AWRI Australian Wine Research Institute

Pilot learning module

Questions and answers

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Topic 1. Breakdown of emissions

For winery emissions, what fraction of GHG emissions are ferments in the winery responsible for?

Around 8% of the total CO2 emissions for the Australian wine sector are from fermentation of grapes (Emissions Reduction Roadmap, 2023). CO2 emissions from fermentation are regarded as 'biogenic CO2' and therefore not required to be included in carbon accounting. Biogenic CO2 comes from biological sources that participate in the short-term carbon cycle. The CO2 released during fermentation is that which the vines pulled out of the atmosphere during the annual year's growth.

How much carbon dioxide is actually produced during fermentation?

The exact amount of CO2 produced during fermentation depends on the sugar content of the grapes, the yield, and the final wine volume.

- According to the 2024 AWRI Annual Report "Fermentation emits around 80 kg of carbon dioxide from each tonne of grapes fermented (the exact amount varies with grape sugar content and yield)." (Robinson and Krstic 2024)
- In addition, Smart et al. (2023) report that "Wine fermentation results in carbon dioxide emissions of approximately 56 L CO2 per litre of wine (Boulton 2019), which is equivalent to 0.11 kg CO2e/L" (p. 3, (Smart et al. 2023))

What fraction of GHG emissions relate to CO2 used to cover wine?

A general number cannot be provided in this case. The fraction of GHG emissions related to CO2 used to cover wine depends on many factors related to your winery's practices, such as how many transfers, how many emptyings/filtrations/rackings, tank sizes, how often you "top up," whether you're making still or sparkling wine, etc.

Is there a way to reuse the CO2 used to cover wine?

The economics of doing this are challenging at present; however, there have been some projects focusing on this area:

- Presentation at WINE ENG 2024 (Barossa, SA) titled "Ferment CO2 capture" (Nordestgaard and Summers 2024) (link to the YouTube video can be accessed by using the link in the reference)
- Simon Nordestgaard wrote a LinkedIn post related to 2025 vintage trials mentioning that "Capturing and reusing fermentation CO2 in wineries is not a simple task. For example, the seasonality of ferments is an economic challenge not faced to the same extent by other fermenting industries like breweries. However, with the different groups innovating around the world to develop cost-effective systems that suit the specifics of the wine sector, I hope that ferment CO2 reuse can become a common practice that brings greater self-sufficiency to wineries. Initially, it will most likely be focused on reuse during the vintage period, but in the future it may be expanded in other ways, such as through reciprocal arrangements with other industries and existing CO2 supplier networks, wineries fermenting juice or other locally available feedstocks outside vintage, or possibly through the development of novel approaches to CO2 storage." (Nordestgaard 2025) (full text can be accessed by using the link in the reference)
- A recent Wine Australia-funded study (AWR 2301), completed in 2023, with Simon Nordestgaard as Chief Investigator, included a review of options for recovering carbon dioxide (CO2) from winery ferments (Nordestgaard 2023) (full text can be accessed by using the link in the reference)
- A company called Grapeworks (https://grapeworks.com.au/) has the CO2 Winery system in Australia and might be willing to be contacted to explore trials, installations, etc.

Does the CO2 per bottle of wine take into consideration the CO2 that the vines use as well?

No, it does not. The CO2 that vines use is considered 'biogenic CO2' and part of the short-term carbon cycle, which is excluded from carbon accounting and treated in the same way as the CO2 released during fermentation.

Is it possible to break down the emissions considering regional differences?

Our longer-term plan is to produce regional emissions reports, but this is not a currently available feature through the Sustainable Winegrowing Australia program.

Topic 2: Use of diesel

What is a better way to mow, either (1) mowing more often = more tractor passes = more diesel used, or (2) mowing less often = fewer tractor passes but more power use (the grass is taller) = more diesel used?

Tractor emissions are proportionate to the amount of fuel used. Anecdotally, fewer passes are likely to result in lower overall emissions, even if the machinery has to work a bit harder if the grass is a bit longer, because the total amount of emissions produced for the slashing is weighted to the 'run time'.

In terms of GHG emissions, is it better to run my diesel plant during the night, or during the day?

Generally, emissions will be lower from diesel plants run during the day rather than the night, especially if in a location where nights are cold and therefore cold air is entering the diesel engines when first started up. Modern diesel tractors often have an oxidation catalyst, a diesel particulate filter, and a selective catalytic reduction system (that controls nitrous oxide emissions). All three of these require minimum operating temperatures to function well and will lead to higher nitrous oxide emissions until the system heats up and the emissions controls become effective.

- Ramadhas and colleagues (2014) undertook engine startability and idling tests on the latest generation of diesel engine in a cold cell at various ambient temperatures ranging between +20°C and −20°C and found that the exhaust emissions during the cold start and idle conditions were higher at very cold ambient conditions compared to normal ambient temperatures (Ramadhas et al. 2014).
- In another study, Ramadhas and colleagues (2016) also note that
    - "Cold start performance of diesel engines is determined by engine design, fuel type, fuel injection strategies, lubricant and ambient temperature conditions." (p. 3330)
    - "Heating of intake air entering the engine at cold ambient temperature conditions improved fuel combustion as well as reduced the cranking period and improved the fuel economy." (p. 3330)
    - "17% reduction in NOx emissions were achieved by intake air heating." (p. 3330) (Ramadhas et al. 2016)
- Avoidance of unnecessary idling will also help reduce emissions. A study found that turning off the engine conserves fuel for idling stops longer than 4.4 seconds (Varani et al. 2022)

In terms of GHG emissions, is there a better diesel type to use?

When looking at the relative impact of use of one fuel type compared to another, we can compare the tonnes of CO2-equivalents associated with the use of various diesel types as reported in the Federal Government's Australian National Greenhouse Accounts Factors. We can model an answer based on 1kL of fuel used, which shows that biodiesel could be considered the 'better fuel type to use' when looking at scope 1 emissions alone.

Just looking at Scope 1 emissions, the formula used is:

total tonnes CO2-e = (Volume fuel consumed x energy content of the fuel x scope 1 emissions factor)/1000.

Therefore:

Scope 1 emissions	Formula	Results (total tonnes CO2-e)
Diesel oil	(1kL x 38.6 GJ/kL x 70.2kg CO2-e/GJ)/1000	2709.72
Renewable diesel	(1kL x 38.6 GJ/kL x 0.30 kg CO2-e/GJ)/1000	0.01158
Biodiesel	(1kL x 34.6 GJ/kL x 0.28 kg CO2-e/GJ)/1000	0.0097

Topic 3. Sheep in the vineyard

Can feeding sheep grape marc reduce their GHG emissions?

According to a report released by Meat & Livestock Australia about lowering methane emissions and raising productivity in Australia's livestock industries "Feeding grape marc [...] has been shown to reduce methane emissions in dairy cows, sheep and cattle in feedlots. [...] In practice, the impact of feeding grape marc on both methane emissions and productivity is variable because grape marc samples vary in active tannin content and have a low energy content for animals." (p. 8, (MLA 2015)). Sheep findings included "Up to 10% reduction in emissions and maintenance of animal weight when offered to sheep during the spring-autumn period." (p. 8, (MLA 2015)). A link to the full report can be found in the reference.

Note that aspects such as agrochemical residues and per cent integration into diet would also need to be considered.

In terms of GHG emissions, would feeding grape marc to the sheep as part of their pasture-based diet, be better or worse than grass-fed?

Based on the answer above, it seems likely that purely from an emissions perspective, supplementing a sheep's grass-fed diet with grape marc has the potential to result in lower methane emissions compared to a purely grass-fed diet.

In terms of GHG emissions, would making silage from the marc and then feeding it to the sheep be better or worse than grass-fed?

Generally speaking, the relative amount of methane emissions produced by animals depends on the amount of dry matter with readily digestible carbohydrates in their feedstock – the higher the readily digestible carbohydrates, the lower the methane emissions. Regarding silage, an advantage of utilising grape marc as a silage is its high oil and tannin content relative to other silage forms (for example, maize), which provides the potential to reduce the generation of methane within the rumen (Moate et al. 2014).

Note that, if factoring in the emissions relating to creating the silage, other factors such as the size of the operation would also need to be evaluated.

For vineyards, what fraction of GHG emissions would grass-fed sheep be responsible for?

The fraction of GHG emissions for which grass-fed sheep are responsible depends on the vineyard size, emissions relating to operating the vineyard, but also how many sheep are being run and for how long in the vineyard over the year, as well as the emission scopes being included and reported. It is also important to consider the potential savings in emissions from machinery use related to weed control and slashing. Traditionally, when emissions from vineyards were quantified, those from livestock were not included, given that they are a side component of the winegrape production. However, as reported by Meat and Livestock Australia, "Methane is a potent GHG and, in Australia, about 10% of all national emissions and two-thirds of agricultural emissions come from enteric methane produced by cattle and sheep." (p. 3 (MLA 2014)).

An 8.3 ha vineyard involved in Agriculture Victoria's On-farm emissions action plan pilot that also runs 120 head of sheep that graze in the vineyard pre-fruiting and post-harvest, including scope 1, 2 and 3 emissions* found that 84% of their emissions come from the enteric methane produced by their sheep, with the remainder from their vineyard, including electricity, fuel, and fertilisers (Nuttall 2024). The article can be accessed by using the link in the reference.

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

Finally, an AWRI case study that includes some estimated emissions and cost savings from the use of sheep can be found at this link: Grazing sheep in vineyards

Topic 4. Sustainable Winegrowing Australia/Freshcare audits, and this learning module

Why were the sustainability topics of greenhouse gas management (focused on emissions reporting) and biodiversity conservation grouped together in this learning module, despite being separate focus areas in Sustainable Winegrowing Australia/Freshcare audit frameworks?

It is correct to query why this learning module included both biodiversity and greenhouse gas emissions, noting that they are presented as different chapters as part of the Sustainable Winegrowing Australia workbook and in the Viticulture and Winery Sustainability Standards.

While these are both sustainability topics in their own right, the learning module was not aimed at making a direct link between them, but to introduce topics that might interest different people. In future, if the learning module's way of presenting a topic area is a method we adopt, we will keep to a singular topic to avoid confusion.

References and further reading

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