MORE MEAT, MILK AND WOOL: LESS METHANE

Latest outcomes of research into lowering methane emissions and raising productivity in Australia's livestock industries

These outcomes are from the National Livestock Methane Program, part of the Australian Government's Filling the Research Gap program.

Australian Government
Department of Agriculture

MEAT & LIVESTOCK AUSTRALIA

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QUICK FACTS

- **Methane, animal productivity and sustainability are very closely linked**
- **There are practices producers can use now that can lift productivity by up to 22% and reduce methane emissions by up to 40%**
- **Research indicates that up to 40% or more of the feed energy lost in methane from livestock can be captured and put to productive purposes.**

Published by Meat & Livestock Australia Limited
ABN 39 081 678 364
July 2015

ISBN 9781740363082

EXECUTIVE SUMMARY

Developing a better understanding of the science of methane emissions in livestock is critical to helping Australian producers increase productivity and improve sustainability.

Researchers have identified a range of treatments – including supplements, forages and genetics – that producers can, or will in the future, apply to their production system to lower methane emissions and either maintain or lift productivity.

For example:

- Using leucaena plantations in northern cattle systems can lift productivity by up to 22% and lower methane emissions by up to 20%
- Feeding wheat to dairy cows can lift milk production by up to 20% and lower methane emissions by up to 40%
- Introducing Australian native shrubs with methane-reducing properties can help lift productivity in sheep during the autumn feed gap and lower methane emissions by 4% across the year
- Feeding red macro-algae has the potential to lift productivity and reduce methane emissions by up to 60% in cattle and sheep.

Scientists have also developed a better understanding of how methane is actually produced in livestock, as well as practical and accurate means to measure it. They have identified opportunities for manipulating rumen function directly, which could substantially improve the capture of energy from feed and reduce the loss of energy in the form of emissions.

Research findings are also being applied and extended in a range of areas, including: Emissions Reduction Fund (ERF) methods, intellectual property, peer-reviewed scientific literature and producer outreach and extension.

In the past five years, science has come a long way towards understanding the complex relationship between methane emissions and productivity in livestock. But there is still work to be done. Research indicates that with the right tools and practices, up to 40% or more of feed energy that is lost in methane can be captured and put to productive purposes.

This summary document provides an overview of the key outcomes from the National Livestock Methane Program (NLMP), the Filling the Research Gap program and relevant outcomes from related programs. It also identifies priority areas for future research, based on the capacity to reduce methane, the potential productivity gains, barriers to implementation and time and cost of research.

The NLMP is managed by Meat & Livestock Australia (MLA) and supported by funding from the Australian Government.

WHY THIS RESEARCH MATTERS

Developing a better understanding of the science of methane emissions in livestock is critical to helping Australian producers increase productivity and improve sustainability. This is because methane, animal productivity and sustainability are very closely linked.

THE PRODUCTIVITY-METHANE CONNECTION

When cattle and sheep digest feed, up to 12% of feed energy is lost in the form of methane gas - a by-product of microorganisms that live in their rumen.

Methane is belched out into the atmosphere and, along with it, feed energy that could otherwise have been used to make muscle, milk or wool.

Scientists have been working to reduce this loss of feed energy by developing treatments and practices that lower methane emissions – and therefore lift productivity.

REDUCING AGRICULTURE'S SHARE OF GHG EMISSIONS

Reducing the amount of methane emitted by livestock is also an important way to help lower Australia's total emissions of greenhouse gases (GHG).

Methane is a potent GHG and, in Australia, about 10% of all national emissions and two thirds of agricultural emissions come from enteric methane produced by cattle and sheep.

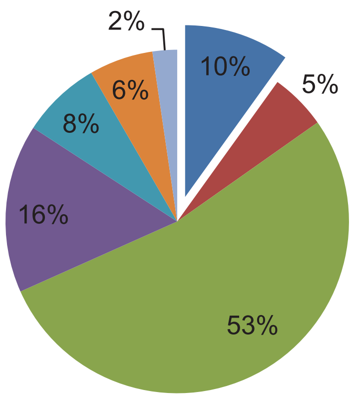
Another key driver for reducing methane is the pressure from consumers and supply chain partners, both domestically and globally, to improve the sustainability of food and fibre industries.

RESEARCH INVESTMENT

In response to these drivers, livestock industries, in partnership with governments, universities, commercial partners and research organisations, have made significant investments in methane research.

These investments have been aimed at growing scientific understanding of the factors controlling methane emissions in livestock, as well as developing practices for producers to reduce emissions and, in doing so, improve productivity on farm.

Findings from this research are also being used to provide the scientific basis for the development of abatement methods under the ERF. These methods will allow eligible producers to claim carbon credits and earn additional income for adopting new practices that reduce emissions.



Major sources of GHG emissions in Australia (CO_2-e)

- Agriculture: enteric methane (55 Mt)
- Agriculture: other (29 Mt)
- Stationary energy (293 Mt)
- Transport (88 Mt)
- Fugitive emissions (41 Mt)
- Industrial processes (33.3 Mt)
- Waste (13 Mt)

Source:
Australian National Greenhouse Accounts: National Inventor Report 2011 (Vol 1). Australian Government.

GHG Emissions in Australia

NLMP collaborating organisations

FILLING THE RESEARCH GAP (FtRG)

This is a Federal Government program aimed at supporting research into emerging abatement technologies, strategies and innovative management practices that reduce greenhouse gas emissions from the land sector or sequester carbon, assisting farmers to adapt to a changing climate and enhancing sustainable agricultural practices.

Filling the Research Gap, which will run from 2012 – 2017, is building on research undertaken through the Climate Change Research Program. Projects target current research gaps in abatement technologies and practices.

The research priorities are reducing methane emissions, reducing nitrous oxide emissions, sequestering carbon, improving modelling capability and adapting to climate change. Research outcomes will underpin the development of new methods that land managers can use to participate in the ERF.

NATIONAL LIVESTOCK METHANE PROGRAM (NLMP)

The NLMP is a $32.8 million research program running from 2012 – 2015. It is funded by the Department of Agriculture, MLA, Dairy Australia and Australian Wool Innovation (AWI), with support from 15 collaborating organisations (see logos on left).

The program aims to provide Australian livestock producers with practical strategies and tools to help increase productivity and profitability and, at the same time, lower methane emissions. It will also provide the scientific basis for abatement methods under the ERF.

The NLMP consists of 17 projects across five research streams: measurement, genetics, supplements, forages and rumen microbiology. The program is managed by MLA.

REDUCING EMISSIONS FROM LIVESTOCK RESEARCH PROGRAM (RERLP)

The Australian Government's RERLP was a three-year national collaborative program coordinated by MLA. It ran from 2009 - 2012 and was focused on methane mitigation from the rumen of sheep and cattle, and methane and nitrous oxide emissions from feedlot manure.

The program aimed to develop knowledge and technologies on methane emissions to enable producers to reduce livestock emissions, while maintaining or improving livestock productivity.

WAYS FOR PRODUCERS TO LIFT PRODUCTIVITY AND LOWER EMISSONS

Researchers have identified a range of practices – including supplements, forages and genetics – that producers can, or will in the future, apply to their production system to lower methane emissions and either maintain or lift productivity. For some practices, the gains are substantial.

Explanation of icons

Methane reduction refers to the potential percentage reduction in the amount of methane emitted as a result of using the practice.

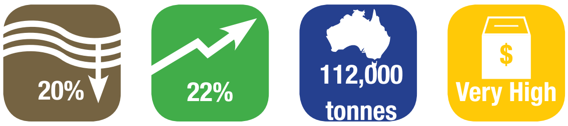
Productivity refers to the potential liveweight gain (or milk yield for dairy cows) possible by using the practice.

National annual emissions savings is an estimate of the total reduction in GHG emission (CO2-e) achievable if the practice were adopted across 10% of the applicable Australian livestock herd.

ERF potential is the estimated potential for the development of an ERF method in the near future based on the current scientific evidence for a particular practice and its expected abatement potential at a national level.

PRACTICES THAT CAN BE IMPLEMENTED NOW

▶ *Leucaena plantations in northern cattle systems*



The use of leucaena, a legume fodder crop that grows in tropical and sub-tropical environments, has been shown to improve productivity and profitability, as well as reduce methane emissions in cattle production systems in northern Australia.

In trials near Rockhampton, Queensland, cattle grazing on both pasture and leucaena had growth rates 22% higher than cattle on pasture only. The cattle on leucaena also produced 20% less methane.

Leucaena can have a strong impact on profitability. Whole farm modelling has shown an increase in gross margins by up to 37% and methane emission down by 17% compared to a base farm without leucaena. This was a result of higher farm production through increased herd size and faster liveweight gain.

A marginal abatement cost curve (MACC) analysis predicted that if the use of leucaena was adopted in 10% of cattle production systems in the northern coastal region of Australia, there would be a reduction of greenhouse gas emissions of 112,000 tonnes annually. This equates to more than 7% of the total emissions from cattle in the region.

The financial rewards for producers using leucaena could be further enhanced if this practice was covered by a method under the ERF. Currently there is strong science and industry support for the development of such a method.

Cattle grazing in leucaena
at Belmont Research Station, near Rockhampton, Queensland

Australian native shrubs

Introducing Australian native shrubs alongside pasture species with methane-reducing properties has been shown to be an effective method for reducing emissions from sheep in south-west Australia, while increasing productivity and profitability.

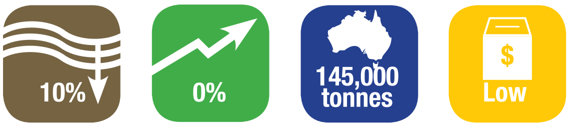
The autumn feed-gap period is a major limitation to sheep productivity in the region as pasture is generally poor quality. Traditionally sheep are offered supplementary grain during this period of the year, which is expensive to supply and labour-intensive to handle.

Studies have shown that strip-grazing sheep on rows of native shrubs with preserved inter-row pasture species for six to eight weeks in autumn, substantially improves growth rates and condition and eliminates the need for supplementary feeding.

Because the species used are known to have methane-reducing properties, this grazing system also leads to up to 26% reductions in methane emissions intensity for the period - or a 4% reduction across the year.

Australian native shrubs that reduce methane on trial at University of Western Australia's Future Farm, West Pingelly, WA

Feeding grape marc



Feeding grape marc – a by-product of winemaking – has been shown to reduce methane emissions in dairy cows, sheep and cattle in feedlots.

Grape marc contains a range of compounds responsible for reducing emissions, including tannins of different compositions and high concentrations of oil.

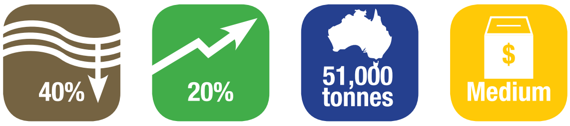
In practice, the impact of feeding grape marc on both methane emissions and productivity is variable because grape marc samples vary in active tannin content and have a low energy content for animals. The following results have been achieved:

- Up to 20% reduction in emissions when fed to dairy cows, but with potential negative impact on milk yield - unless replacing an ingredient with the same energy content
- Up to 10% reduction in emissions and maintenance of animal weight when offered to sheep during the spring-autumn period.

It appears that feeding grape marc could be most effective and profitable when used as a replacement to low quality diets, or during feed shortages for sheep in southern Australia.

Dairy cows at the Department of Economic Development, Jobs, Transport and Resources' Ellinbank Dairy Centre, Ellinbank, Victoria

▶ *Wheat feeding to dairy cows*



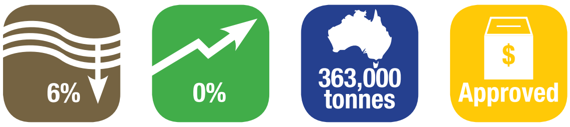
Feeding wheat grain to dairy cows is an effective way to both reduce methane emissions and increase milk production.

Experiments have shown that methane is reduced by 30-50% and milk production is increased by up to 20% when lactating dairy cows are fed nine kilograms of wheat per day in conjunction with freshly cut ryegrass pasture or chopped lucerne hay.

While feeding wheat is not common practice in the dairy industry, particularly for pasture-based systems, it would be a straightforward process on farms where cows are already fed mixed rations. Producers would need to exercise care to ensure they do not feed cows too much wheat, however, as this can increase the risk of ruminal acidosis.

When used safely, this practice would be highly profitable for the dairy industry on the basis of productivity improvements alone. Any emission savings on top of that are an added bonus for producers.

▶ *Nitrate instead of urea in northern cattle systems*



Many cattle producers, particularly in northern Australia, feed non-protein nitrogen to cattle in the form of urea during the dry season to improve pasture consumption and animal productivity.

It has been shown that substituting nitrate for urea can have the added benefit of also reducing methane emissions. For example, feeding nitrate at 10 grams per kilogram of dry matter intake can reduce methane by 10%.

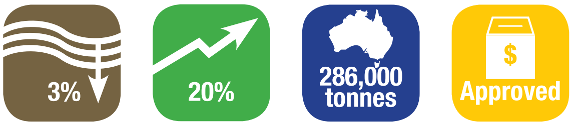
Producers wanting to improve the overall environmental impact of their production system may be interested in applying this technique.

An abatement method for the use of nitrates has been approved under the ERF, so producers may also be eligible to obtain carbon credits.

There is a downside to feeding nitrates, however, because if too much is consumed too quickly, it is potentially toxic to cattle. A set of Best Management Practice (BMP) guidelines is being developed to help producers decide how to feed nitrates to their herd safely.

To find out more about the ERF method for nitrates visit www.cleanenergyregulator.gov.au

Best management practices for reproductive performance and feed utilisation



A great deal of research has been conducted in the past that has allowed development of on-farm practices to improve reproductive performance and efficiency of feed utilisation.

The focus of any management practice aimed at reducing methane emissions is to reduce the amount of feed that is used for maintaining the animal and not being used for productive purposes.

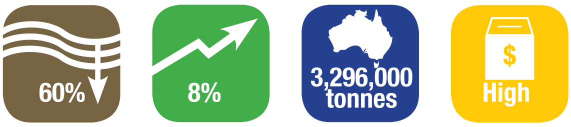
Therefore, improving reproductive performance, reducing the proportion of reproducing animals in a herd or flock and increasing growth rate of animals for sale will reduce the total amount of feed eaten by the herd or flock that is used for animal maintenance.

Although total methane emissions may increase if improving the efficiency of feed use results in a larger animal carrying capacity, methane intensity - or the amount emitted per unit of saleable product - will be reduced.

The key factor limiting the uptake of these best management practices by producers is not a lack of knowledge, but rather a lack of adoption of existing knowledge.

PRACTICES WITH POTENTIAL

Red macro-algae



One of the most effective supplements for reducing methane emissions in livestock is marine red macro-algae.

Experiments in cattle and sheep have shown that feeding dried and ground preparations of the species *Asparagopsis taxiformis* reduced emissions by up to 80%. Total feed intake was not significantly affected and in some cases actually increased.

The red algae appear to change the concentration of short-chain fatty acids in the rumen, particularly propionate, which provides an alternative sink for hydrogen - a key element in methane production.

There is potential for red algae to have a major role in reducing methane emissions across all Australian livestock industries. However, the key barrier to widespread adoption is its relatively high cost and low availability.

Work is underway to develop commercially viable production systems, potentially in conjunction with marine aquaculture operations, which would have the added benefit of reducing pollution. If production costs of red algae can be reduced, this practice would be profitable for many producers.

James Cook University's (JCU) Dr Rocky de Nys (left) with NLMP's Dr John Black inspecting macro-algae at JCU, Townsville, Queensland

Trials of native shrubs that reduce methane emissions in sheep, UWA Future Farm, Pingelly, WA

▶ *Bioactive compounds from plants*

25% | 3.5% | 1,373,000 tonnes | $ Medium

Two bioactive compounds, extracted from native Australian leptospermum and melaleuca plants, have shown to reduce methane emissions in ruminants by up to 97% in laboratory experiments.

It has been estimated that when provided as supplements in commercial conditions, these compounds (referred to as ‘C’ and ‘L’) would reduce methane emissions by approximately 25%.

The cost of the compounds is difficult to estimate. However, it’s probable both can be manufactured, either as a supplement or lick–block, and readily fed to cattle or sheep anywhere in Australia because the amounts needed are very low.

Because of the wide applicability of these compounds, further research to validate their effect in animal trials is warranted.

▶ *Genetics in beef cattle*

6% | 0.8% | 487,000 tonnes | $ Low

Research has shown that low methane emissions are a moderately heritable trait in beef cattle. It appears that lower emitting animals have smaller rumens, with different populations of microorganisms, compared to normal animals.

The gain from genetic selection is cumulative. It’s been estimated there is potential for reduction in emissions of 8% per year after 20 years when selecting for this trait and for improved productivity.

However, the impact of genetic selection for reduced methane nationally depends on the extent to which the genes are passed through the national herds.

A project is currently underway to evaluate the use of BREEDPLAN, the beef sire selection tool used by most southern cattle breed societies, to reduce methane emissions while maintaining or improving productivity.

Using the knowledge from this project, Australian beef cattle producers will potentially be able to select and buy bulls to breed cattle with profitable traits for their production system, while naturally producing less methane.

Unfortunately, it is not so easy for stud breeders to select low methane emitting animals and the availability of desirable sires will be delayed while genomic methods are developed to enable selection for this trait. These constraints are less of an issue for the dairy industry.

Based on current research, there is not a strong case for a genetics/breeding-based solution to reduce methane in beef cattle in the short to medium term. Breeding solutions are permanent, but the overall genetic potential is small (even after 10 years of investment by producers) and potentially diverts selection away from productive traits.

UNDERSTANDING AND MEASURING EMISSIONS

The development of better ways to lower methane emissions requires a deep understanding of how the gas is actually produced in livestock and a practical and accurate means to measure it.

IDENTIFYING NEW METHANE PATHWAYS IN THE RUMEN

Finding new ways to reduce methane and lift productivity relies on having a better understanding of what's actually happening in the rumen of livestock when they eat. In other words, what are the biochemical pathways that underpin feed digestion and methane synthesis?

Research into rumen function has been instrumental in identifying the contributions of these different pathways and identifying methods for manipulating them.

For example, NLMP scientists have recently identified a new species of microorganism that is responsible for a previously unknown biochemical pathway that produces methane in the rumen.

Critically, they also found that the efficiency of this pathway is four times greater than other methane-producing pathways. This means that the potential for reducing methane is significantly greater if this pathway can be manipulated, or even blocked.

One way to do this is through a vaccine against the methane-producing organisms in the rumen. Researchers are at the early stages of this process, having already identified surface proteins that could play a role in the development a potential vaccine.

CSIRO's Dr Chris McSweeney is leading new research into methane pathways in the rumen

GreenFeed Emission Monitoring (GEM) unit on trial, UNE Armidale

Lasers measure methane emissions at Belmont Research Station, near Rockhampton, Queensland

INCREASING ENERGY CAPTURE AND PRODUCTIVITY

The methane that is belched into the atmosphere by an animal represents a loss of energy that could otherwise have been used to convert feed into muscle, milk or wool.

Studies suggest that animals could use 35-40% of the energy captured as a result of inhibiting methane emissions for productive purposes.

Research into the mechanisms of rumen function has led scientists to believe that the amount of energy captured from digestion of feed in the rumen could be greatly increased by manipulating the known methane producing pathways.

They have recently identified a number of opportunities for manipulating rumen function directly to substantially improve the capture of energy from feed and to reduce the loss of energy in the form of methane emissions.

For example, enhancing the activity of microbes - called acetogens - which take up hydrogen for conversion to the energy source acetic acid instead of creating methane.

BETTER MEASUREMENT

Being able to measure methane emissions accurately is a critical part of knowing which reduction practices work best. Researchers have developed a number of new techniques and methods to improve measurement, particularly of emissions from individual animals in the field.

Among these is a revolutionary new membrane that makes it possible to use wireless sensors in the rumen that can detect the concentration of various gases, including methane and carbon dioxide.

The sensors have the advantage of being able to measure methane emissions from cattle under any production system. When fully developed, these will provide a cost-effective alternative to current measurement methods, which generally only assess a few animals at a time and can be time consuming and expensive.

Researchers have also tested a new paddock-based system developed in the United States for measuring emissions from cattle, the GreenFeed Emission Monitoring (GEM) unit. They have confirmed the accuracy of the unit as well as ensuring it is suitable for Australian conditions, including long-term use in remote grazing environments.

They have also designed and developed a GEM unit specifically designed for measuring emissions from sheep. This is an important breakthrough, as there are few tools available to accurately measure emissions from these animals.

Australian scientists have also played a leading role in the development of international guidelines for the more accurate and effective use of the chemical tracer, sulphur hexafluoride (SF6), which is a popular method globally for measuring methane emissions in ruminants.

APPLYING AND EXTENDING KNOWLEDGE

Findings from research into reducing methane emissions in livestock are being applied and extended in a range of areas, including: ERF methods, intellectual property, peer-reviewed scientific literature and producer outreach and extension.

SCIENCE TO UNDERPIN ERF METHODS

Findings from research into reducing methane emissions in livestock industries are being used to support government policy to cut national GHG emissions.

Specifically, this research is providing the scientific underpinnings for abatement methods under the ERF. These methods allow producers to earn additional income by applying practices that lower methane emissions.

The Feeding Nitrates to Beef Cattle method was approved by the Government's Clean Energy Regulator in March 2014. This method allows producers to claim carbon credits by fully or partially replacing urea supplements with nitrate supplements in pasture-fed beef cattle.

The Beef Cattle Herd Management method allows producers to claim carbon credits through a range of actions that improve the diet, breeding efficiency or structure of cattle herds. This method is currently before the Clean Energy Regulator and is expected to be approved by mid-2015.

Research findings are also being used to explore new abatement methods. Outlined below are some of the potential methods currently under investigation.

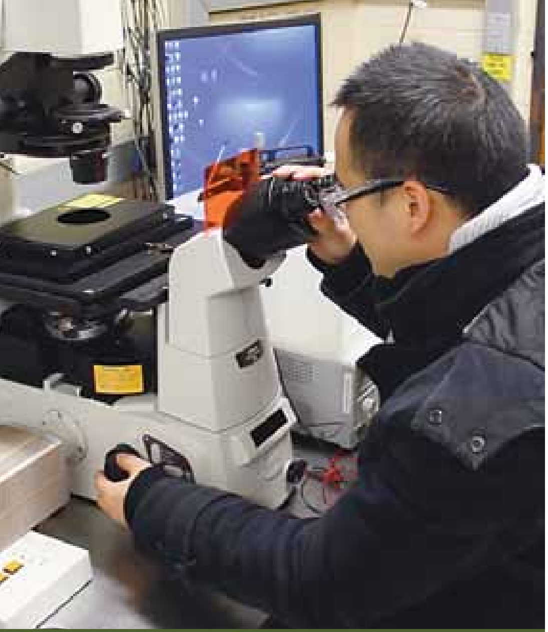
Leucaena feeding

This potential method involves cattle grazing on a combination of pasture and leucaena shrubs. It complements the Beef Cattle Herd Management method that captures emissions reductions achieved through the faster weight gain and earlier turnoff achieved by providing supplementary feed, but targets the daily reduction in methane emissions caused by the leucaena itself.

CSIRO's Dr Nigel Tomkins inspects leucaena

Sheep management

This potential method is similar to Beef Cattle Herd Management, but applies to sheep flocks. It involves practices that aim to more efficiently convert feed energy consumed by sheep into saleable product, with a commensurate reduction in the emissions intensity of the production system. Practices include improved reproduction performance, improving the feed base, better feed efficiency and changing flock structure.



RMIT University's Dr Jian Ou examines a membrane under a total internal reflection flourescence microscope

Algae-based feed supplements

This potential method involves feeding cattle specified algae-based functional foods to reduce methane emissions. While feedlots may be the most readily applicable context for the use of these feed supplements, pasture-based systems may also be considered for a future method.

Genetics

This potential method involves the selective breeding of beef cattle for low methane emissions. A reduction in methane may be based on a number of efficiency traits for which Estimated Breeding Values (EBVs) have already been developed, including Residual Methane, Net Feed Intake, weight and fertility.

INTELLECTUAL PROPERTY

Methane research has led to a number of breakthough technologies that are the subject of existing patents and patent applications. These include:

- An extension of the existing patent for the intra-ruminal gas measuring tool – technology that allows for the measurement of methane gas in individual animals via a wireless sensor placed in the rumen
- A provisional patent application for the use of red marine macro-algae to manipulate microorganisms in the rumen of livestock for the purposes of reducing methane emissions and lifting productivity
- A provisional patent application for gas sensor membranes, which are made of nanocomposite materials and potentially applicable to a range of uses in both animals and humans.

In addition to these applications, other research findings have the potential to develop new intellectual property bases. These include:

- Specific plant compounds that have been shown to have anti-methanogenic properties (i.e. reduce methane emissions) in livestock
- Analyses of proteins specific to methanogens (microorganisms in the rumen that produce methane) that could be used for novel mitigation strategies.

EXTENSION AND OUTREACH

A number of extension and outreach programs around Australia are leveraging the findings from methane research. These are instrumental in getting practical tools and practices into the hands of livestock producers so they can implement change.

For example:

The Farm300 program run by MLA has provided training to more than 128 cattle and sheep advisers, building knowledge and skills that can boost on-farm production and profitability by reducing greenhouse gas emissions from livestock. Twenty three of the advisers who went through the training program were selected as farm coaches and worked directly with 330 producers between October 2014 and April 2015. Farm300 is funded by the Australian Government and managed by MLA in partnership with the Australian Farm Institute, AWI and Dairy Australia.

More Lambs More Often, a program developed by Rural Industries Skill Training (RIST), will develop information and tools for consultants and agribusiness staff that service the sheep industry and producers relating to management options to reduce methane emissions in a changing climate. The program helps producers understand: how carbon pricing is likely to affect their business, GHG emissions from sheep production and relationships between emissions and production. It aims to work with more than 2500 sheep producers to assist them to manage GHG emissions in a changing climate and to participate in the ERF.

The dairy industry's natural resource management program, Dairying for Tomorrow, incorporates information and practices about lowering emissions and lifting productivity across its range of extension and outreach activities. These include: field days, focus farm meetings, workshops, presentations, focus farms and innovation hubs. To date the program has reached more than 2500 dairy farmers and service providers.

Farm300 producers at a spring field day

Find out more about extension and outreach programs to raise productivity and lower GHG emissions in livestock industries:

- Farm300 www.mla.com.au
- More lambs more often / Project 2020 www.rist.edu.au
- Dairying for tomorrow www.dairyingfortomorrow.com
- More beef from pastures www.mla.com.au/mbfp/home
- Profitable dairying in a carbon constrained future http://frds.dairyaustralia.com.au
- Whole farm systems analysis of greenhouse gas abatement options for the southern Australian grazing industries (WFSAM) www.piccc.org.au/WFSAM
- Reducing land sector emissions & effecting carbon farming in Tasmania www.rmcg.com.au
- Climate change and carbon economy extension and outreach in SA arid lands www.saalnrm.sa.gov.au
- Carbon Farming and your business www.holbrooklandcare.org.au/carbon
- CFI Knowledge Platform www.myCFI.com.au
- My Carbon Farming Extension & Outreach projects www.mycarbonfarming.com.au/extension-and-outreach

PROMISING FUTURE RESEARCH DIRECTIONS

In the past five years, science has come a long way towards understanding the complex relationship between methane emissions and productivity in livestock. But there is still work to be done.

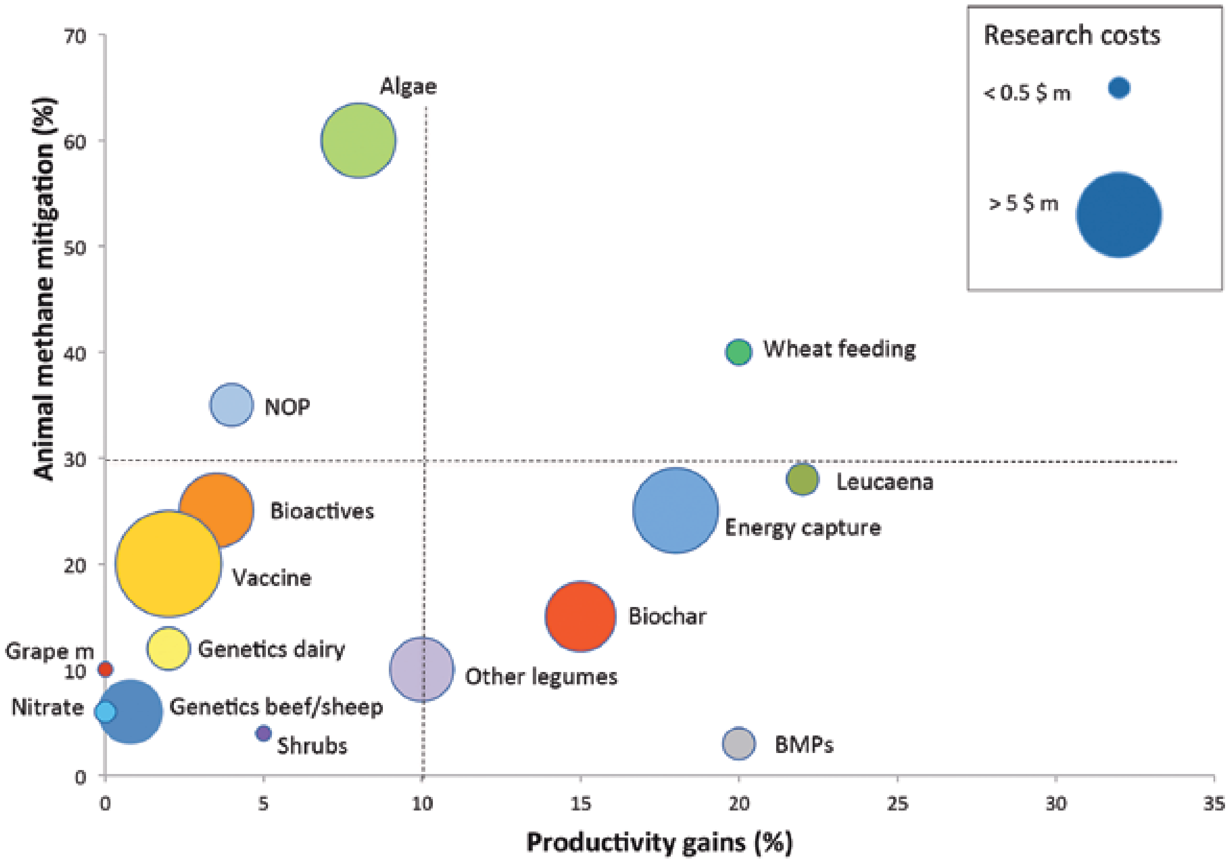
Research indicates that, with the right tools and practices, up to 40% or more of feed energy that is lost in methane can be captured and put to productive purposes. Not only would this represent a major productivity gain, it would significantly reduce GHG emissions from the livestock sector each year.

But achieving an outcome of this scale requires continued investment in targeted areas of research.

The following are considered priorities based on capacity to reduce methane, potential productivity gain, barriers to implementation and time and cost of research:

- Red marine macro-algae, particularly evaluation in different classes of ruminants, and commercial growing, harvesting and drying processes
- Manipulation of rumen function and biochemical pathways to allow markedly enhanced capture of energy from digestion and reduced methane emissions
- Leucaena, particularly the development of a dose response curve, to support the development of an ERF method
- Plant bioactive compounds in sheep for reducing methane emissions and quantify effects on productivity
- New supplements not studied within the current program, such as biochar and 3-nitrooxypropanol (NOP), and the impact on rumen function, methane emissions and animal productivity in Australia
- Legumes, specifically lucerne and red clover, with superior agronomic characteristics for methane mitigation properties
- Plant breeding programs for biserrula to improve productivity and palatability and reduce photosensitivity in animals - and chicory for improving persistence and ability to fill identified feed gaps
- Wheat as a supplementary feed for dairy cows, particularly a dose response curve or other information needed for development of an ERF methodology
- Vaccine development, specifically the routes for vaccination against Archaea (a key rumen microorganism responsible for methane production).

SUMMARY OF EFFECTIVENESS OF METHANE REDUCTION PRACTICES



This graphic summarises the effectiveness of the different practices for raising productivity and lowering methane, as well as an indicative cost for continued research into each. The horizontal and vertical dashed lines represent the original targets for NLMP research.

FOR MORE INFORMATION

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