.
- investigate the costs, benefits and requirements of programs for carbon credits, carbon in-setting or other incentives to implement on-farm actions to reduce emissions or increase carbon sequestration.
- continue to strive for low emissions per unit of product (emissions intensity), to be competitive over time.

Further information

For more information on carbon and emissions management and each of the key action areas, visit www.agriculture.vic.gov.au/carbon-emissions

New edition.

Authorised and published by the Victorian Government, 1 Treasury Place, Melbourne with support from the Victorian Carbon Farming Outreach Program.

Print managed by Finsbury Green

May 2026

ISBN **978-1-76090-312-1** (Print)
ISBN **978-1-76090-313-8** (pdf/online/MS word)

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CS-2279