Reducing GHGs on farms

A summary of options for reducing greenhouse gas emissions on New Zealand livestock farms

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CONTENTS

CURRENT OPTIONS

Farm Management
- *Once-a-day Milking*
- *Reducing Stocking Rates*
- *Removing on-farm cropping*
- *Managing Fertiliser Inputs*

Renewable Generation
- *Biogas*
- *Solar Power*
- *Energy Efficiency*

Alternative transport and Machinery
- *Electric Farm Bikes*
- *Electric Tractors*
- *Biofuel*

Effluent Management
- *Managing Fertiliser Inputs*
- *Land Application of Effluent*
- *Effluent Capture*
- *Off-Paddock Facilities*

Nitrification and Urease Inhibitors
- *Nitrification Inhibitors*
- *Urease Inhibitors*

Forest Sequestration
- *Commercial Forests*
- *Permanent Exotic Forests*
- *Permanent Native Forests*
- *Non-ETS land*

Energy Efficiency

POTENTIAL OPTIONS UNDERGOING RESEARCH

Low Methane Feeds
- *Forage Rape*
- *Fodder Beet*
- *Other Feeds*

New Inhibitors
- *Nitrification Inhibitors*
- *Methane Inhibitors*
- *Methane Vaccine*

Breeding for Low Emissions

Soil Sequestration
- *Soil Management*
- *Peat Soils*
- *Biochar*
- *Biofilters*

Low Nitrogen Feeds and Crops
- *Supplementary Feeds*
- *Plantains*
- *Fodder Beet*

Executive Summary

Purpose
The purpose of this report is to provide a high-level summary of the current options that are available to New Zealand livestock farmers to reduce their greenhouse gas emissions. Greenhouse gases include biological emissions (e.g. methane and nitrous oxide) and energy-related emissions (carbon dioxide). The report contains hyperlinks and references which provide more detail on these options.

Key findings
New Zealand's agricultural greenhouse gas emissions profile is dominated by biological greenhouse gas emissions, particularly methane and nitrous oxide. Approximately 90% of these emissions are attributed to livestock farming, particularly dairy farming and to a lesser extent, sheep and beef farming.

Current options for reducing biological emissions centre around farm management changes; toward high efficiency and high value production with lower inputs. Lower stocking rates, improved breeding and animal health, effluent management and low nitrogen inputs are key strategies but must be considered at the whole farm system level and often require increased farmer skill. There is no single 'best' reduction method: different farm locations, soils, farmers and farm systems will require different solutions.

Modelling of farm systems across New Zealand suggest that widespread adoption of current best practice low-emissions farming could result in absolute reductions in agricultural sector biological emissions of up to 10%. Research is active into new options such as methane and nitrification inhibitors, feed and crop systems, soil carbon and methane vaccines.

Energy-related emissions are a relatively small contributor to overall emissions but may be "low-hanging fruit". Electric vehicles are already cost-effective and methods for improving farm energy efficiency have been available for many years. Farmers can also invest in renewable energy generation, such as solar or biogas from effluent (for larger farms).

Forest planting remains a key strategy for offsetting GHG emissions, and there is a range of funding options for various plantation categories including from government and under the Emissions Trading Scheme.

The facing page summarises the main ways that are currently available to farmers to reduce greenhouse gas emissions (top of page) which are covered in Section 2 of this report, and potential future options that are still being researched (bottom of page) which are covered in Section 3.

1. Introduction

1.1 New Zealand's agricultural greenhouse gas emissions

The agricultural sector contributes nearly 50% of NZ's gross greenhouse gas emissions.[1] This includes emissions originating from animals and land use and is dominated by emissions from two biological greenhouse gases, methane (CH_4) and nitrous oxide (N_2O), which together contribute more than 95% of agricultural sector emissions. [2]

Methane
In 2016, methane emissions from enteric fermentation (digestive processes of sheep and cows) contributed 35.3% to New Zealand's gross emissions. Methane from manure management has been reported as an additional 1.5%[3] but could be as high as 7%.[4]

Nitrous oxide
Nitrous oxide emissions from agricultural soils contribute 10.9% of New Zealand's gross emissions. Nitrogen is contained within the urine and dung that livestock deposit on soils as well as some of the fertilisers that farmers apply to pasture. Microbes in the soil interact with excess nitrogen not used to fertilise pastures to release N_2O into the atmosphere.[5] Urine and dung are the biggest source of New Zealand's N_2O emissions, and account for over 75% of N_2O emissions from land use. Emissions from soils occur more readily when soils are in an anaerobic state, due to being wet or waterlogged, or with soil compression (pugging). Conditions for high nitrous oxide emissions are very similar to the conditions conducive to surface runoff and nitrate pollution in waterways, such that these impacts can be managed in tandem.

The remaining emissions within the agricultural sector are attributed to liming (0.7%), urea application (0.7%) and field burning of agricultural residues (<0.1%).[6]

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[1] Ministry for the Environment, GHG Inventory: http://www.mfe.govt.nz/sites/default/files/media/Climate%20Change/National%20GHG%20Inventory%20Report%201990-2016-final.pdf

[2] All emissions are considered within the GWP100 framework, as reported in international climate accounting and publications by the Ministry for the Environment. 2018 publications present data up to 2016.

[3] Ministry for the Environment, 2018: New Zealand's interactive emissions tracker. Retrieved from https://emissionstracker.mfe.govt.nz/

[4] Laubach et. al, 2014: Review of gaseous emissions of methane, nitrous oxide and ammonia, and nitrate leaching to water, from farm dairy effluent storage and application to land, MPI technical paper 2018/39. https://www.mpi.govt.nz/dmsdocument/30131/send

[5] Wright, Jan., 2016 (Parliamentary Commissioner for the Environment). "climate change and agriculture: understanding biological GHG emissions". Retrieved from: https://www.pce.parliament.nz/media/1678/climate-change-and-agriculture-web.pdf

[6] Ministry for the Environment, 2018: New Zealand's interactive emissions tracker. Retrieved from https://emissionstracker.mfe.govt.nz/

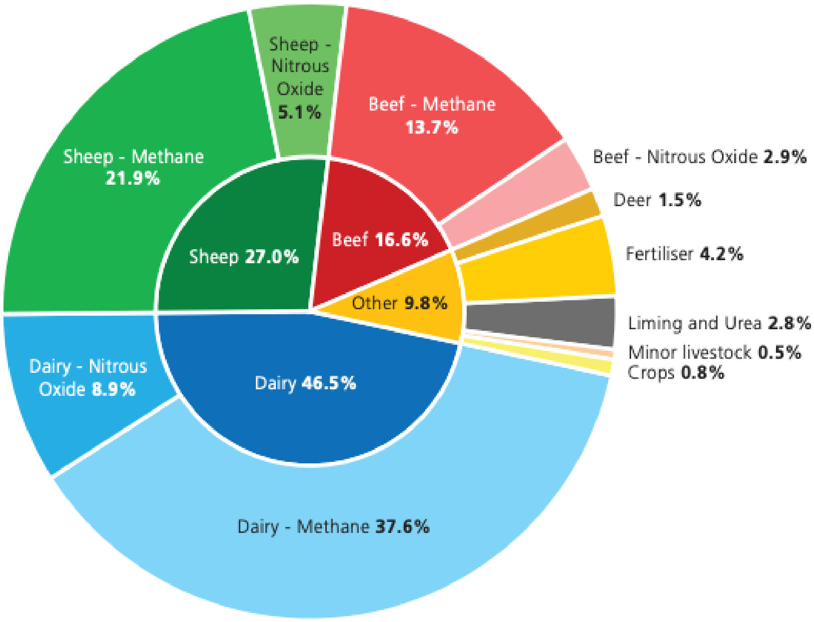

Figure 1. Farm sector contributions to biological emissions (2016). Source: Reisinger et. al 2018, Report to the Biological Emissions Reference Group (BERG).

Carbon Dioxide

The figures above do not include energy-related emissions. An estimated additional 2% of gross NZ emissions can be attributed to on-farm energy use, but these vary significantly between farm types.[7]

On-farm carbon dioxide emissions arise predominantly from energy use (electricity, diesel and petrol). Highly mechanised operations such as dairy farms and irrigated farms are relatively high electricity users, and this creates some GHG emissions because electricity generation in the national supply involves approximately 15-20% fossil fuels such as coal and gas. Farm machinery such as tractors, farm bikes and stand-alone generators use petrol and diesel, resulting in carbon emissions.

Biological carbon dioxide emissions, such as from carbon stored in soils, are not well understood.

1.2 Emissions intensity

Within the sheep, beef and dairying sectors, increasing the productivity of animals has frequently been considered to be the main tool farmers possess for reducing their on-farm emissions[8]. By doing so, New Zealand farmers are able to lower emissions intensity of

[7] Fitzgerald et al., 2017. Future-proofing New Zealand's Agricultural Food System: Energy https://www.otago.ac.nz/centre-sustainability/otago623147.pdf
[8] DairyNZ 2018. Mitigation options. Retrieved from: https://www.dairynz.co.nz/environment/climate-change/mitigation-options/
Beef and Lamb New Zealand, 2018. Environment Strategy: https://beeflambnz.com/environment-strategy

agricultural products, thus increasing the value of the emissions generated through agricultural activities.

Improvements in emissions intensity since 1990 have already limited gross emissions increases from dairying to 15%, rather than the 48% increase that would have otherwise occurred.[9] However, productivity increases have also driven the expansion of the agricultural sector – in particular the dairying sector - and increasing productivity will only reduce total emissions if production is appropriately constrained.[10] While NZ farm emission intensities are good by world standards, total emissions from farms will need to be reduced to contribute to NZ's commitments as a nation to reduce its greenhouse gas emissions.

1.3 Research

New Zealand is active in research on agricultural mitigation. Currently, the Government invests roughly $20 million each year into researching mitigation technologies, most of which helps fund three research centres:

- The Pastoral Greenhouse Gas Research Consortium, (PGgRC), established 2003. Works in partnership with the NZAGRC focussing on the mitigation of CH_4 and N_2o emissions.
- The New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) established 2009. Researches ways to reduce CH_4 and N_2o emissions and increase the carbon stored in soils.
- The Global Research Alliance on Agricultural Greenhouse Gases (GRA), established 2009.

Research and innovation in energy generation and energy technologies is also relevant to reducing farm-based carbon emissions.

This report draws from research by these and other research institutions, as well as technical papers from government and sector agencies.

1.4 Advice for farmers

Online advice, videos and workshops for farmers are increasingly available.

The NZ Institute of Primary Industry Management runs greenhouse gas seminars: https://www.nzipim.co.nz/. The AgMatters website has videos and other material on greenhouse gas mitigation: https://www.agmatters.nz/

Productivity Commission, 2018. Low Emissions Economy. Retrieved from: https://www.productivity.govt.nz/assets/Documents/lowemissions/4e01d69a83/Productivity-Commission_Low-emissions-economy_Final-Report_FINAL_2.pdf
Pastoral Greenhouse Gas Research Consortium, 2016. "What we are doing". Retrieved from: https://www.pggrc.co.nz/files/1499904137329.pdf

[9] DairyNZ 2018. Mitigation options. Retrieved from: https://www.dairynz.co.nz/environment/climate-change/mitigation-options/

[10] Kerr, Suzi, 2016: "Agricultural Emissions in New Zealand: Answers to questions from the Parliamentary Commissioner for the Environment" retrieved from: https://www.pce.parliament.nz/media/1679/agricultural-emissions-mitigation-in-new-zealand_final.pdf

2. Current Options

There are many options currently available to reduce greenhouse gas emissions on farms. These include changing farm management practices (2.1), effluent management (2.2), inhibitors (2.3), forestry (2.4), energy use and generation (2.5), and transport and machinery (2.6). The impacts and challenges of each option are summarised below.

2.1 Farm management changes

Changes in farm management can significantly reduce biological emissions. The options summarised in this section are drawn from a report produced for the Biological Emissions Reference Group (BERG) in 2017.[11]

2.1.1 Reducing stocking rates

Reducing the number of livestock per hectare reduces GHG emissions, as long as their dry matter intake is not increased.

Impact

Reducing stocking rates by 5-15% (and thus proportionally increasing per animal productivity) achieves 3-9% emissions reductions. This also increases profitability compared to the base farm system (up to 15-16% if stocking rate is reduced by 15%).[11]

Challenges

This approach requires enhanced farmer skill and may expose farmers to more risk of reduced pasture quality if not well managed.

2.1.2 Once-a-day milking

Impact

Switching from milking dairy cows twice a day to once a day can result in potential emissions reductions of 6-7% while maintaining profitability. To achieve this benefit, dry matter consumption needs to also reduce.

Challenges

Experience with this approach is not widespread in New Zealand, and the profitability depends on factors such as milk solids prices, and labour cost reductions. The effects on production and emission reduction is also likely to change over time as herds adjust to once-a-day milking, so further investigation is required.

[11] Reisinger et al. (2017). On-farm options to reduce agricultural GHG emissions in New Zealand. https://www.mpi.govt.nz/dmsdocument/32158/send

2.1.3 Less cropping

Returning cropped areas to pasture will result in emissions reductions due to lower overall productivity, as long as supplementary feeds purchased off farm remain at the same level.

Impact
The potential emissions reductions range from up to 8% in some regions to 1.5% in others.

Challenges
Overall profitability varies by region.

2.1.4 Managing fertiliser inputs

Reducing nitrogen fertiliser inputs will reduce nitrous oxide emissions. This approach will require farmers to undertake more careful nutrient management, and possibly use precision agricultural technology.

Impact
Research[12] shows that the removal of nitrogen fertilisers altogether from dairy operations would reduce biological greenhouse gas emissions by between 6 and 14% in different regions. This is predominantly the result of reduced productivity, but due to reduced input costs may still be a profitable approach. Impacts on profitability will vary depending on the region and farm type. While removing nitrogen fertilisers altogether from farms may not be a practicable option for farms for other reasons, this indicates that there is potential for some farms to reduce excessive N fertiliser use.

Challenges
Removing or reducing N fertiliser also increases the farm management skills necessary to maintain the productivity, since it reduces flexibility for farmers to cope with climate variability.[13]

2.2 Capture and management of effluent

Of the major livestock categories in New Zealand, only dairy cattle have excreta stored in anaerobic lagoon waste systems, collected during milking. Stored excreta represent between 5-20% of total effluent, depending on the farming system and whether off-paddock facilities are used[14].

A requirement for farm dairy effluent (FDE) ponds is driven by most councils under the RMA, and specific aspects of design and construction are regulated by regional and District

[12] Reisinger et al. (2017). On-farm options to reduce agricultural GHG emissions in New Zealand. https://www.mpi.govt.nz/dmsdocument/32158/send

[13] DairyNZ best practice for nutrient management and fertiliser application: https://www.dairynz.co.nz/environment/nutrient-management/

[14] Laubach et al, 2015. Review of greenhouse gas emissions from the storage and land application of farm dairy effluent https://www.tandfonline.com/doi/full/10.1080/00288233.2015.1011284

councils[15]. The primary source of farm dairy effluent is milking sheds, where FDE is more dilute than stored manure in other countries, and therefore relevant research for New Zealand is limited. Manure from other sources is increasingly being collected. As of 2010/11, 27% of farms had feed pads, 22% had stand-off pads and 2% had winter shelter or housing. Manure from these facilities can be added to FDE ponds, or anaerobically digested in solid form.[16]

Options for reducing greenhouse gas emissions from dairy effluent storage have been understood for many years[17]. Biogas is the most attractive of these, as the effluent is used to generate electricity and heat (or possibly fuel), creating energy cost savings for the farm. This will be discussed later on in section on Renewable generation.

2.2.1 Capturing methane from effluent ponds

Effluent pond can be covered, and the methane can be captured, and used for biogas or flared without energy recovery. This involves covering the anaerobic pond in a conventional pond treatment system and collecting the biogas being released from the pond surface.[17]

Impact:
This can achieve close to a 100% reduction in methane emissions from the pond and has already been implemented in a small number of farms in New Zealand.

Challenges
Bio-digestion and capture of methane from anaerobic ponds is an established technology but the economics are challenging with small herd sizes.[18]

2.2.2 Land application of effluent[19]

Nitrous oxide emissions can be limited by applying effluent when soils are dry, as is already best practice. Research is ongoing on the impact of timing and application rate of FDE on emissions.

Another indirect way to reduce N_2O emissions from FDE application would be complete or near complete anaerobic digestion of the FDE before application. This can be achieved by using a covered pond or biogas system, which lowers carbon availability for N_2O generation.

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[15] IPENZ 2017, Farm Dairy Effluent Ponds (Practice Note 21) https://www.engineeringnz.org/resources/practice-notes-and-guidelines/
[16] Rollo et al., 2017. Trends in Dairy Effluent Management: https://www.biosecurity.govt.nz/dmsdocument/32854/direct
[17] Shilton A, Guieysse B, Pratt C and Walcroft A 2009. GHG abatement: the new paradigm for wastewater management in the agricultural industry – Economic evaluation of options for a typical New Zealand dairy farm. International Water Association (IWA) Specialist Conference, Palmerston North, New Zealand.
[18] Reisinger et al, 2018. Future options to reduce biological GHG emissions on-farm: critical assumptions and national-scale impact. Report to the Biological Emissions Reference Group. https://www.mpi.govt.nz/dmsdocument/32128/send
[19] Laubach et al, 2015. Review of greenhouse gas emissions from the storage and land application of farm dairy effluent https://www.tandfonline.com/doi/full/10.1080/00288233.2015.1011284

Slurry tankers with subsurface manure injectors are being considered overseas, and have been shown to have low emissions impacts, but the benefits in New Zealand are not clear.

Impact

The impacts on emissions is very small for New Zealand farms, estimated at less than 0.2% of biological emissions.

Challenges

The main benefit of land application is its value as a fertiliser. As a method to reduce GHG emissions only, it is unlikely to be worth the high investment costs of new machinery.

2.2.3 Off-paddock facilities[20]

Additional off-paddock facilities can be added to the farm system, ranging from feed pads to covered barn systems. Common practice (in Southland in particular) is to winter on brassica or other forage crops, where grazing conditions are known to be conducive to N_2O emissions. In general, off-paddock facilities can be used to reduce N_2O emissions by keeping animals off paddocks at times where we know emissions will be high – when there is wet soil, soil compaction and low plant growth (i.e. winter/high rainfall).

Impact

A system where animals are kept off in emissive conditions, waste is collected, and applied to soil in spring, can result in total reductions in N_2O emissions. Stand-off pads have been shown in studies to reduce emissions by up to 8%.[21] This may also result in reduced fertiliser costs as extra effluent provides an alternative to fertiliser inputs.

If designed and used correctly, off-paddock facilities can also be beneficial for animal welfare in areas with wet or boggy soils.

Challenges

The storage of effluent is a source of emissions itself, unless there is a pond cover or enclosed biodigester tank (see section 2.5.3).

It is often considered a sensible economic strategy for a farm to increase intensity after installing an off-paddock facility, due to desire to recoup substantial investment costs. However, this will almost certainly result in a net increase in total emissions on-farm (although emissions intensity may be lowered).[22]

[20] DairyNZ, "Off-Paddock Facilities" webpage. Retrieved on 15/02/19 from: https://www.dairynz.co.nz/business/infrastructure-investment/off-paddock-facilities

[21] De Klein, C., Ledgard, S. F., Clark, H. 2002. "Evaluation of two on-farm measures for reducing greenhouse gas emissions from an average dairy farm on the West Coast of the South Island of New Zealand. Proceedings of the New Zealand Grassland Association 64:159-165. Retrieved from: https://www.grassland.org.nz/publications/nzgrassland_publication_478.pdf\

[22] Economic & Environmental Analysis of Dairy Farms with Barns https://www.agfirst.co.nz/wp-content/uploads/2016/02/Economic_Analysis_of_Wintering_Barns.pdf

2.3 Inhibitors

Inhibitors are fertiliser additives that reduce GHG emissions from pastures.

2.3.1 Nitrification inhibitors

Nitrification inhibitors slow the conversion of ammonium into nitrate (which leaches into waterways) and nitrous oxide.

Impact

Both dicyandiamide (DCD) and a similar product, DMPP are equally effective in reducing nitrous oxide emissions from urine patches in grazed pasture, with emissions reductions of about 60% under a range of conditions.[23]

Challenges

DCD (alongside similar products) was removed from use in dairy farming in 2013 after DCD was added to the Codex Alimentarius, an international list of substances to be tested for by organisations such as the USFDA. DCD is likely to remain unusable in NZ due to the risk to NZ's dairy export reputation.[24]

Nitrification inhibitors have generally not been cost effective when used only for emissions ($100-250 per hectare), particularly as they are only effective in 5 months of the year (winter). However, they also work to reduce nitrate leaching and may be cost-effective when used to meet water quality requirements, with beneficial side-effects of reducing nitrous oxide emissions.[23]

Research is underway to develop new nitrification inhibitors. See section 3.3.

2.3.2 Urease inhibitors

Urease inhibitors interrupt the microbial process that breaks down urea into N_2o. These are currently available, and in 2016, 26.5% of all urea fertilisers contained a urease inhibitor.[25]

Impacts

Any emissions reductions achieved by urease inhibitors are very minor, on an order of 0.2% or less of total biological emissions from agriculture, even with universal uptake.

Challenges

They are only effective in preventing indirect emissions resulting from synthetic nitrogen fertilisers.

[23] New Zealand Agricultural Greenhouse Gas Research Consortium web page. "How much could DCD help reduce emissions?" https://www.nzagrc.org.nz/faq-1,listing,388,how-much-could-dcd-help-reduce-emissions.html
[24] Farmers Weekly, 2013: https://farmersweekly.co.nz/#
[25] Reisinger et. al, 2018. "Future options to reduce biological GHG emissions on-farm". Report to the Biological Emissions Reference Group. Retrieved from: https://www.mpi.govt.nz/dmsdocument/32128/send

2.4 Forestry[26]

Large-scale afforestation is identified by the Productivity Commission as being "critical" for offsetting New Zealand's remaining emissions. They called for up to 2.8 million hectares of land to be converted to forest as a carbon mitigation strategy.[27] However forestry is not a permanent solution as a carbon sink – this effect ends when the trees are harvested or when the forest matures. At best it 'buys time' (20-30 years for a commercial forest) for permanent GHG mitigations to be achieved.

New Zealand farmers can earn carbon credits through the NZ Emissions Trading Scheme for forest land. Forest land is defined as at least 1 hectare of forest species established after 1989 with:

- Tree crown cover of more than 30% in each hectare
- An average width of tree crown cover of at least 30 metres

ETS-eligible forests may be exotic or native, and may be planted for eventual harvest or may be permanent. These have different implications for their value for sequestration (carbon capture and storage).

2.4.1 Commercial forests

Farmers can plant suitable parts of their farms in commercial forestry (usually exotic species such as *pinus radiata*) to be harvested when mature. NZ has an active farm forestry organisation which can help advise suitable species.[28]

Impacts

For the purposes of GHG accounting, commercial forests that are harvested and equivalently replanted are carbon neutral. Sequestration from forest growth is considered to be neutralised at the harvest of a plantation, generally 20 to 30 years in the future.[29]

Challenges

Conversion of dairy farms to commercial forestry is generally not an attractive option (where land prices are high), and conversions are much more likely to happen on marginal land on sheep and beef farms, or land not currently grazed. However many types of marginal land are too steep or inaccessible for logging and transport to ports and processing. Economic viability is highly dependent on price of land, carbon pricing during growth and at harvest, and timber prices. Small foresters may face cashflow issues, and a lack of flexibility given they must wait 20-30 years for harvest.

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[26] Ministry for Primary Industries: https://www.mpi.govt.nz/dmsdocument/6991/loggedIn
The practice of Carbon Farming in New Zealand: https://motu.nz/our-work/environment-and-resources/lurnz/the-practice-of-carbon-farming-in-new-zealand/

[27] Productivity Commission, 2018. Low Emissions Economy. Retrieved from: https://www.productivity.govt.nz/assets/Documents/lowemissions/4e01d69a83/Productivity-Commission_Low-emissions-economy_Final-Report_FINAL_2.pdf

[28] Farm Forestry Association website http://www.nzffa.org.nz/

[29] Forestry in the ETS: https://www.mpi.govt.nz/growing-and-harvesting/forestry/forestry-in-the-emissions-trading-scheme/

2.4.2 Permanent exotic forests

On some marginal land the most profitable option for the landowner (if the price of carbon under the ETS is sufficiently high) may be to plant exotic trees such as *pinus radiata* and simply leave them to grow.

There has been some speculation about whether or not these exotic plantations will revert to native forest if a suitable seed source is nearby. This may require the removal of exotic species seedlings, but there is limited research on this possibility.[30]

Impacts

Permanent forests create a net carbon sink until they reach maturity when they eventually become carbon neutral, which could be 100 years or longer for pines, and even longer for other species. Even during the growth period, permanent forests sequester more carbon over a longer period than forests intended for harvesting due to the different management methods. Permanent afforestation can also have co-benefits such as erosion control and pollution prevention in waterways.

Challenges

The large-scale establishment of exotic forest may meet with opposition due to the effect on landscape values and the risks of the spread of wildings.

2.4.3 Permanent native forests

There are increasing examples of new permanent native forests being established for carbon farming and other benefits. Some companies specialise in permanent forest initiatives.[31]

Impact

In the first 30 years of growth, native forests sequester only one half or a third as much carbon as a *pinus radiata* forest. However, native forests sequester carbon over a much longer period as they mature over hundreds of years. Native planting offers co-benefits by fostering cultural, landscape and biodiversity values, alongside erosion control and waterway pollution prevention, depending on the location of planting.[32]

Challenges

In general, native forests are more costly to plant than exotic, but with natural regeneration they may be more cost-effective. Maintaining native forestry may be more costly than exotics if pest control is required (e.g. possums).

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[30] Productivity Commission, 2018. Low Emissions Economy. Retrieved from: https://www.productivity.govt.nz/assets/Documents/lowemissions/4e01d69a83/Productivity-Commission_Low-emissions-economy_Final-Report_FINAL_2.pdf

[31] Ekos https://ekos.org.nz/for-land-owners;
Permanent Forests NZ http://www.permanentforests.com/Services/About-Us

[32] Carver, T & Kerr, S. 2017. Facilitating Carbon Offsets from Native Forests. Motu Working Paper 17-01. Motu Economic and Public Policy Research. http://motu-www.motu.org.nz/wpapers/17_01.pdf

2.4.4 Non-ETS plantings

Some kinds of tree planting are not eligible to be considered forest land and are therefore not able to earn carbon credits. These forms of planting still offer carbon sequestration benefits, as well as erosion control, animal shelter, and waterway pollution prevention. Examples include

- Narrow shelterbelts
- Riparian planting blocks
- Small woodlots

These areas already sequester a portion of farm emissions on dairy and sheep and beef farms, and there is potential for increased sequestration in some landscapes. More research is needed to assess the amount and longevity of carbon capture by non-ETS tree plantings.[33]

2.5 Energy

The use of fossil fuels (such as petrol, diesel, gas or coal) produces carbon dioxide which is another greenhouse gas. There are a number of ways that farmers can reduce their carbon emissions through more efficient use of energy, changing to renewable fuels, or generating their own energy. Many of these options are already cost-effective, especially energy efficiency.

Replacing fossil fuels with renewable fuels such as biogas or electricity can result in total or near-total reductions in emissions. New Zealand's electricity is around 80 - 85% renewable.

2.5.1 Energy efficiency

Many aspects of farm operations can be made more efficient:

- *Irrigation*
  Irrigation uniformity of application is usually around 70%. Increasing uniformity of application can reduce the energy costs of irrigation, by increasing the irrigated area by up to 50% for the same amount of water. Improving the energy efficiency of irrigation saves costs and emissions. There are a range of precision farming systems farmers may choose to invest in in order to improve efficiency.
- *Heat Recovery Systems*
  Refrigeration of milk vats in the dairy shed generates waste heat, which can be used for water heating, creating savings of up to 30% from the dairy shed electricity bill.
- *Vacuum pump variable speed drive*
  This can reduce energy use from the vacuum pump by up to half, and create other benefits, such as milk quality, noise reductions, less maintenance and peak energy use reductions. Potential saving of 10-15%.

[33] Manaaki Whenua Landcare Research 2018. Carbon Sequestration on non-ETS land. Report for MPI https://www.mpi.govt.nz/dmsdocument/32134/send

- *Milk vat insulation*
  Insulation on the piping and vats can help meet compliance and reduce energy use at peak times and generate savings of 3-6% from the electricity bill.
- *Fuel Efficient Farm Machinery*
  Electric, hybrid, and high efficiency machinery can reduce emissions and energy costs. See previous section on alternative transport and machinery.
- *No-tillage farming*
  As well as having possible positive effects on soil carbon, reducing tillage or opting for no-tillage farming reduces the energy required to run farm machinery for tillage.

The Energy Efficiency and Conservation Authority (EECA) offers advice to farmers on improving energy efficiency.[34]

2.5.2 Solar energy

Two types of solar systems are already widely used in New Zealand. Solar water systems use the heat from the sun to directly heat water. Solar photovoltaic (PV) systems generate electricity from the sun. EECA case studies illustrate the effectiveness of various systems.[35]

Impacts

Dairy farms are the highest electricity users in NZ agriculture, and they may have the greatest potential for solar water heating and solar generation (PV).

PV may reduce energy costs and/or provide security of supply especially if coupled with batteries. Suitability will vary depending on factors such as the sunshine availability, energy use patterns and energy costs on a particular farm, but in many instances solar is already a cost-effective option.[36]

2.5.3 Biogas

Biogas is produced by the anaerobic breakdown of a wide range of materials such as effluent or crop wastes. [37] Systems for extracting and using biogas on farms have been used

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[34] https://www.eecabusiness.govt.nz/sectors/farming/dairy-farming/
https://www.eecabusiness.govt.nz/assets/Resources-Business/dairy-farm-energy-efficiency-guide-march-09.pdf
[35] EECA advice on solar options:
https://www.eeca.govt.nz/energy-use-in-new-zealand/renewable-energy-resources/solar/
EECA case study of solar thermal:
https://www.solarthermalworld.org/sites/gstec/files/New%20Zealand%20Dairy%20Farms.pdf
[36] Examples of solar powered farms and dairy sheds:
Various farms: https://powersmartsolar.co.nz/commercial-solar-case-studies/c/132
Tirohanga farms: https://www.mysolarquotes.co.nz/blog/solar-power-new-zealand/commercial-solar-power-system-installed-on-matakana-island-farm-near-tauranga/
McConnell Robotic Farms: https://powersmartsolar.co.nz/robotic-farm-powered-by-solar
[37] Reisinger et. al, 2018. "Future options to reduce biological GHG emissions on-farm". Report to the Biological Emissions Reference Group. Retrieved from: https://www.mpi.govt.nz/dmsdocument/32128/send

for decades in North America and Europe. Several biogas extraction systems are now in operation on piggeries[38] and dairy farms[39] around New Zealand.

Biodigester tanks designed for dairy farms are widely available.[40] However, farms may not need to install a new tank. Instead, they may opt to invest in pond covers and a biogas generator which can be converted from a diesel generator relatively easily.[41]

This report from the Waikato Institute of Technology provides a useful overview of biodigesters [42]

Biogas can be used directly, such as for gas heating or refrigeration, or it can be converted to electricity with a generator.[43]

Impacts

As well as capturing almost all methane emissions from effluent that is already being stored, biogas systems allow substantial savings on power generation. The digestate that is left after the methane is collected has lower levels of pathogens than raw manure and can be used on paddocks as an effective bio-fertiliser. Covering or containing stored effluent also reduces odour.[44]

Challenges

The key barrier to biogas adoption on farms is profitability. For investment in biogas on dairy farms to be feasible, research suggests a herd size of around 1000 cows is necessary, or slightly less if a large amount of effluent is collected from off-paddock facilities. Since only around 5% of farms in New Zealand are of this size, the applicability of biodigester systems is limited, unless farms are able to work together to install and use digesters collectively as occurs in Europe.[45] With regard to piggeries, a larger farm is also necessary for biogas generation to be feasible.

Examples

- *Glenarlea Farms*
  In Southland, a pilot project funded by EECA, venture Southland, ASB, NIWA and Dairy Green has made national news as a successful biogas project. The 900 cow

[38] https://www.bioenergyfacilities.org/facility/lepperton-piggery
[39] https://www.bioenergy.org.nz/documents/resource/CaseStudy-EECA-biogas-on-your-farm-technical-guide-08-09.pdf
[40] https://www.greentank.co.nz/your-solutions/bio-digesters/
http://www.timbertanks.co.nz/treatment-solutions/biodigesters.aspx
http://www.permastore.com/applications/farmbiogas/
[41] https://www.niwa.co.nz/publications/cesu/issue-20-2007/biogas-power-made-easy
https://www.niwa.co.nz/energy/research-projects/biogas-recovery-from-wastewater
[42] http://researcharchive.wintec.ac.nz/4450/1/Overview%20Biodigesters.pdf
[43] The Bioenergy Association has resources available regarding farm biogas:
https://www.bioenergy.org.nz/documents/resource/CaseStudy-EECA-biogas-on-your-farm-technical-guide-08-09.pdf
[44] EECA, 2009. “Biogas on your farm”. Technical guide. Retrieved from:
https://www.bioenergy.org.nz/documents/resource/CaseStudy-EECA-biogas-on-your-farm-technical-guide-08-09.pdf
[45] https://www.bioenergy.org.nz/documents/resource/Information-Sheets/IS24-Revenue-from-biogas.pdf

dairy farm operates the generator 16 hours per day, producing 30kW, and has been able to save $25,000 per year from their electricity bill. The system cost around $200,000 to install and is a key demonstration for the farming industry that biogas systems can be effective in cooler areas such as Southland.[46]

- *Eyrewell, North Canterbury*
  A prototype digester operated for several years on a Landcorp farm in Eyrewell. Manure from 900 cows was collected on a concrete pad and pumped to a tank digester. Gas was used to power a generator that supplied around a third of the farm's energy requirements.[47]
- *Lepperton Piggery, Taranaki*
  Piggery effluent is fed into a covered anaerobic pond, where coarse solids are removed for composting and sold. Methane from the digester runs a 40kW generator, and heat recovery systems capture the remaining energy for water heating. The Lepper Trust was named winner in the small-to-medium business category in the 2010 EECA awards.[48]

2.6 Low-emissions transport and machinery

2.6.1 Electric vehicles

Electric vehicles have very low greenhouse gas emissions in New Zealand because our electricity is 80-85% renewable. If charged from solar panels (PV) they would have no direct emissions.

Electric road vehicles are already widely available and increasingly cost-competitive, with extremely low running and maintenance costs despite a higher upfront cost. The range of models is still limited but growing.[49]

NZ company UBCO have created the world's first dual electric drive motorbike. It is designed for use on farms, with accessory lugs and the option to power tools using the lithium-ion battery.[50]

Tractors and other farm vehicles are well suited to a transition to electric, due to the high torque of electric motors, and the relatively short periods they are used for. These are currently advertised as working prototypes overseas but are not available yet. They are a promising option for low-carbon farm investment in the near future.[51]

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[46] https://www.stuff.co.nz/business/farming/dairy/97035790/poo-is-powering-a-southland-dairy-farm-shed
https://www.nzherald.co.nz/the-country/news/article.cfm?c_id=16&objectid=11848674
[47] http://www.stuff.co.nz/business/farming/602110/Finding-power-in-effluent
https://www.bioenergy.org.nz/documents/resource/Information-Sheets/IS24-Revenue-from-biogas.pdf
[48] https://www.bioenergyfacilities.org/facility/lepperton-piggery
https://www.build-a-biogas-plant.com/farms-and-biogas/
http://www.stuff.co.nz/taranaki-daily-news/4391277/Farmers-sweet-smell-of-success
[49] https://www.eecabusiness.govt.nz/technologies/electric-vehicles/electric-vehicles-in-new-zealand/
[50] https://www.ubcobikes.com/
[51] John Deere:

2.6.2 Biofuels

Biofuels are sourced from plant material or biological oils or fats (e.g. tallow). The most widely available liquid biofuels are bioethanol and biodiesel. For example, Z Energy has a commercial biodiesel production facility.[52]

Currently, transport biofuels are usually used in a blend with petrol or diesel. Bioethanol-blended petrol is available from a few petrol stations in blends of 10% bioethanol. This blend results in 5–6.5% reductions in greenhouse gas emissions per litre compared with standard petrol. 5% (B5) biodiesel blends are suitable for almost all diesel vehicles, and some vehicles can use up to B20 without modification. Some vehicles are able to be converted to run entirely on biofuels.[53]

Research is ongoing to produce liquid biofuels as a 100% replacement for petrol and diesel that meet NZ fuel standards.

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https://www.agriland.ie/farming-news/electric-john-deere-tractor-runs-for-4-hours-on-a-charge/
Fendt: https://www.futurefarming.com/Machinery/Articles/2018/1/This-is-the-Fendt-e100-Vario-electric-tractor-4419WP/

[52] https://z.co.nz/keeping-business-on-the-move/fuels/z-biodiesel/

[53] Bioenergy Association of New Zealand: https://www.bioenergy.org.nz/documents/resource/IEA39-Opportunities-for-biofuels-NZ.pdf
EECA: https://www.eecabusiness.govt.nz/technologies/renewable-energy/biofuels/

3. Emerging Options

This section outlines options for GHG mitigation that are still being developed or studied. These include low methane feeds (3.1), low nitrogen feeds (3.2), new inhibitors (3.3), breeding for low emissions livestock (3.4), biofilters (3.5) and carbon sequestration in soils (3.6).

3.1 Low methane feeds

Research is under way on feeds that reduce methane emissions from the digestive system. Fodder beet and brassica crops such as forage rape are promising options but more research is needed to quantify the whole-farm impacts, applicability and long-term impacts of these feed options under New Zealand conditions. A key limitation is that it is not feasible for most NZ farm systems to include these feeds at high enough levels in the diet to see significant emissions reductions. Also some feeds that reduce methane may result in higher nitrous oxide emissions. This section draws from work by the Pastoral Greenhouse Gas Research Consortium.[54]

3.1.1 Forage rape

Forage rape is the most extensively tested of the brassica crops, which are commonly used as a winter forage crop in New Zealand farming systems.

Impact

Research with sheep has shown a consistent reduction of methane emissions of 20-30%, when rape is a full diet. Emissions reductions reduce linearly as dietary proportion drops, so that impacts are limited when forage rape is fed as a low proportion of the diet.

More general claims about other brassicas cannot yet be made, and other species may not be as effective as forage rape.

Challenges

Evidence regarding the impacts on cattle is less well understood, and a potential issue is that brassicas such as forage rape may be fed in wet and boggy conditions conducive to increased nitrous oxide emissions.

3.1.2 Fodder beet

Fodder beet is becoming increasingly popular as a feed crop, particularly in the South Island.

Impact

Research has shown 20% reductions in methane when fed at high levels of inclusion in the diet (greater than 70% of diet). Low levels of nitrous oxide in the feed mean that lower

[54] PGGRC, 2018. Low Greenhouse Gas emissions feeds: https://www.pggrc.co.nz/files/154319600485.pdf)

levels of nitrogen in urine, which should reduce nitrous oxide emissions. However, similar to brassicas, an increase in nitrous oxide is possible because of the conditions under which fodder beet is grazed.

Challenges

It is not yet clear from research what the long-term impacts may be, or whether emissions reductions persist through time.

3.1.3 Other feeds

A range of other feeds have also been tested by the PGGRC, but none have shown sustained reductions in emissions. High sugar feeds showed promise in overseas trials, but a testing program in New Zealand identified that sugar concentrations in general do not affect emissions of methane or nitrogen concentrations in urine. High lipid pasture grasses have shown promise overseas also, and have recently been developed by AgResearch. They have not been tested as to any impact on methane emissions, and are unlikely to see widespread use in the near future due to being genetically modified. Other initial research with pasture grass supplemented with added oils showed no effect on methane emissions.

3.2 Low nitrogen feeds

Animal urine patches are the key source of nitrous oxide (N_2O) emissions from grazing systems. The amount of nitrogen excreted in urine is determined by plant nitrogen content.[55]

3.2.1 Supplements

Low nitrogen feeds have potential to lower the nitrogen content of urine patches, thereby reducing N_2O emissions. Low-nitrogen supplements could either replace supplements with a higher nitrogen content (e.g. replacing Palm Kernel Expeller with maize silage, or pasture silage with barley grain), or substitute pasture with low-N supplements.

Impacts

Increasing the use of low-N supplementary feeds could result in minor emission reductions if the supplements are grown on-farm, whereas the benefits if supplements are grown off-farm would depend on how off-farm emissions are accounted for. Profitability impacts for the farm systems vary between farms and regions. Modelling for Waikato/Bay of Plenty Farms suggests that there would be little or no effect on profitability from increasing use of maize silage, with moderate emissions reductions. Canterbury farms may see an increase in profitability and small emissions reductions from increasing the use of fodder beet on farm. [56]

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[55] NZAGRC annual report 2017: https://www.nzagrc.org.nz/annualreport,listing,411,annual-report-2017.html
[56] Reisinger et. al, 2017: https://www.mpi.govt.nz/dmsdocument/32158/send

Challenges

Feeding fodder beet in situ over winter presents its own problems, including potentially heavy pugging. Installing feed pads or barns to avoid this problem would have their own capital and labour requirements also.

Whole farm system modelling for each individual farm is necessary to determine the outcomes of changes to supplementary feed and feeding systems. Even then, quantification of emissions changes is subject to uncertainty given the inconsistent assumptions on ME, N content and utilisation rates between FARMAX and OVERSEER.

3.2.2 Plantain

Impact

Preliminary findings of research into plantain have found:[57]

- a reduction in urinary nitrous oxide concentration with increasing proportions of plantain and associated reductions in nitrous oxide emissions from urine patches. Plantain reduced N2O emissions from urine patches by c. 35-70% compared with perennial ryegrass.
- differences in methane per kilogram of dry matter intake between the treatment groups. However, methane emissions were unusually high for the control group so these data need careful interpretation.
- nitrous oxide emission factors reduced with increasing proportions of plantain in the sward, most likely due to an effect of plantain plants on soil processes.

3.2.3 Fodder beet

Impact

Trials conducted with winter forage crops and using crop-specific urine, showed that, at the same rate of urine-N returned, N_2O emissions from fodder beet were about 40% lower than from a kale crop.[58]

Challenges

The reasons why fodder beet had lower N_2O emissions are not yet known. Possible reasons include differences in the urine composition or plant-effects on the soil microclimate.

3.3 New inhibitors

3.3.1 Nitrification inhibitors

Research led by Lincoln University is under way to identify and commercialise new nitrification inhibitors that have a wider applicability, lower cost and equally low or lower risk of residues as DCD. A suite of promising compounds has been identified in the laboratory, and testing has begun to deliver proof of concept in the field. Assuming that at

[57] https://www.nzagrc.org.nz/knowledge,listing,528,nzagrc-highlights-2018.html
[58] NZAGRC Annual report 2017: https://www.nzagrc.org.nz/annualreport,listing,411,annual-report-2017.html

least some of the most promising novel compounds prove effective in field conditions and are able to be commercialised, additional nitrification inhibitors could be on the market by 2025.[59]

Like DCD, these potential nitrification inhibitors will likely need to overcome challenges regarding their impact on New Zealand's 'natural' farming image.

Nitrification inhibitors have generally not been cost effective when used only for emissions ($100-250 per hectare), particularly as they are only effective in 5 months of the year (winter). However, they also work to reduce nitrate leaching and may be cost-effective when used to meet water quality requirements, with beneficial side-effects of reducing nitrous oxide emissions.

3.3.2 Methane inhibitors

Methanogens are microbes that take advantage of the low-oxygen environment in the rumen but are not thought to be essential to cow health. They feed off the hydrogen by-products of digestion and convert it to water and methane. One way of preventing methane emissions is to target the methanogens that are most active in producing methane.

A Swiss-based company (DSM nutritional products) has developed a promising inhibitor that has shown 30% reductions in methane with no other observable disadvantages. This is expected to be on the market in 2019, but must be fed continually as a feed additive, meaning it is not particularly well suited to New Zealand pastoral farming.[60]

New Zealand research is focussing on options suitable for pastoral grazing systems and has entered the 'commercialisation' phase of development. Expected commercial availability is projected for 2023.[61]

3.3.3 Vaccine inhibitors

Research has begun exploring the possibility of administering a methane inhibitor as a vaccine. If successful this would have large impacts on sector emissions, as it could be implemented rapidly and cost-effectively across virtually all farming systems. Work on this option is in an early phase, however, and solutions are not guaranteed.[61]

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[59] NZAGRC, 2018: https://www.nzagrc.org.nz/knowledge,listing,528,nzagrc-highlights-2018.html
[60] PGGRC & NZAGRC "Methane Inhibitors" 2017: https://www.pggrc.co.nz/files/1501479614891.pdf
[61] NZAGRC highlights 2018: https://www.nzagrc.org.nz/knowledge,listing,528,nzagrc-highlights-2018.html; NZAGRC website: https://www.nzagrc.org.nz/methane,listing,550,methane-inhibitors.html

3.4 Breeding for low emissions

Breeding for low emissions livestock is a slow process. Research through the NZAGRC and the PGgRC has so far achieved a divergence in breeding lines for low and high methane emissions sheep of 10%. This divergence continues to increase. Trials for cows began 2015/16, with the key challenge being measuring both feed intake and emissions in real-time. The NZAGRC is starting trials to test bulls coming into the AI breeding programme.[62]

3.5 Biofilters

Biofilters use methanotrophic bacteria to prevent emissions of methane. The bacteria oxidise the CH_4 and convert it to CO_2, which has a significantly lower warming potential under standard greenhouse gas accounting systems.

Impact

2012 research identified the potential effectiveness of a volcanic pumice soil or compost-base filter cover to oxidise 95% of methane emissions from a dairy effluent pond.[63]

Challenges

This technology was deemed "too expensive for use on farms" in a review of AgResearch funding in 2013. Research before then showed promising results in terms of effectiveness, with 98% reductions in emissions recorded in preliminary study. Work has not progressed to field trials. Since then research has looked at capturing methane from animal housing facilities, and filtering through soils containing methanotrophs to 'fix' the methane to CO_2. This research has also been defunded, as it was found to be uneconomical. [64]

3.6 Carbon sequestration in soils

Soil carbon management has recently gained popularity internationally as a new method of carbon management and sequestration. It is well known that different land uses and land management strategies, as well as other environmental conditions, have a large impact on the amount of carbon in soil. In many countries intensive land use has severely depleted soil carbon levels, giving large scope for carbon sequestration by increasing soil carbon. Increases in soil carbon are also known to be beneficial for soil health and productive capacity.

3.6.1 Soil carbon

New Zealand pastoral soils already have relatively high levels of soil carbon (on average around 106 tonnes of carbon a hectare). Soil carbon has been shown to increase over time

[62] NZAGRC, 2018: https://www.nzagrc.org.nz/knowledge,listing,528,nzagrc-highlights-2018.html
[63] MPI, 2012: https://www.mpi.govt.nz/dmsdocument/28281/send
[64] NZAGRC, 2017: https://www.nzagrc.org.nz/methane,listing,549,feasibility-study-for-methane-capture.html

on low-intensity, hilly farms, but to decline on flat-land pasture. Irrigation has been found to increase soil carbon in some instances and to decrease it in other circumstances.[65] Research findings are still unclear as to how to achieve consistent and lasting increases in soil carbon for New Zealand soils, and what the potential is for significant further carbon storage.[66] Further research is also needed on how to reliably measure soil carbon changes.[67]

Even if soil carbon stocks were measurable, compensation for sequestration is likely to open farmers to a high level of risk, as carbon takes time to build up in the soil and can be lost quickly through land management practices such as cultivation, and through events such as drought that lie beyond a farmer's control.[68]

3.6.2 Peat soils[69]

Peat soils are known to contribute disproportionately to GHG emissions in New Zealand. They cover a very small proportion of NZ land, yet they store an amount of carbon equivalent to approximately 20% of carbon stored in all vegetation in NZ.

Impact

When drained, peat soils emit large amounts of carbon for decades following. Drained peat soils are estimated to release 2.9 tonnes of carbon per hectare per year. As these soils degrade, drainage becomes more expensive for farmers, making restoration more appealing. Farmers could reduce peat-related GHGs by re-wetting and restoring a drained wetland or peat area.

Challenges

The key challenge for reducing GHGs from peat soils is the cost to farmers, as agriculture on peat soils is estimated to be worth $700m per year.

3.6.3 Biochar

Biochar is fine-grained charcoal produced through pyrolysis (burning without oxygen) from waste biomass. Biochar is available commercially in New Zealand as a soil stabiliser, used

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[65] Meduna, 2017: https://motu.nz/assets/Documents/our-work/environment-and-resources/climate-change-mitigation/emissions-trading/Offset-options-for-NZ2.pdf
NZAGRC 2017: https://www.nzagrc.org.nz/annualreport,listing,411,annual-report-2017.html
[66] Productivity Commission, 2018. Low Emissions Economy. Retrieved from: https://www.productivity.govt.nz/assets/Documents/lowemissions/4e01d69a83/Productivity-Commission_Low-emissions-economy_Final-Report_FINAL_2.pdf
Reisinger et.al, 2017. "On-farm options to reduce agricultural greenhouse gas emissions in New Zealand. NZAGRC report to the BERG. Retrieved from: https://www.mpi.govt.nz/dmsdocument/32158/send
[67] BERG, 2018: https://www.mpi.govt.nz/protection-and-response/environment-and-natural-resources/biological-emissions-reference-group/
[68] Whitehead et. al, 2018: https://www.nzagrc.org.nz/soil-carbon,listing,484,management-practices-to-reduce-losses-or-increase-soil-carbon-stocks-in-temperate-grazed-grasslands-new-zealand-as-a-case-study.html
[69] Meduna, 2017: https://motu.nz/assets/Documents/our-work/environment-and-resources/climate-change-mitigation/emissions-trading/Offset-options-for-NZ2.pdf

in gardens[70] and experimentally within viticulture.[71] Internationally there is some use of biochar in agricultural systems.[72]

Impact

Biochar is a very stable form of carbon, and can have beneficial impacts on soil drainage, nutrient retention (nitrate leaching), increase in pH and reductions in mineral fertilisers.[73] However its properties are highly dependent on the techniques used to process it, and the type of biomass used. Its long-term carbon storage capacity is not yet well understood in the New Zealand context.

Challenges

Production and distribution of biochar for agricultural sequestration is likely to be costly. Possible configurations for biochar production, such as farmer collectives or a contracted portable pyrolysis system, are yet to be explored in the NZ context. Portable pyrolysis for forestry has been explored overseas.[74]

[70] https://biochar.co.nz/
[71] Ahika, 2014: http://ahika.co.nz/biochar/
[72] http://biocharfarms.org/biochar_production_energy/. See also: http://biocharfarms.org/farming/
[73] Biochar Interest Group Website: http://soilcarbon.org.nz/
[74] Coleman et. al, 2010: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.434.9179&rep=rep1&type=pdf#page=165

4. Current Funding for Mitigation Actions on Farms

4.1 Forestry

4.1.1 Forestry in the ETS

Under the New Zealand emissions trading scheme, land owners can earn carbon Credits (1 New Zealand Unit = 1 tonne CO_2) for carbon sequestered by forests established after 1989. They are also liable for the deforestation of pre-1990 forest land. Forest land must consist of at least 1 hectare of forest species, with tree crown cover by forest species of more than 30%, and an average width of tree crown cover of at least 30 metres.[75]

Previously, owners of forests established in 1990 or later had the opportunity to earn emission units for the carbon absorbed by their forests through the permanent forest sink initiative (Forests may be either exotic or indigenous species, including indigenous forests that have naturally regenerated since 1990). This is now being integrated into the ETS.[76]

4.1.2 One Billion Trees

Farmers can apply for direct Landowner grants or Partnership Grants from Te Uru Rākau, to assist with the planting of trees on their land.[77]

Direct Landowner Grants
Landowners can receive between $1500 (exotic planting) and $4000 (indigenous mix) per hectare of funding with top ups for erosion-prone land, fencing for natives and ecological restoration partnership projects. Land areas must be between 1-300 hectares for indigenous mix, and between 5-300 hectares for other types of planting.[78]

Partnership Grants
These grants focus on supporting partnerships between groups in order to enable increase in tree-planting through research, innovation or sector development. [79]

4.1.3 Trees That Count

Crowdfunding for native tree-planting on community owned and private land. Trees that count campaigns for donations from the public as well as businesses to fund native trees that are donated to registered planters around the country. These include private landowners, community groups, and individuals. Trees That Count also facilitate

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[75] https://www.mpi.govt.nz/dmsdocument/6991/loggedIn
[76] https://www.mpi.govt.nz/funding-and-programmes/forestry/permanent-forest-sink-initiative/
[77] https://www.teururakau.govt.nz/funding-and-programmes/forestry/planting-one-billion-trees/one-billion-tree-fund/
[78] https://www.teururakau.govt.nz/funding-and-programmes/forestry/planting-one-billion-trees/one-billion-tree-fund/direct-landowner-grants-from-the-one-billion-trees-fund/
[79] https://www.teururakau.govt.nz/funding-and-programmes/forestry/planting-one-billion-trees/one-billion-tree-fund/partnership-grants-from-the-one-billion-trees-fund/

recruitment of volunteers for planting. Trees That Count also works with land owners who wish to pledge their land to generate carbon offsets.[80]

4.1.4 Sustainable Food and Fibre Futures, MPI

SFF Futures is an MPI programme that invests with others in innovative projects to grow New Zealand's food and fibre industries sustainably. Low-carbon farming investments are a strong candidate for co-investment by the sustainable food and fibre futures initiative. The funding is flexible in size and type. [81]

4.2 Energy Efficiency

More funding is available for "large energy users" who spend more than $200,000 or $1m per year on energy. As the average yearly energy costs for a dairy farm are generally well below $100,000 many of these are not suitable for dairy farms. Given that there are strong returns on investment in energy-saving technology, farmers are offered resources and advice through EECA, and encouraged to invest in energy saving measures.

4.2.1 EECA Technology Demonstration

EECA will help fund the cost of investment in new or under-utilised energy saving technology or process improvement that could benefit the industry sector. The technology may improve energy efficiency and/or reduce carbon emissions.[82]

It funds up to 40% of project costs, up to a total of $100,000. If projects save energy and carbon through process heat technology, funding may be up to 250,000.

EECA won't fund projects involving the following:

- small-scale heat pumps (<10 kW)
- residential products
- standard commercial lighting, including LED's and office products
- solar hot water and photovoltaic panels
- electric light passenger vehicles (specialist electric vehicles may be considered)
- wind, hydro and marine electricity generation
- products under research and development.

It could potentially be used for biogas on-farm generation, biochar trials, electric farm vehicles or biofuel conversion projects. For these projects it is likely that carbon mitigation outcomes could be uncertain, but they are necessary step in proving carbon mitigation practices for wider uptake.

[80] https://grow.treesthatcount.co.nz/get-involved
[81] https://www.mpi.govt.nz/funding-and-programmes/sustainable-food-and-fibre-futures/about-sustainable-food-and-fibre-futures/
[82] https://www.eecabusiness.govt.nz/funding-and-support/technology-demonstration-projects/

4.2.2 EECA Low emissions vehicles contestable fund

This fund is to encourage innovation and investment to accelerate the uptake of electric and other low emissions vehicles in New Zealand, which might not otherwise occur.[83]

4.2.3 EECA Energy audit funding

Pumping and fan systems, process heat, and refrigeration technology are eligible for funding toward a base-level audit or an investment audit. These are all used in dairy sheds, and an audit will help farmers determine how best to optimise these systems. [84]

4.2.4 Waste minimisation fund

The fund, operated from the Ministry for the Environment, supports projects that promote waste minimisation, and increase efficiency, reuse recovery and recycling. Recovering economic value from waste is a key goal. This could be an option for farmers wishing to innovate with farm waste minimisation such as biogas systems. [85]

[83] https://www.eeca.govt.nz/funding-and-support/low-emission-vehicles-contestable-fund/
[84] https://www.eecabusiness.govt.nz/funding-and-support/energy-audits/
[85] http://www.mfe.govt.nz/sites/default/files/media/Funding/waste-fund-leaflet-final.pdf

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CURRENT OPTIONS

Farm Management
- *Once-a-day Milking*
- *Reducing Stocking Rates*
- *Removing on-farm cropping*
- *Managing Fertiliser Inputs*

Renewable Generation
- *Biogas*
- *Solar Power*
- *Energy Efficiency*

Alternative transport and Machinery
- *Electric Farm Bikes*
- *Electric Tractors*
- *Biofuel*

Effluent Management
- *Managing Fertiliser Inputs*
- *Land Application of Effluent*
- *Effluent Capture*
- *Off-Paddock Facilities*

Nitrification and Urease Inhibitors
- *Nitrification Inhibitors*
- *Urease Inhibitors*

Forest Sequestration
- *Commercial Forests*
- *Permanent Exotic Forests*
- *Permanent Native Forests*
- *Non-ETS land*

Energy Efficiency

POTENTIAL OPTIONS UNDERGOING RESEARCH

Low Methane Feeds
- *Forage Rape*
- *Fodder Beet*
- *Other Feeds*

New Inhibitors
- *Nitrification Inhibitors*
- *Methane Inhibitors*
- *Methane Vaccine*

Breeding for Low Emissions

Soil Sequestration
- *Soil Management*
- *Peat Soils*
- *Biochar*
- *Biofilters*

Low Nitrogen Feeds and Crops
- *Supplementary Feeds*
- *Plantains*
- *Fodder Beet*