How Hepburn Shire Farms can reach Z-NET

Baseline year emmissions

Tonnes of carbon dioxide equivalent in 2018

262,041

Agriculture sector

106,325

znet HEPBURN SHIRE

Acknowledgements
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For all things Z-NET related to agriculture, go to: www.hepburnznet.org.au/action/farm

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A

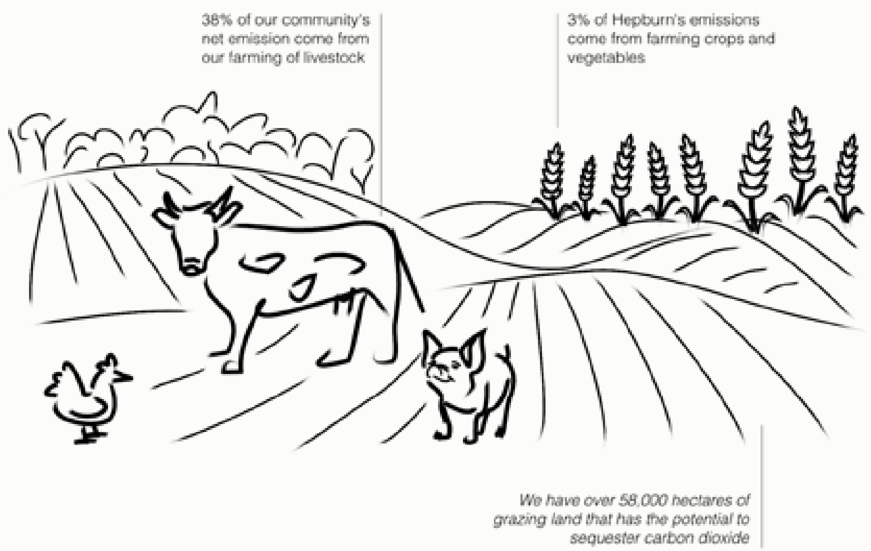
Overview

Introduction

There is a great deal of public commentary about the agricultural sector's contribution to climate change, due to factors like land use, tillage, supply of animal products etc. While a genuine risk of environmental harm exists as part of some agricultural actions, agriculture (or agricultural products) and environmental harm are not synonymous; farms often are - and increasingly should be - net carbon sinks, havens for biodiversity and functional ecosystems, and a base for supporting industries of local food, energy and resources. This document is intended to act as a guide, to help farmers and community members better understand the agriculture-based drivers of climate change, and what types of action can make a material difference to greenhouse gas emissions.

It should also be mentioned that carbon accounting is a relatively "simple" analysis of quite complex and long-existing carbon cycles: a very useful tool for determining impact of human activities and natural occurrences, but not one to be considered without context. It is certainly important to strive for a better balance and to achieve net emission reductions in short-term carbon cycles – animals, trees and vegetation, soil carbon – and these types of actions are discussed here. However, this should not detract from the need to take action on stabilising long-term carbon cycles: most notably through stemming the release of long-sequestered carbon by burning fossil fuels.

This document aims to show that agriculture has the opportunity to pivot relatively quickly, using existing techniques and knowledge to change from a net emitter of greenhouse gases to a net carbon sink. In doing so, it can provide fast emissions reductions and support to other sectors, while new technologies develop. Over this next 'critical decade', the agricultural sector is well-placed to transition to zero net emissions. The first step in achieving this change is an open discussion about what the problems actually are, and what can be done to improve them.



In 2018, the Hepburn Shire Zero Net Emissions Transition (Z-NET) project began, building on a long history of local environmental action in the Hepburn Shire. Beginning with the development of a localised greenhouse gas (GHG) emissions profile, this project aimed to quantify and address emissions in the Shire, using local data and developing local projects to address climate change.

With input from all the local sustainability groups, community members, and a team of over 30 domestic and international project partners, the Community Transition Plan (CTP) was launched in 2019. The CTP outlines how zero net energy could be achieved locally by 2025, followed by zero net emissions by 2030. This is in line with the 2018 Intergovernmental Panel on Climate Change's (IPCC) Special Report on Global Warming of 1.5°C [1], which sets the impetus for drastic action on greenhouse gas emissions within 12 years. The implementation of the CTP is overseen by the Z-NET Roundtable.

The vision for the Hepburn Shire is a three phased roadmap:

- Phase 1: 2019 – 2021 (quick wins)
- Phase 2: 2022 – 2024 (zero-net energy)
- Phase 3: 2025 – 2029 (zero-net emissions)

The approach taken in the development of the CTP differs from the approach most commonly adopted in emission reduction planning, as it is a combination of top-down and bottom-up action in: carbon accounting, policy development, local action and tangible projects. This amalgamation of different approaches carries inherent imperfectness, caused by blurred boundaries, inconsistencies in reporting, and limited budgets; however, the Z-NET approach offers clear and measurable outcomes, within a specified and necessary timeframe.

Of all the emission sectors identified in the CTP, the largest (for the Hepburn Shire) was agriculture, which varies significantly from state, national and international averages. This variation is not because the Hepburn Shire has a particularly emissions-intense agricultural industry; it is due to the scope of what has been considered within the Shire's boundary, as well as the fact that the Shire has limited industrial activity, low population density and high levels of existing renewable energy generation/self-consumption.

Because of these findings, and although the project began with a strong focus on energy, electricity and fossil fuels, a strengthened focus on agricultural emissions is a necessary step. Fortunately, Hepburn Shire is home to a large number of innovative and open-minded individuals, many of whom are farmers. This positions the Shire well to consider, review and significantly improve the agricultural emissions profile identified in the original CTP, and implement on-the-ground actions to address it.
Z-NET also identifies that the journey to carbon neutrality needs to be carried out in a way which is socially, ethically, practically and financially acceptable; it must not dismiss the potential impacts on local community. For this reason, all actions taken consider the social justice elements of transition, by realising that many within the community may need support and guidance along the way.

The CTP [2] was primarily focussed on climate change 'mitigation', i.e. reducing greenhouse gas emissions to mitigate the impact of climate change. Since the release of the CTP, in light of significant climate change-fuelled events, there has been a renewed focus on climate change 'adaptation'. Adaptation is identifying that, irrespective of future success of emissions reductions, climate change impacts are already being felt, and that there is a need to adapt to this changing climate.

Considering all of the above, the agricultural sector faces a series of complex challenges. For Hepburn Shire, it has a significant emissions footprint to reduce; it must continue to feed a growing population in an ethical and ecologically sound manner; and it must achieve this while facing the high likelihood of a hotter, drier and more volatile climate. This Guide is written for farmers in the Hepburn Shire, to share some of the learnings from the Z-NET project and to enable and encourage farms to set their own goals for carbon neutrality and to work towards those goals.

1. https://www.ipcc.ch/sr15/
2. https://hepburnznet.org.au/resources

Why the focus on agriculture?

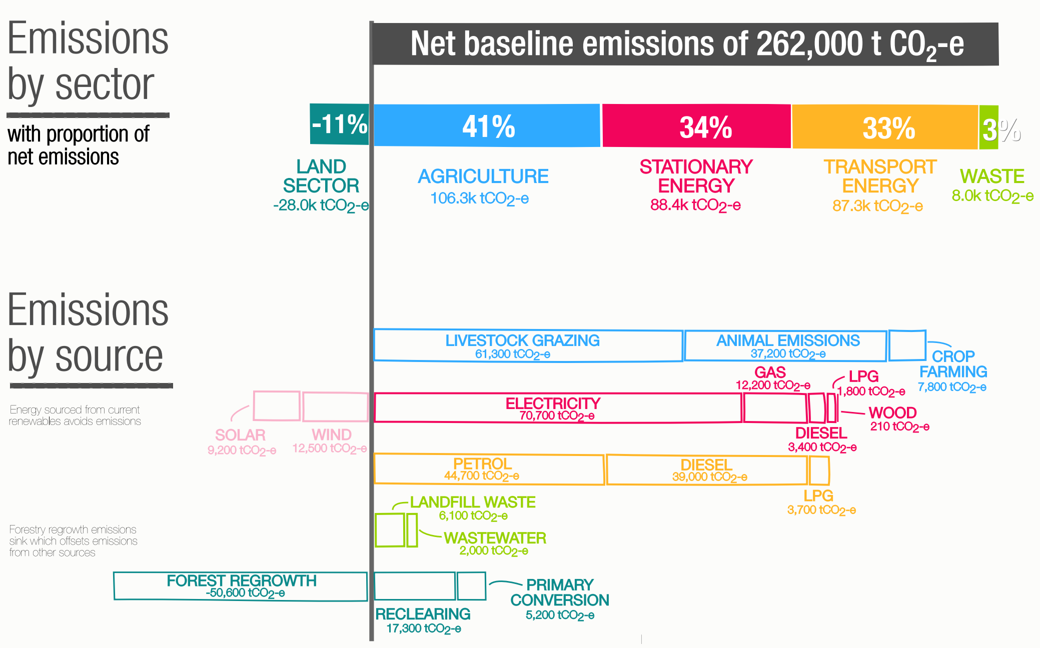
For the baseline year of 2018, the CTP identified total annual greenhouse gas emissions of 262,041t CO2-e within the Hepburn Shire. Of this, the emissions attributable to each sector were:

Agriculture = 41%
Stationary energy = 34%
Transport = 33%
Waste = 3%
Land use = -11% (negative indicates a carbon sink)

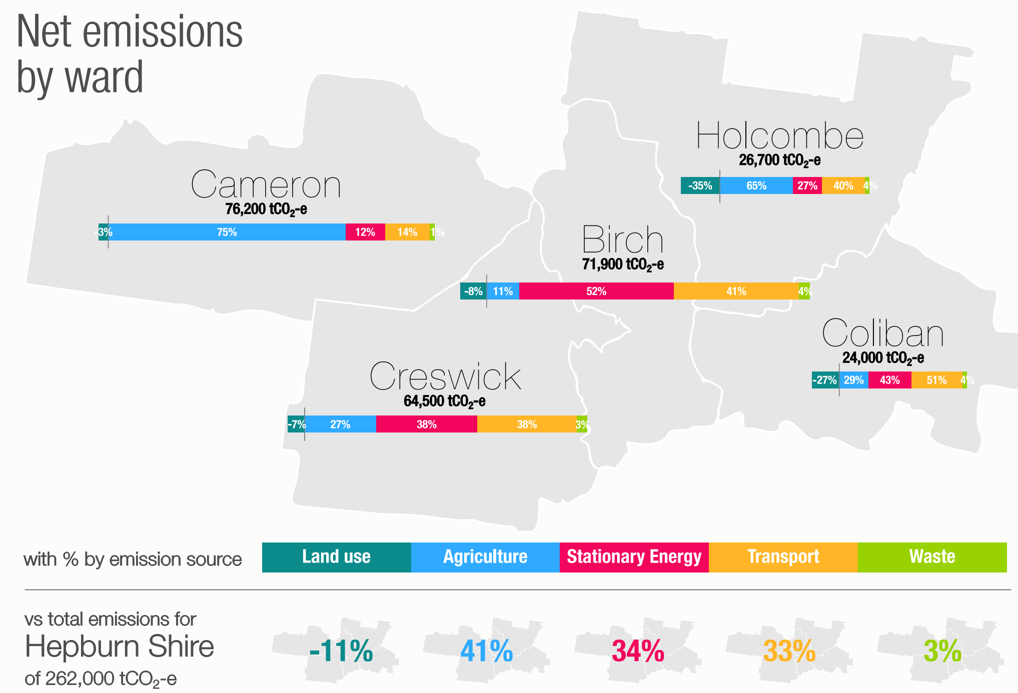
As previously mentioned, this breakdown above varies from the state average, due to factors such as Hepburn Shire's high agricultural activity, relatively low population density, and limited heavy industry. The agricultural emissions profile was developed using data on local commodities, together with greenhouse accounting methodologies[3] and tools[4]. Further details are provided in the open-source Z-NET Options Model.

As a significant emissions sector in the Hepburn Shire, and also a key economic sector, the agricultural sector needs to be a major focus in the Shire's journey to zero net emissions. It is important to also give consideration to the specific geographic areas within the Shire that host the majority of the farming communities and, within these, explore the priorities and most appropriate actions for emission reductions. The following graphic represents the emissions breakdown across the wards in the Shire.

HEPBURN SHIRE BASELINE EMISSIONS



HEPBURN SHIRE BASELINE EMISSIONS



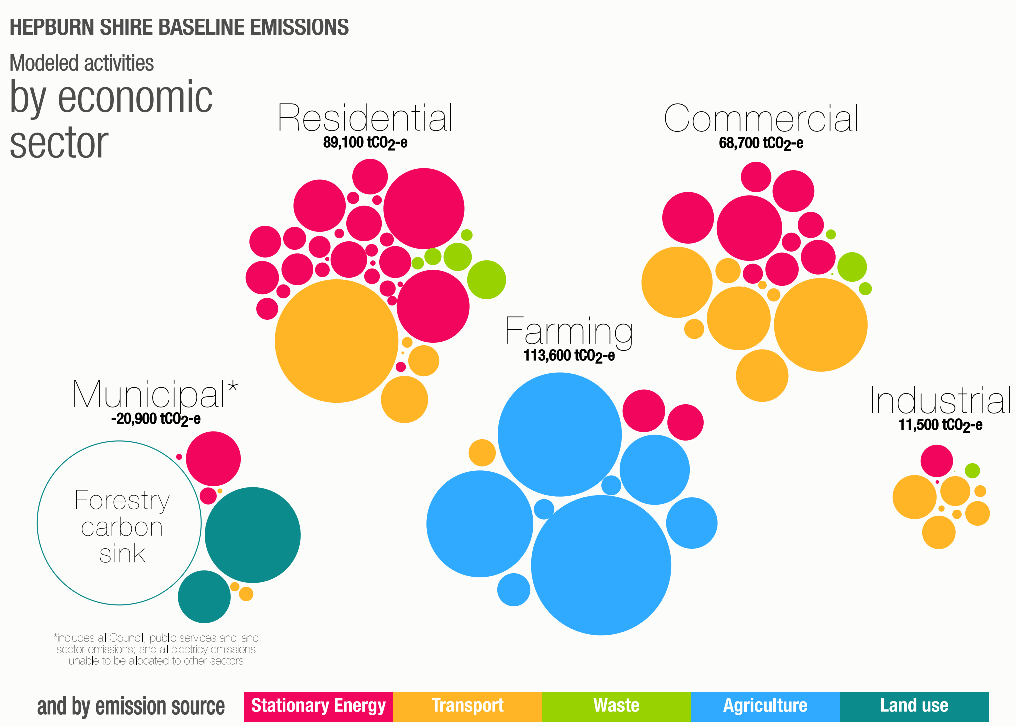
3. https://www.industry.gov.au/data-and-publications/national-greenhouse-gas-inventory-report-2018
4. http://www.greenhouse.unimelb.edu.au/Tools.htm

Within agriculture, the total emissions are attributable to:

Sheep (Direct emissions 27%)
Cattle - Beef/Dairy (Direct emissions 30%)
Pigs (Direct emissions 1%)
All livestock (Indirect emissions 35%)
Cropping (7%)

In regards to the breakdown of emissions across agriculture as an economic sector, the following graphic represents the key aspects of emissions for farms, namely agricultural emissions (as listed above), with transport and stationary energy also playing a role.

The context for these figures, include commentary around how they must be interpreted, is discussed further within this Guide.



What does zero net agricultural emissions looks like?

This Guide discusses the key emissions sources from agriculture and potential actions to mitigate, or reverse, their net increase. It is proposed that the solution is not one action or technology, but instead a suite of actions aimed at reducing the diverse environmental impacts of agriculture.

Sources of agricultural emissions are commonly linked to different sectors such as livestock, nutrient inputs or land clearing, amongst others. While this is correct in many instances, our food system is inherently more complex; there is no single commodity to focus on. Further, the specifics of each operation and commodity need to be considered, as there are countless examples of farmers growing certain products - which are often seen as environmentally detrimental (such as red meat) - in environmentally beneficial ways.

There is a need to consider the non-emissions impacts of agriculture also. Whether it is addressing biodiversity loss, human health outcomes, food sovereignty, animal welfare or other factors, the transition to zero net emissions offers a pathway to also deliver a holistically more robust food system.

Reaching zero-net emissions from agriculture in the Hepburn Shire will help to ensure a robust, vibrant and diverse local industry into the future. It includes the commodities currently farmed, together with emergent products, continued local ownership and local employment through reciprocal supporting industries. Zero-net emissions can be achieved in the Hepburn Shire, while retaining and strengthening its agricultural sector in the face of a changing climate.

What are agricultural emissions actually from?

Greenhouse accounting is a dynamic and imperfect science, and agricultural emissions are difficult to reliably quantify at a local level. Variations between properties, crops, seasons, weather, genetics, inputs, management, and a suite of other factors will impact the correlation between theory and practice. These variations are an important point for consideration when 'ground-truthing' emissions profiles and, importantly, when trying to develop tangible actions for reduction. Further, quantifying many agricultural emissions is not as simple as when assessing the release of additional, fossilised carbon to the atmosphere (through burning coal for example).

Agricultural emissions are largely attributable to naturally occurring elements and mechanisms, which are already present in some form as part of most ecosystems and cycles. These natural systems include sources of greenhouse gases (e.g. emissions of naturally occurring carbon dioxide or methane, such as from decomposing organic matter or grazing animals) and also carbon sinks (e.g. sequestration of carbon in organic material such as vegetation, soils or wool). For this reason, when considering the impact of agricultural activity it is important to consider what the current system is being compared to, which can sometimes be difficult as land use changes over time. Forests cleared for raising cattle, for example, will result in a greater net increase in greenhouse gases than sustainably grazing areas which were traditionally grassland.

Problems arise when agricultural systems amplify increases in greenhouse gases, while dismantling naturally occurring carbon sinks: resulting in a net increase in emissions. For these reasons, there is a need to consider agricultural systems as a whole, including the different greenhouse gas sources and sinks at play. It is through this lens that it possible to modify and improve existing systems and achieve zero net emissions, while improving various other environmental, social and financial objectives. Some of these options are discussed within this document.

Emissions and opportunities in this Guide have been allocated to the following categories:

1. Fossil fuels
2. Livestock
3. Land use
4. Soil carbon
5. Agricultural inputs
6. Non-agricultural emissions

B

Emission sectors and actions

1. Fossil fuels
2. Livestock
3. Land use
4. Soil Carbon
5. Agricultural inputs
6. Non-agricultural emissions

1 Fossil fuels

This sector includes a discussion of the emissions due to the burning of fossil fuels during, or as a result of, farm operations. This includes:

Fuel usage

- transport fuels
- pumps and irrigators
- farm machinery
- heat loads
- small plant equipment

Electricity usage

- pumps and irrigators
- equipment use
- lighting
- heating and refrigeration

Fossil fuel emission reduction opportunities

Use less

As with non-agricultural energy use, the quickest, cheapest and lowest impact way to reduce impact is to use less. This may be through improved efficiency in the use of fuel, pumps, heating/cooling, compressed air, lighting etc. A basic review of energy demands on-farm, power demand of equipment, running times and wastage can often highlight areas for improvement. Larger operations can have a more detailed energy audit completed by an external assessor, which can often highlight significant energy savings.

On-site renewable electricity generation and fuel switching

Electricity loads can often be paired with behind-the-meter renewable energy technologies to meet on-site needs, for example:

- Solar panels and/or battery storage for electrical loads. A range of subsidies and grant programs are available for installing solar photovoltaics (solar PV) or batteries, making it a very financially viable option in many instances.

  Without subsidies, and despite gradual price decreases, batteries remain an expensive undertaking. However, when coupled with cheap renewable energy or a need to safeguard valuable produce (e.g. refrigerated products), installing battery storage can still be a viable option.

Solar pumps and irrigators

Switching petrol or diesel pumps to electric alternatives can significantly reduce fuel consumption on farm, while reducing labour inputs. Electrical/solar pumps can easily meet the pumping demands of small petrol engines, with larger pumps also being suitable for conversion in many instances.

Load shifting

For example, changing the times for pumping or heating water to a window when cheap renewable energy is available.

Information about local solar and battery storage program is available at https://hepburnznet.org.au/action/farm

Bioenergy

Bioenergy often receives less coverage than other technologies such as solar PV or wind, but currently represents the largest source of renewable energy in Australia[5]. Suppliers and supporting industries for some bioenergy technologies are still somewhat limited in Australia, but this is rapidly changing.

Bioenergy offers huge potential for addressing continuous, high thermal and electrical loads from industry and agriculture. Agricultural business can look to bioenergy solutions by utilising renewable biomass, sourced on-site or nearby.

Bioenergy technologies applicable to agricultural industries include:

Biomass burners, boilers and generators - Generating high grade heat or electricity from low emission fuels such as wood or straw pellets. Systems can be sized at a domestic scale (for example pellet or grain burners), or much larger scales (for example wood-fired boilers for industrial heat).

Anaerobic digestion
Generating biogas from manure or other putrescible wastes, to be used for heat and/or electrical loads

Pyrolysis and gasification
Generating a flammable gas (producer gas or synthesis gas) from solid biomass for heat and/or power for on-site loads

Fermentation - Producing ethanol from residues high in starch and sugar, or of hydrolysed cellulose.

Transterification - Creating biofuels, such as biodiesel, from vegetable oil products. It should be noted that such processes are commonly considered energy intensive or uneconomical at present, unless 'waste' products are used for this process.

Uptake of bioenergy is growing rapidly in Australia, with an increasing number of suppliers offering small to large-scale bioenergy systems, and dozens of sites now operational around Victoria.

Electric vehicles are becoming increasingly widespread in Australia, due to a combination of price reduction, range increases, and improved charging infrastructure[7]. These factors make the purchase of electric road vehicles cost-effective and practicable in many instances, particularly when the Total Cost of Ownership of the vehicle is considered. With a rapidly increasing fleet of electric road vehicles, a supply of electric light machinery is also possible in the foreseeable future.

Hydrogen is often presented as a solution for addressing storage challenges faced by renewable energy technologies, together with addressing the energy-dense fuel requirements of heavy vehicle transport. However, the generation and broad implementation of renewable hydrogen still faces significant economic, technical and practical challenges, which will need to be further improved before the technology becomes more widely adopted and viable. If these challenges can be overcome, hydrogen could potentially form part of the mix of renewable energy/storage into the future.

Procurement of renewable electricity may be an option for consumers aiming to reduce their environmental footprint, but where generation onsite is not a feasible option. For large electricity contracts, procurement through Power Purchase Agreements (PPAs) offers a pathway for cheap renewable energy, while providing price certainty to both the consumer and renewable energy generator.

5. https://www.energy.gov.au/sites/default/files/australian_energy_statistics_2019_energy_update_report_september.pdf
6. https://www.energy.vic.gov.au/renewable-energy/bioenergy
7. http://www.cvga.org.au/charging-the-regions-local-government-ev-charging-network-study.html

Case Study

Energy Case Study - Jonai Farms and Meatsmiths

Site Context

Jonai Farms is a small-scale agroecological community-supported agriculture (CSA) farm, with pastured heritage breed Large Black pigs, Speckleline cattle and Australian purple hard-necked garlic.

Livestock are fed so-called 'waste' – surplus, damaged, or unwanted produce from other food and agriculture systems in Victoria (e.g. brewers' grain, eggs, milk), creating a net ecological benefit by diverting many tonnes of organic waste from landfill, and exiting the fossil-fuel-intensive model of segregating feed production from livestock farming.

Water is moved around the property by old piston pumps powered by secondhand solar panels via treadmill motors salvaged from the local tip, as the farm strives to reduce its dependency on fossil fuels.

While animals are slaughtered off site, carcasses are returned for further processing and value adding in the on-farm butcher's shop and commercial kitchen. A small team work to produce a range of fresh cuts, smallgoods including ham, bacon, and seasonal sausages with salt, pepper, and ingredients grown onsite or by neighbouring farms. Pigs' heads become pâté de tête, excess fat makes soap, and bones are transformed into bone broth.
After being processed for bone broth, bones are pyrolised in a retort to become bonechar. This mineral rich material is then activated in fertiliser made on the farm from waste stream whey, molasses, rusty nails, and manure, before incorporating into the soil to help produce the small commercial crop of garlic and the family's vegetables.

95% of produce is sold to 80 household CSA members in Melbourne and the region, who commit to purchase a portion of the farm's output for a minimum of one year – providing security and connectivity between farmer and consumer.

Appliances/Loads

The site comprises both a residence and the farm operations. From an energy load/appliance perspective, there are:

House and farmhand residence:

- refrigerator x 2
- freezer x 1
- electric heater
- gas stoves x 2
- gas oven x 1
- electric oven x 1
- exhaust hood x 1
- dishwasher x 1
- washing machine
- electric pump for water
- split system HVAC
- Solar hot water system boosted with mains electricity overnight
- Wood stove x 2

Shed

- electric farm tools
- freezers x 3

Butcher's shop / Commercial kitchen

- Display refrigerator x 1
- Freezers x 2
- Walk-in chiller in a boning room
- Walk in curing room
- De-humidifier
- Electric bandsaw
- Cryovac machine
- Electric smoker oven x 1
- Gas stove x 1
- Gas oven x 1
- Exhaust hood x 1
- Electric pump for water
- Split system HVAC x 2
- Solar hot water system boosted with electric at daytime load

Belvedere (events venue):

- Refrigerator x 1
- Electric pump for water
- Instantaneous gas water heater

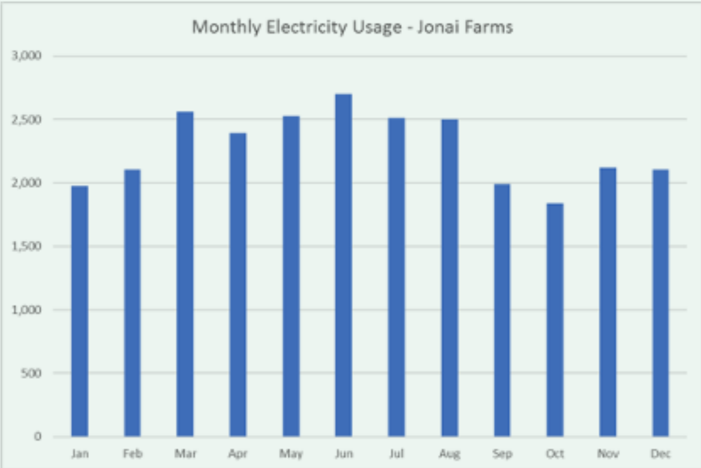
As can be seen, there are not significant gas loads at the site. Gas is supplied via LPG bottles, with an annual spend of around $1,000.

Electricity Usage Profile

The entire site has a single point of connection to the electricity distribution network, with a single phase (80 amp) supply. Three separate meters exist across the site, one being a dedicated off-peak circuit.

The electricity bills and the latest 12 months of smart meter data from the farm owners show that over the past 12 months, the site has drawn 27,396 kilowatt hours (kWh) from the electricity grid, with an average daily usage of 75.06 kWh per day.

Monthly electricity usage for the last 12 months looks like this, with winter usage around 25% higher than summer usage:



Case Study

Energy Case Study - Jonai Farms and Meatsmiths

Solar & Battery Analysis

Given the load size and the single point of connection, the site is an excellent candidate for a solar photovoltaic (PV) and battery system. Given the site is single phase, Powercor have advised that any solar/battery system will be limited to 5 kilowatts (kW) at the point of the inverter. In line with current installation standards, solar panels can be oversized (to the inverter) by a factor of 1.3. This means that a maximum of 6.6 kW of panels could be part of the grid connected system.

Given this context, analysis was done using Renew's Sunulator[8] model, which simulates generation, consumption, battery charge/discharge, export to grid and tariffs on a 30-minute basis to produce the results below.

Renew modelled the following different system sizes:

- BAU – energy usage and costs without a solar or battery system in place;
- 3kW solar-only system (a typical, "small" household size);
- 6.6kW solar-only system (a typical, "medium" household size);
- 10kW solar-only system (a typical, "large" household size);
- 6.6kW + 13.5kW solar & battery system (a typical "medium" household size);
- 10W + 13.5kW solar & battery system (a typical "large" household size).

8. https://renew.org.au/resources/sunulator/

Item	BAU	3kW	6.6kW	10kW	6.6kW+13.5kWh	10kW+13.5kWh
Simulation Results - Environment						
CO2e Offset p.a. (tonnes)		4.1	8.9	13.5	8.8	13.3
Equivalent no. cars off the road		1.2	2.6	3.9	2.6	3.8
Simulation Results - Energy						
Self-consumption of solar generation		91%	78%	65%	98%	90%
Average battery utilisation					23%	51%
Simulation Results - Economic						
Up-Front System Cost		$3,000	$5,940	$9,000	$15,053	$18,113
Electricity Bill p.a.	$7,710	$6,637	$5,557	$4,747	$5,263	$4,231
Maintenance Cost p.a.		$50	$66	$100	$100	$120
Total Cost p.a.	$7,710	$6,687	$5,623	$4,847	$5,363	$4,351
Cost Saving p.a.		$1,023	$2,087	$2,863	$2,347	$3,359
Net Present Value (@ 20 Years)		$12,070	$24,947	$33,286	$16,592	$28,519
Simple payback period, years		3	3	4	7	6
Discounted payback period, years		3	3	4	7	6
Return on Investment		33.8%	34.9%	31.3%	12.4%	16.2%

Case Study

Energy Case Study - Jonai Farms and Meatsmiths

The green cells indicate the best result in that category. As can be seen:

- The current annual electricity bill for the site is approximately $7,700 per year;

- Adding a small solar-only system (3kW) would:
  - cost around $3,000 installed;
  - save just over 4 tonnes of carbon;
  - use more than 90% of the solar electricity on-site;
  - save around $1,000 per year, with a simple payback time of 3 years.

- Larger systems involve higher costs but higher environmental and economic savings;

- The large 10kW solar plus 13.5kWh battery system would:
  - cost around $18,000 installed;
  - save just over 13 tonnes of carbon;
  - use around 90% of the solar electricity on-site;
  - use approximately 51% of the battery capacity on average each day; and
  - save around $3,300 per year, with a simple payback time of 6 years.

- Solar-only systems result in:
  - better economics – as the cost of solar is low and solar does most of the electricity bill saving;
  - roughly the same environmental outcomes as solar-battery systems – as adding a battery does not involve additional renewable generation (just storage).

As stated above, the site is limited to 5kW per phase at the inverter. This means that only a maximum of 6.6kW panels can be grid connected. As such, the 10kW solar system is prohibited, but is shown here for context, to improve understanding of how a solar-battery would perform. Ideally, a well-designed solar-battery system will use more than 51% if the battery's capacity on average. However, there are many systems where this level of battery performance is common.

The battery performance of the 6.6kW+13.5kWh system leads to less than a quarter (23%) of the battery capacity being used on average. The reasons for this are two-fold:

- the daily load (75kWh) of the site is high; and due to that
- most of the 6.6kW solar generation is being used to directly supply household appliances during the day – with insufficient solar energy left to charge the battery.

The site owners are very interested in a battery from the perspective of having protection from blackouts – and being able to continue running specific loads and appliances when the grid goes down. Therefore it will be important to set the battery storage threshold levels to ensure in blackouts there is enough storage available for the farm needs.

2 Livestock

Livestock emissions may appear to be an insurmountable challenge to address, however, there are several possible actions to reduce the environmental impact of livestock. It should also be noted that Australia's peak body for red meat and livestock, Meat and Livestock Australia (MLA), have a commitment to zero net emissions from industry by 2030[9]. Emissions attributable to livestock include:

Enteric fermentation

Methane from enteric fermentation in livestock is a commonly acknowledged source of agricultural greenhouse gas emissions. Livestock consume feed such as grass, grain and other fibrous material, which results in the production of methane (and carbon dioxide etc.). Methane is produced by bacteria in the ruminant gut (with some excess burped out) as a key part of the digestive process of ruminant animals, which includes cattle, sheep and goats. However, lower levels of methane emissions are also generated from some livestock with other types of digestive system.

As with other short-lived greenhouse gases, methane then breaks down as part of a naturally occurring cycle, and its elements are again used to form grass, water etc. Methane is considered a potent greenhouse gas because it has a Global Warming Potential (GWP) significantly higher than that of carbon dioxide. Because methane has a relatively short atmospheric residence time (i.e. length of time it remains in the atmosphere before breaking down) its warming potential is averaged over a specified time period. This standardisation aims to allow some comparison between different greenhouse gases, using the common notation of CO2-e (carbon dioxide equivalent). The period of time used for this standardisation is often 100 years (GWP 100), however different time scales are used in different methodologies[10].

Because of this deterioration, there reaches a point where the release of greenhouse gases to the atmosphere matches the rate of deterioration, i.e. the amount of gas in the atmosphere remains constant. Consequently, livestock numbers which are consistent over the selected time period can be seen as maintaining a heightened level of atmospheric greenhouse gas. Conversely, changes in livestock numbers produce a 'step change' in the greenhouse gases present in the atmosphere.

Urine and manure

Urine and manure from livestock is very nutrient dense, as livestock concentrate the nutrients which they take up during grazing. While much of this is returned to the soil and taken up by plants, a large percentage of this nutrient-rich effluent is lost to the environment – either through volatilisation to the atmosphere, leaching into the soil, run-off into waterways, or other mechanisms of decomposition and degradation. These processes result in the generation of greenhouse gas such as carbon dioxide, nitrous oxide and methane (levels will vary depending on the time of year, volumes of waste concentrated etc.), however the relative impact of these is lower than emissions from enteric fermentation.

9. https://www.mla.com.au/research-and-development/Environment-sustainability/carbon-neutral-2030-rd/cn30/
10. https://www.moffittsfarm.com.au/2020/08/23/ruminant-methane-decision-pending-gwp100-versus-gwpstar/

Quick wins

Waste (and use) less of the animal or product. Producing anything requires energy, water, resources, and often carries a corresponding emission footprint. Ensuring that waste is minimised results in lower embedded resources within a given product. Diversifying industries and engaging with consumers to ensure that all viable products are used (for example by utilising all viable parts of an animal), offers a pathway to more efficient, and therefore less harmful industry. In a similar vein, there is opportunity to consider the current meat consumption rate, which in Australia is amongst the highest in the world on a per capita basis [11]. 'Eat better meat, less often' is a phrase which highlights the need for a broader discussion about how dozens of small changes can cumulatively reduce environmental impact.

Buy/sell local and seasonal

In a society which is becoming increasingly disconnected from its food supply, Hepburn Shire and much of regional Victoria is well placed to help reverse this trend. With a community of innovative and open-minded farmers, restaurateurs, and eaters, supported by proactive government policy at the local and state levels, the benefits of local and seasonal food – processed and eaten close to where it is produced - can be realised.

Reduction in ruminant emissions

Ruminant methane emissions occur as a result of the foregut (rumen) fermentation of food, prior to further digestion. Animal methane reductions are therefore dependant on altering this process in some way, or preventing the release of methane to the atmosphere. Commonly discussed options for achieving this outcome include:

Feed supplements

Changing a ruminant's feed can alter the methane it emits, through processes which inhibit methane generation. Under normal conditions this can change by small amounts, due to naturally occurring variations such as feed quality and type. In many cases it is difficult for this to achieve significant impact, as farmers are reliant on the available (or stockpiled) feed on their property at a given time.

However, reducing emissions from ruminants is a major field of scientific research, and more substantial emission reductions can be achieved through the addition of specific feedstocks. Commonly recognised feedstocks include:

- Fats, tannins and oils

The addition of fats, tannins and/or oils to animal feed has shown the potential to reduce methane emissions by up to 20%. For successful implementation into farming operations, however, challenges include consistent integration into an animal's feed, on top of sourcing the material in the first place. Potential supplies of these feedstocks include waste edible oil from hospitality or manufacturing industries, grape marc, tannins from local trees and plants, or other suitable industries.

- 3 Nitro-oxypropanol (3-NOP)

3 NOP is an organic compound, which acts as an inhibitor to methane production in ruminant animals. When fed to ruminants, it has been shown to reduce methane emissions by up to 80% [12 13 14].

- Red seaweed (asparagopsis taxiformis) [15]

Feeding red seaweed as a feedstock to ruminants has been shown to reduce methane emissions by around 80% and up to 99% [16 17] in some instances. However, this is an example of a feedstock which poses difficulties in implementation, due to logistics, palatability to animals, and the risk of unintended environmental impacts.

Introducing microbiome bacteria

Various studies have been carried out on introducing different bacteria to the rumen, in order to reduce methane generation in ruminants. While some results are evident, this is an ongoing field of research.

It should be noted that, while various feedstock supplements have shown significant potential for emission reductions in controlled environments, the successful transition from theoretical to on-the-ground reductions requires some consideration. The volume of material required to supplement feed on a global scale is enormous, as are the logistical challenges involved in distribution. Such implementation would carry financial and environmental costs, and it is important to ensure that these do not outweigh the perceived benefits.

Practical considerations for feed supplements

Feedstock supplements can only mitigate methane generation when they are present in the digestion process, in the correct quantities and at the correct time. Variations in the presence of methane inhibiting agents in the rumen will result in a corresponding fluctuation in the methane emission reductions achieved. While achieving a highly consistent feed supply may be possible for animals which are constantly handled, such as in some dairy industries or feedlots, successful implementation poses challenges to pasture-based graziers, who may need to look to alternative methods to integrate different feeds into their grazing program [18].

Further, there is potential for the animal to adapt to these changes over time – effectively negating their impact. For these reasons, it will take time for such solutions to become widely adopted, as long-term trials will be necessary. Additionally, other environmental benefits of pastured livestock (and the potential environmental or food quality impacts of external feedstocks), together with animal welfare challenges, must be assessed when considering feedstock supplements to reduce ruminant emission.

Environmental improvements

For farmers interested in reducing animal methane intensity without pursuing external feed supplements – better quality feed means a higher amount of sugars and protein, leading to faster breakdown in the gut and consequently better animal performance. Good shelter, as can be provided by shelter belts, can also improve milk production and therefore livestock growth rates. Both of these factors will result in lower emissions per unit volume of finished animal product.

Genetic selection possibilities

There are also possibilities to selectively breed livestock which produce less methane. This poses challenges, as many of the indicators used for genetic selection are difficult and/or expensive to record. However, this is a potential pathway to consider and research is being conducted into this option [19].

Further, consideration is required of any potential unintended consequences from selective breeding with a narrow focus on certain traits. Given that the desire is to develop systems which are inherently more holistic, there is also a need to consider animal traits which work well within those systems (e.g. behaviour, animal performance, reproductive performance etc.)

11. https://data.oecd.org/agroutput/meat-consumption.htm
12. https://www.sciencedirect.com/science/article/pii/S0022030218311111
13. https://www.sciencedirect.com/science/article/pii/S0022030216301801
14. https://www.dsm.com/content/dam/dsm/corporate/en_US/documents/summary-scientific-papers-3nop-booklet.pdf
15. https://research.csiro.au/futurefeed/faq
16. https://animalmicrobiome.biomedcentral.com/articles/10.1186/s42523-019-0004-4
17. https://www.mla.com.au/research-and-development/reports/2015/development-of-algae-based-functional-foods-for-reducing-enteric-methane-emissions-from-cattle/
18. https://www.mla.com.au/research-and-development/search-rd-reports/final-report-details/environment-on-farm/best-choice-shrub-and-inter-row-species-for-reducing-methane-emissions-intensity/3011
19. https://www.sciencedirect.com/science/article/pii/S0022030216308335

3 Land use

Emissions attributable to land use/land use change include:

Clearing of land

Removing existing vegetation for agricultural purposes - which oxidises to create CO2 or is lost to the atmosphere through other mechanisms (e.g. burning) - releases carbon dioxide. That loss of previously vegetated land is considered a step change in atmospheric carbon, which continues indefinitely unless the area is reforested.

Stubble burning

Burning of stubble releases carbon dioxide, methane and nitrous oxide into the atmosphere [20]. Biomass, such as stubble, sequesters carbon from the atmosphere during its growth, which is then released during burning, forming a closed cycle. However, the release of other gases due to burning stubble is considered a net emissions increase, due to the higher warming potential of those gases.

Bushfires

Similarly to the above, growth of biomass must draw carbon down from the atmosphere during growth. However, burning it releases greenhouse gases into the atmosphere and causes a net increase in atmospheric carbon emissions.

Land use emissions reduction opportunities

It is important to note that the Hepburn Shire was not previously a fully forested region. The Shire includes areas of the following Victorian Bioregions:

- Central Victorian Uplands
- Goldfields
- Victorian Volcanic Plains

While some previously forested areas in the Shire have been cleared for agricultural purposes, other areas now used for agriculture were previously native grasslands or woodlands. While it may be tempting to plant a significant amount of trees to sequester carbon, consideration should also be given to:

- The types of species used [21, 22]
- The desired use of the area, including by wildlife [23]
- Whether forest, grasslands or woodlands are more appropriate aspirations for that area
- Whether other beneficial species may be planted in the area.

Afforestation/reforestation

Planting of vegetation in areas which were previously cleared creates a net carbon sink, as atmospheric carbon is drawn down and stored within vegetation. However, once a reforested area reaches maturity, the rate of carbon sequestration matches the rate of carbon release; this area cannot continue to draw down more atmospheric carbon indefinitely. Nevertheless, if this area remains vegetated into the future, then this process results in a step change reduction in atmospheric carbon dioxide. Planting of shelter belts or pasture trees provides a carbon sink amongst agricultural operations, bringing the entire property closer to net zero emissions.

Stubble retention

Retention of stubble prevents the release of GHGs, which would otherwise be generated during burning. Much of the stubble will oxidise and return to carbon dioxide, but this process replicates a natural carbon cycle, with biomass growth in subsequent years drawing down that carbon dioxide again.

Further, some stubble will become incorporated into the soil, helping to increase heavily depleted soil carbon levels, protect soil and therefore maintain soil health, together with other beneficial outcomes such as minimising soil erosion.

Bushfire management

Ongoing work for the prevention of bushfires is vital in the Hepburn Shire. In the context of increasing risk of severe fires due to climate change, bushfire management is more important now than ever. Removal of excessive fuel loads through mechanical methods or burning are commonly adopted options for bushfire prevention. Sustainably harvesting wood also offers opportunity for helping with emission mitigation from other sectors, through providing a source of low emissions, sustainable biomass for use in offsetting fossil fuel use.

The use of goats for vegetation management is also gaining momentum locally through the Goathand Co-operative [24], as the goats can access difficult locations and reliably remove vegetation. This approach poses risks in areas with rare plant species which are palatable to livestock; however this can be managed through adequate planning around areas of significant vegetation.

Agroforestry

Agroforestry [25] involves incorporating trees into agricultural systems to be later harvested for use. With logging in Victoria's native forests to cease by 2030 [26], there is potential for a local industry to be nourished in the Hepburn Shire. This is a fitting option, considering that the town of Creswick was traditionally, and is still known as, the home of forestry.

Given the potential benefits of trees for carbon sinks, shelter belts, biomass for energy production, posts and poles, honey, habitats for biodiversity and high grade timber products [27], this option offers significant potential for reaching the goals of zero net emissions locally.

Agroforestry also builds resilience into agricultural enterprises, by ensuring that there are products to provide income in future, particularly during times of low income from other farm outputs [28].

Carbon sequestration markets

With a growing number of government bodies, organisations and individuals developing aspirations for emission reductions, there is a potential for local farms to help with filling this demand through carbon sequestration.

It is possible to go through an accreditation and auditing process for creating certified carbon offsets, however this can be an expensive and onerous process to undertake. In line with the localised focus in many other Z-NET actions, the purchase of local carbon sequestration offsets (known as 'insetting') is a potential avenue which can be mutually beneficial to the purchaser and farmer. There is interest for such a model locally; the development of a financial, auditing and governance framework around such transactions (ideally with a more streamlined verification process) could help to foster a new industry in the Hepburn Shire. This may include plantations or agricultural actions which increase soil carbon levels (discussed in later sections).

This planting and harvesting arrangement could also be extended to other end purposes, such as the sustainable supply of firewood for community or industry use.

20. https://www.industry.gov.au/sites/default/files/2020-05/nga-national-inventory-report-2018-volume-1.pdf
21. http://anpsa.org.au/sgap1a.html
22. https://apsvic.org.au/how-to-select-the-right-plant/
23. https://www.hepburn.vic.gov.au/wp-content/uploads/2018/08/Hepburn-Biodiversity-Strategy-Version-2.4.pdf
24. https://goathand.blogspot.com/
25. https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/forestry/plantation-farm/ffrole.pdf
26. https://www.ces.vic.gov.au/articles/victorian-governments-action-long-term-sustainability-victorias-native-timber-forests
27. https://www.agrifutures.com.au/wp-content/uploads/publications/09-015.pdf
28. https://www.agrifutures.com.au/wp-content/uploads/publications/04-069.pdf

Case Study

Agroforestry – The role of regenerative approaches to forestry

Hepburn Shire and the Wombat Forest have a long history of forestry. In the 21st Century, with the advent of climate change, the focus has shifted from use of the public forest estate to the role that private farm forestry can play in securing a climate-safe future.

Farm forestry has the potential to sequester significant quantities of atmospheric carbon with a recent South Australian study [29] determining an average sequestration of nine tonnes of atmospheric CO2 per hectare per annum across a range of plantation sites.

Managed on a long rotation and selectively thinned, these types of private forest assets have the potential to sequester consistent annual levels of carbon in perpetuity, with continuous tree/canopy cover.

Further, local landowners have recently begun to realise the financial benefits of private forest assets established in the early 2000s. These plantations are now being strategically thinned, taking trees of poor form for firewood and fencing, and leaving trees to grow on to become valuable timber trees in the coming years.

Locally produced firewood from plantations has been shown by CSIRO [30] not only to be more carbon efficient than other domestic heat-sources, but to entail a net carbon benefit. Additionally, these assets, managed for continuous canopy cover have the potential to contribute to local biodiversity conservation efforts in concert with conservation zones, biolinks and re vegetation.

Local firewood supply reduces pressure on other woodland ecosystems from the felling and import of trees for firewood. These sources often have low transparency and low traceability.

Overall, local farm forestry models have the potential to contribute to a range of UN Sustainable Development Goals, chiefly Goal 8 (Decent Work and Economic Growth), Goal 12 (Responsible Consumption and Production) and Goal 13 (Climate Action). Managed well, local farm forestry also contributes Goal 15 (protecting, restoring and promoting the sustainable use of terrestrial ecosystems, including sustainably managing forests, halting and reversing land degradation and halting biodiversity loss) [31].

wood4good [32] is a Central-Victorian-based start-up that practices regenerative forestry to develop high value timber assets and outputs alongside net environmental benefits. These benefits can be measured in terms of carbon sequestration, biodiversity, soil restoration, localised microclimatic impacts and hydrology.

Regenerative forestry methods aim to restore degraded landscapes by establishing, utilising and managing multi-age, multi-species forest assets. These are selectively thinned and managed for perpetual tree and canopy cover.

Initial planting densities at establishment are very high, resulting in a 're-set' of the site, crowding out introduced species. Selective thinning occurs over 15 years to deliver high-value timber outputs, and importantly, to actively promote regeneration and establishment of native under and mid-storey plants.

Placement of these assets near and around areas of strategic or high conservation value ensure that there is additional benefit as the forest cover acts as a buffer to those conservation zones, providing additional range for endemic species, and reducing open range and edge impacts of predator and pest species.

wood4good currently manages 600 hectares, across eight separately-owned properties, and employs 6 people. It markets ethical firewood across the region and into Melbourne along with class-1 durable timbers harvested regeneratively from sites across the region.

29. http://www.environment.sa.gov.au/files/841bbdf6-7752-4031-b3aa-9f1e010048d6/kb-report-carbonsequestrationbiomassagroforestry.pdf
30. https://ceresfairwood.org.au/wp-content/uploads/2020/05/greenhouse-gas-emissions.pdf
31 https://sdgs.un.org/goals
32 https://www.wood4good.com.au/

4 Soil Carbon

Emissions attributable to soil carbon include:

Loss of soil carbon

Agricultural is one of the major contributing factors to the loss of soil carbon globally. While this degradation has been occurring for thousands of years, its rate has accelerated in the past 200 years or so. In addition to several detrimental impacts including loss of soil health and structure, water retention and microbial activity, this loss of soil carbon has led to an increase in atmospheric carbon dioxide. Globally, losses in soil carbon are estimated to be 133 billion tonnes since the beginning of agriculture (12,000 years ago) [33].

Soil carbon emission reduction opportunities

Soil carbon is a lesser discussed option for addressing climate change, but offers potential avenues for significant sequestration. Unlike vegetation, the metrics for sequestration of carbon in the soil are not as widely and comprehensively discussed as a long term carbon sequestration option. This may be due, in part, to the volatility of soil carbon levels and ease with which soil carbon can be lost. Nevertheless, significant loss of soil carbon has occurred because of agriculture and land use, and stemming or reversing this loss is an important avenue to consider.

Preventing further loss

Protection of topsoil is considered paramount in most farming operations. Farmers know that in many instances bare soil risks, or sometime guarantees, erosion. Nevertheless, high tillage, chemical fallowing, and long periods of low or no ground cover are still regular components of many agricultural operations and commodities, including in the Hepburn Shire. Practices such as stubble retention, low and no-till cropping, or increasing of perennial pastures are potential actions to protect soil erosion and, in a similar manner, reduce the loss of soil carbon.

Grazing management

Variations of rotational grazing are commonplace amongst many livestock graziers. Holistic planned grazing [34] is one such method, which is aimed at closely replicating the high intensity, short grazing periods experienced in natural ecosystems. This methodology involves managing pastures around the plant's growth, in order to maximise above and below ground biomass (among other benefits). Grazing management has been shown to achieve increases in soil carbon, water infiltration and retention, soil health and structure, nutrient availability and, ultimately, yield.

Cover cropping

Cover cropping is a method commonly used between annual primary or 'cash crops', or when rejuvenating a paddock, in order to achieve a beneficial outcome for the paddock/soil. This may be to prevent leaving a paddock fallow, to build organic matter, or other objectives. Cover cropping, particularly multi-species cover cropping, is rapidly gaining popularity due to its potential soil health benefits.

Multi species cover cropping involves sowing a combination of dissimilar species, ranging from around 4 species, but commonly up to 8-12. In some instances, farmers are establishing and maintaining pastures ranging from 20 to over 100 species. Multi species cover crops often include a combination of legumes, brassicas, grasses, cereals and pseudo-cereals, forbs and others, which are then grazed, cut, terminated and re-incorporated as green manure (for example with a crimper/roller), or potentially harvested.

This diverse crop provides:

- Soil cover as an alternative to fallow
- Feed for livestock
- Fast growing species which fix nitrogen
- Fast growing species with large tuber roots, which aid in breaking up compaction
- Potential for inclusion of perennials to gradually increase consistent biomass
- Diverse species which help build soil microbiology, while supporting diverse invertebrate and vertebrate species.

Growing cash crops using two complementary crops is also a possible option, with intercropping trials being conducted in broad acre applications [35]. The objective here is to harvest both crops simultaneously, with seed later separated prior to sale. This approach aims to increase yield through improved performance of both crops when sown together.

Pasture cropping

Pasture cropping is a method which incorporates high intensity grazing and cropping, in order to achieve improved yield and soil health outcomes.

Perennial pastures are rotationally grazed heavily, outside of their growing season, prior to being sown with a single or multi-species annual crop. The fast growing annual can become established in the dormant pasture, although will likely achieve a reduced yield due to being sown within the perennial pasture. Once harvested or grazed, the perennial pasture is again coming into its growing season.

Pasture cropping offers the potential to combine the fast growth of annuals, together with the year-round ground cover and high biomass growth of perennials, to achieve increases in soil carbon and corresponding beneficial outcomes.

33 https://www.pnas.org/content/114/36/9575.full
34 https://savory.global/holistic-planned-grazing/
35 https://www.thehorshamtimes.com.au/intercropping-a-new-way-of-farming

Case Study

Soil carbon – Brooklands Free Range farms

Brooklands Free Range Farms breeds rare Berkshire pigs and British White cattle for meat consumption on their farm at Blampied, in the Hepburn Shire, which are then sold through local avenues such as farmers' markets.

A range of different actions are implemented across the business, in order to reduce environmental impact and build soil health on farm, and in turn produce healthier animals and food. Pigs are supplemented with whole food waste from businesses, which would otherwise be waste product, while cattle are fed entirely on pasture. Every few days, livestock are rotated around different paddocks on the property - ensuring heavy animal impact in a paddock, followed by long rest periods to allow pasture recovery.

Multi-species forage crops are also occasionally sown following livestock grazing, which includes species that complement each other to build soil health. Some species fix nitrogen to the soil or have large tuber roots which break up compaction; others attract pollinators or other beneficial insects. All species add diversity, provide groundcover and are eventually grazed, sometimes on multiple occasions.

Use of livestock helps to break up soil, aiding with water infiltration and nutrient cycling. Additional amendments of worm tea and other biologically active materials are also applied in some areas, with formal trials currently underway on the property to determine the impact of different cover-cropping management techniques. This includes soil tests at shallow depths (0-10cm), deep core sampling (0-90cm), dry matter cuts, visual inspections, compaction tests and brix readings.

To date, dry matter cuts have shown a significantly higher yield in areas where biological amendments are applied (70% higher in some tests as at 31/8/2020), with some cropping and livestock paddocks having soil organic carbon (SOC) levels of 4.4 - 4.8% (0-10cm). Deep core sampling is planned, to determine SOC levels at depth and allow verification of changes over time. Rotational grazing has also allowed some native plants to return to the pasture, with kangaroo grass, wallaby grass and sundews being identified on the property.

Brooklands' aim is to achieve healthy soils, healthy pastures, healthy animals, and healthy food. They do this through using their animals to improve soils and sequester carbon. Use of rare livestock breeds helps to protect breed diversity, while management practices on-farm encourage biodiversity and builds farm and ecosystem health. Their sales avenues result in short supply chains – minimising transport and refrigeration costs while retaining money in the local community. Brooklands are implementing numerous small changes, resulting in the production of local food in an environmentally conscious way.

28. https://www.agrifutures.com.au/wp-content/uploads/publications/04-069.pdf
29. http://www.environment.sa.gov.au/files/841bbdf6-7752-4031-b3aa-9f1e010048d6/kb-report-carbonsequestrationbiomassagroforestry.pdf
30. https://ceresfairwood.org.au/wp-content/uploads/2020/05/greenhouse-gas-emissions.pdf

5 Agricultural inputs

Greenhouse gas emissions attributable to applying inputs to agricultural land include:

- Application of lime
- Application of fertilisers
- Application of manure

Growing food requires nutrients. In agricultural systems, where products are sold off-property (or brought onto the property) a significant and largely predictable change in those nutrient levels often occurs. The required management of this will vary between systems that are inherently extractive (such as horticulture), and those that risk too much nutrient (such as pig and poultry farming). Similarly, operations which integrate diverse, complementary products can form a closed loop farming system, where the outputs of one can be used to benefit the others.

These nutrients are often replenished through the application of external inputs, most commonly Nitrogen (N), Phosphorous (P), and Potassium (K), although a number of other elements are also added where deficiencies are identified. Manure and other inputs such as compost are also spread, when available, in order to reclaim some of those nutrients. Soil pH greatly impacts the availability of different nutrients to plants, together with other soil health outcomes, and so soil pH is also commonly adjusted through the application of lime.

These inputs are not all effectively incorporated into the soil, but instead some is lost to volatilisation, leaching and runoff. This leads to a higher rate of application being required in order to achieve the desired levels, together with the release of carbon dioxide, methane, nitrous oxide and ammonia.

Agricultural inputs emission reduction opportunities

Reduction of embedded energy in inputs can be achieved through shortening supply chains and opting for products which are inherently less resource-intensive to produce. It should be noted that the embedded energy in inputs is not considered in the scope of the Z-NET profile however, as this is considered outside of the emissions boundary.

It is often difficult to reduce direct greenhouse gas emissions where inputs are used, due to the inherent losses outlined above, which occur in the paddock. Because of the above-mentioned mechanisms, some inputs risk producing direct emissions, regardless of whether nutrients come from artificial inputs (such are urea), or more natural sources (such as manure application). For this reason, careful consideration should be given to the manner in which inputs are applied, whatever their source. Potential mitigation methods include:

Timing and volume of application

Being selective in the timing and volume of inputs applied can help to minimise losses and maximise plant take-up. Consideration of soil type is also necessary to prevent leaching into the subsoil and potentially into water sources. Another option is to use inhibitors with urea and urea-based fertilisers, in order to reduce the rate of breakdown, thereby increasing the amount of nitrogen retained [36].

Use leguminous plants

Legumes fix atmospheric nitrogen to the soil through root nodules on the plant, providing that the seed is inoculated or that the correct rhizobia bacteria are present within the soil already. While even this nitrogen can potentially volatilise and create nitrous oxide emissions, this approach reduces the concentrated application of nitrogen, and also avoids the energy intensive process which is required for creating synthetic nitrogen fertilisers.

Improve soil health

One potential pathway to reducing agricultural inputs is through improving soil health. While common practice is to measure 'plant available nutrients' and use this to determine nutrient deficiencies, proponents of soil health and regenerative agriculture propose that 'total nutrients' is also an important indicator. This is verified in several scientific papers, for example where functional soil microbiology has been shown to mediate phosphorus availability to plants; in effect mitigating the need for application of P and instead allowing plants to access P already available within the soil [37 38].

Soil microbiology is a fascinating and continually developing science, which includes many complex mechanisms relating to soil, plant, animal and human health. While it is not possible to infinitely mine nutrients from soils without replacing them, these findings on nutrient availability show that there is potential to reduce certain inputs if soil health is improved. Soil health is not just a measure of chemistry, but also soil biology; both are important aspects and interrelated.

In any case, the nitrogen component of fertilisers, which is the primary source of resultant emissions considered here, can potentially be reduced through integration of legumes, coupled with considered application of external inputs.

Application of biological inputs

Application of biological inputs such as compost, kelp, worm tea, rock minerals, biosolids or others, can work to supplement nutrient losses in the soil. Many of these still carry the same challenges around volatilisation, runoff or leaching, and so should not automatically be considered a 'no impact' alternative from a greenhouse gas emissions or environmental perspective. However, these inputs also work to build soil health, microbial activity or humus, which have ongoing soil health benefits, including increased carbon sequestration.

Further, many of these inputs (worm tea, compost, biosolids) will incorporate the same nutrients which were removed from the farm in the first place, and so there is a need to encourage these industries and ensure that nutrient rich materials are diverted from landfill, and instead returned to the land in a more circular process.

Biochar, a by-product from the bioenergy technology process pyrolysis, is another beneficial soil ameliorant. Biochar is a stable form of carbon, which can be inoculated with biologically active materials such as worm tea and added as a conditioner to build soil health and soil organic carbon levels. Biochar has also been shown to reduce ruminant emissions when added as a feedstock supplement [39]. Bones resulting from the further processing of animals for food can also be pyrolysed for bonechar, with similar properties to biochar and an increased mineral profile.

35. https://www.sciencedirect.com/science/article/pii/S2351989419306961
36. http://www.plantphysiol.org/content/156/3/989
37. https://www.researchgate.net/publication/51159777_Soil_Microorganisms_Mediating_Phosphorus_Availability_Update_on_Microbial_Phosphorus
38. https://www.frontiersin.org/articles/10.3389/fmicb.2019.01534/full

6 Non Agricultural emissions

When developing a greenhouse gas emissions profile, it is important to consider what is included in that profile and what isn't. The Z-NET profile is within the boundary of the Hepburn Shire, so emissions which are linked to agricultural products, but which may occur outside the boundary of the Shire, are not considered. Similarly, some emissions have been attributed to other sectors in Z-NET, but have clear links to agriculture (e.g. electricity, transport fuel):

Emissions arising as a result of agriculture include:

- Post-production transport
- Refrigeration
- Food waste
- Supporting industries, such as agrochemical manufacture or embedded energy in supplementary feed

These are emissions which do not necessarily fall into the remit of the agricultural sector to address, but should be highlighted. Many of these impacts can be reduced by options already discussed, such as supporting local and seasonal food, or reduced wastage. This sector is listed because, as with many actions on the path to zero net emissions, sectors are interdependent upon each other.

Non-agricultural emission reduction opportunities

Farms have an opportunity not only to reduce their own emissions footprint, but to also partner with other groups to help address some of the challenges they face in emission reductions.

These opportunities include:

Conscientious purchasing

The industries supporting agriculture have an intensive emissions footprint themselves. While this footprint is accounted for by each respective industry, it is worth noting that these actions are driven by market and consumer demand. Some notable processes include:

- Synthetic nitrogen fertiliser is created through the energy intensive Haber-Bosch process, which converts atmospheric nitrogen to ammonia
- Application of any inputs requires the extraction, processing, packaging, end-of-life disposal and/or transport of that product.
- Refrigeration of products for extended periods of time
- Transport of products, particularly when this is across vast distances to provide out-of-season products or to meet pricing constraints with imported goods
- Wasted food has a detrimental impact along the entire food supply chain, from farm through to landfill.

Organic waste to landfill

Unlike plastics or other relatively inert wastes, organic waste (predominantly food and other putrescible waste, but also green waste) sent to landfill continues to have ongoing negative environmental impacts for decades. This is because organic waste in landfill breaks down anaerobically (in the absence of oxygen), creating carbon dioxide and methane. The remaining nutrient rich resources are also lost from our food system, and risk leaching into ground or surface water supplies.

One opportunity is for food and garden organic (FOGO) collection to be implemented in the Hepburn Shire and be directed to generate renewable energy through anaerobic digestion, or be composted responsibly on local farms or at composting facilities. This process would remove organic waste from landfill, thereby preventing the release of methane into the atmosphere. Given the Hepburn Shire's relatively low volume of waste and large area, opportunity exists to have localised processing facilities serving the Shire's main towns. This would reduce transport requirements, while recovering nutrients locally.

Source of biomass for energy generation

Renewable energy, including electricity and also heat, can be largely met by extracting energy from biomass. Agricultural industries cover significant land area and have huge amounts of biomass which are currently undervalued or wasted entirely. Because of this, agriculture can potentially become a net exporter of renewable energy, as is the case in many other parts of the world.

This may be through using existing resources for anaerobic digestion to create electricity and heat, or combustion of existing agricultural residues such as straw. Further, there is scope to increase existing supplies of biomass, such as forestry residues. Planting trees on-farm provides several benefits – shelter belts, which improve livestock performance; increases in stored carbon on-site; habitat for wildlife; revenue from high-grade timber; and ongoing supply of biomass for energy supply to domestic and industry markets.

Medium-scale renewable electricity generation

Renewable energy generators, co-located with farming operations, provide emission reductions and financial security for landholders. While many regions have many large scale generators, Hepburn Shire only has the two wind turbines at Hepburn Wind's Leonards Hill site. Integrating more small to medium generators around the Shire offers opportunity for the local communities to retain ownership of this energy transition, while ensuring appropriate development. This aligns with the need for more mid-scale energy projects to be built in order to meet the ambition of zero-net energy by 2025.

Case Study

Waste case study - Hepburn Shire Council

The State Government's Recycling Victoria: A New Economy is a 10-year policy and action plan that includes the introduction of a Food and Garden Organics (FOGO) service and an increase to the landfill levy. As a result, councils across Victoria are, or will be, seeking solutions to divert FOGO from landfill. Hepburn Shire Council understands the need to develop additional methods of processing FOGO to meet the Shire's waste disposal requirements and reduce emissions.

HSC are investigating methods to process FOGO into compost that can be used as soil conditioner. They are taking a two-pronged approach to this: the first is to develop a forced aeration composting model to be used on site and managed by HSC. The second is to pilot a distributed model, where landholders (such as farmers with acreage and adequate setbacks) can receive small portions of FOGO to compost and use onsite or sell (subject to conditions). Each project approach is being examined for risks and benefits, but HSC are committed to understanding the processing of FOGO within the Shire.

C

Actions

How the agricultural sector can support renewables in the Shire

To reach 100% renewable electricity supply, the electricity component of approximately 60,000MWh is to be offset by 2025. A portion of this 2,487 tCO2-e can be reduced on-farm through local farms switching to renewable energy. The balance could be supplied by more rooftop solar and mid-scale generation (from a range of technologies) across the Shire. Local farms could host mid-scale projects on behalf of the community, this can be a mutually beneficial exchange as farms collect reliable rent in exchange for hosting the infrastructure on their properties. The local grid infrastructure is currently largely limited to low voltage and distribution level supply, with a single 220kV transmission line across a small area of the Shire.

In regards to rooftop solar PV, approximately 10,000MWh could be reduced through 50% penetration of solar PV on 1254 households – a further 6.2MW of new rooftop solar deployed in the Shire.

The remaining supply could be locally provided through more mid-scale (1-10MW) grid connected generation projects. 50,000MWh could be provided through 2-5 local projects dependant on technology and the scale deployed. This could look like a combined total of 20MW of wind or 30MW of solar (or a combination of technologies) and could also consider the role of bioenergy in the mix.

Case Study

Renewables case study – Hepburn Wind

There are new innovations in how to deploy solar farms in ways that are appropriate for local land use. The community-owned co-operative Hepburn Wind is planning to build a sensitively designed solar farm next to the existing wind turbines, on Leonards Hill. The proposed solar farm at 7.44MW will almost double the co-operatives energy generation, offsetting another 1,500 homes and making a substantial contribution to the Shire's zero-net energy target for 2025 and zero-net emissions for 2030. The hybrid facility has also allowed for a future battery storage facility of 10MWh.

The co-operative seeking has used best practice 'sensitive' design principles to minimise impacts on the valuable agricultural land and to the neighbourhood. For example, the solar array will be placed on the least arable area on the farm, using a technology which reduces the footprint of the solar system by over 50% and the arrays will be a mixture of east-west and north-south orientation which means they can fit the system to the natural topography and not undertake earthworks or topsoil removal. The site's generation infrastructure is sized to match current grid constraints; the location of generators considers the potential impact to the surrounding environment and visual amenity and the site remains a functional and productive farming operation.

Non-emissions considerations

In addition to the challenges of climate change, the agricultural sector faces other challenges too. While these challenges are not the focus of this Guide, consideration of them is necessary to ensure that this transition can achieve as many beneficial outcomes as possible.

Food security

The outbreak of COVID-19 in 2020 has had far-reaching impacts. Almost universally, it has highlighted the fact that a global economy carries risks from biosecurity, long supply chains, and intensive and seasonal labour markets. Locally, these challenges have been addressed by a noticeable shift towards communities supporting local producers and retaking ownership of aspects of their food supply. There would be a significant risk to local communities if the market supply challenges of 2020 were compounded with food shortages, due to climate change and other environmental degradation impacts.

Loss of biodiversity, in commodity products and natural ecosystems.

As market demands drive practices towards high volume, low margin products, there has been a loss of biodiversity across farming operations. A similar loss of diversity can occur as smaller farms are sold off and consolidated into larger operations. While transitioning to zero net emissions, it is important to ensure that the pathway fosters the increase of biodiversity.

Loss of topsoil

It is estimated that half the world's topsoil has been lost in the past 150 [40] years, and that all topsoil could be lost within 60 years [41] if current rates of decline continue. It is vital to ensure that topsoil loss is reversed, and in doing so many of the climate change mitigation outcomes can also be achieved. Great progress has already been made in preventing topsoil loss, through adoption of minimum till cropping.

Climate change adaptation

Adapting to the climate change impacts already occurring, and locked in to occur, is a vital step for the agricultural sector. With climate modelling predicting temperature increases of at least 1.5˚C [42], coupled with a reduction in rainfall, the agriculture sector will be heavily impacted. This means that the zero net emissions transition may not just be dictated by a desire to mitigate climate change, but also but a need to change commodities and farm differently in order to adapt to its impacts.

Environmental impact of inputs

As food systems have become more industrialised, there has also been a shift towards high input systems which use more fertilisers, pesticides, herbicides and other products. While these products are serving a purpose, their application must be considered and moderated to achieve the desired outcomes while minimising environmental impacts. Further, there is opportunity to shift to lower impact inputs, particularly those that are by-products of more circular industries, such as digestate from anaerobic digestion.

[40] https://www.worldwildlife.org/threats/soil-erosion-and-degradation
[41] https://www.scientificamerican.com/article/only-60-years-of-farming-left-if-soil-degradation-continues/
[42] https://www.csiro.au/en/Research/OandA/Areas/Oceans-and-climate/Climate-change-information

Developing an on-farm plan to reach Z-NET

Agriculture is an industry continually undertaking change. Farmers have shown time and again that they can quickly change direction based on conditions, whether market or environmentally driven. Climate change presents an opportunity to improve environmental outcomes, and in doing so achieve improved outcomes in other sectors. In agriculture, the range of environmental challenges covers numerous sectors, and there is a need to consider these challenges and potential solutions holistically.

Don't let the perfect be the enemy of the good.

Few people know the entire pathway to zero net emissions in agriculture, but many know a few steps that could help along the way. Don't be so worried about not getting it perfect that you don't do anything at all.

Planting the "wrong" tree species will still yield a tree, or selecting the wrong sized solar system will still reduce your demand on fossil fuels. The most important thing is to get started, and there will be more opportunities to perfect it down the track

Developing an on-farm plan to emission reduction is an important step in this process. As a guide to potential areas for focus and actions, an on-farm plan to emissions reduction could include:

Determine what you would like to achieve

For example year-round groundcover, carbon neutrality, increased diversity, increased soil health, value chain control, all-electric, or other aspirations.

Pull together details of your current operation

Size of farm, current commodities, fuel and electricity usage, existing vegetation, and any other relevant data.

Develop an estimate of your current emissions footprint.

This doesn't have to be perfect, in fact it rarely will be. Starting somewhere gives you a basis for improvement, and on-the-ground actions are the most important thing of all. For details on emission profiles, refer to online tools from Z-NET.

Speak with other farmers, government and industry bodies

Listen to what are others are doing to address climate change and try to develop some projects which you could complete to begin your journey to zero net emissions. There is no need to start with a huge capital outlay; pick something that you can achieve with your current resources.

Implement the project

Keep records of your results, including successes, outcomes and failures. It's unlikely that you will achieve a zero net emissions farm in one go, but everything needs to start somewhere.

Evaluate, modify and expand your actions

Assess what went well and improve what didn't. Modify crops, grazing management, tree species, pumps, or whatever else is needed, based on what you learn. Speak with others for guidance, and give guidance in return. Once you have achieved your goal in one area, you can move onto the next.

There are several agricultural or food production methodologies and ideologies which challenge the status quo of our food production systems, and offer alternatives. The steps which will help mitigate - and hopefully reverse - agriculture's role in accelerating climate change are those that focus on conserving and regenerating the land; on considering systems as a whole; on looking outside the box to grow food in a holistically and environmentally responsible way.

This Guide is not a complete outline of climate change mitigation, but aims to paint a picture of the different sources of agricultural emissions and potential solutions to addressing them. In this ever-evolving field, there are sure to be changes required, and this document will be updated periodically to reflect the current best-practice approaches.

In the meantime, interested farmers and community members are encouraged to engage with their local groups, such as Landcare or other groups focussing on local food, regenerative agriculture, permaculture, food sovereignty or a suite of other issues.

Perform trials, follow research conducted, speak with others, and implement improved practices wherever possible. It is a long road to achieving zero net emissions from agriculture, but it needs to start somewhere.

Conclusion

The imminent risk of climate change is now widely accepted, with an impetus for net zero GHG emission to be achieved by 2030 in order to mitigate the worst impacts of climate change. As the largest emissions sector for the Hepburn Shire, and the fourth largest sector nationally, opportunity exists for the local agricultural sector to set about reducing its greenhouse gas emissions.

It should be noted that, while agriculture represents a significant portion of the Z-NET profile, it presents an opportunity to dramatically reduce and reverse its contribution to greenhouse gas emissions. Unfortunately, it may prove more difficult to reverse the impact of other sectors, such as electricity and transport, which have released huge amounts of fossilised carbon into the atmosphere.

Consequently, it is now clear that mitigation of climate change is no longer adequate; adaptation is necessary for the climate change impacts already underway. This will be a major transition, and the pathway to zero net emissions is not yet clear; however there are many groups already well down the path to achieving this.

By facing these challenges now, while also considering the non-emissions aspects of the transition, it will be possible to maintain a resilient agricultural industry into the future.

Community programs to reach Z-NET

Hepburn Z-NET has released a one-stop-shop for climate action www.hepburnznet.org.au, and the key agricultural options are available here www.hepburnznet.org.au/action/farm some current programs and links are listed below:

- The Hepburn Solar Bulk-Buy : https://hepburnznet.org.au/program/hepburn-solar-bulk-buy/
- The Z-NET Home Energy Assessments and Energy Savvy Upgrades Program: https://hepburnznet.org.au/program/z-net-audit-and-retrofitting-support/
- EV Bulk Buy: https://hepburnznet.org.au/program/ev-bulk-buy
- Electric Vehicle Charging Stations: https://hepburnznet.org.au/program/ev-charging-network
- Business Environmental Upgrade Finance: https://hepburnznet.org.au/program/business-environmental-upgrade-finance

Additional groups near Hepburn that you can get involved with:

- Farmers for Climate Action: www.farmersforclimateaction.org.au/
- North Central Catchment Management Authority : www.nccma.vic.gov.au/projects/agriculture#node-2041
- Central Victorian Regenerative Farmers
- Victorian Bioenergy Network
- Australian Food Sovereignty Alliance: www.afsa.org.au/
- Carbon Farmers of Australia: www.carbonfarmersofaustralia.com.au/
- Vic no till: www.vicnotill.com.au

Further reading and reference list

Is available as an Appendix at: www.hepburnznet.org.au/action/farm

znet
HEPBURN SHIRE