



Report

Hills and Fleurieu Landscape Board – On-Farm Emissions Forecasting

Project staff and contacts

Affinity Labs / AWRI contact: Kieran Hirlam, Project Team Manager, Affinity Labs
M: 0414 935 441, kieran.hirlam@affinitylabs.com.au,
PO Box 197 Glen Osmond SA 5064

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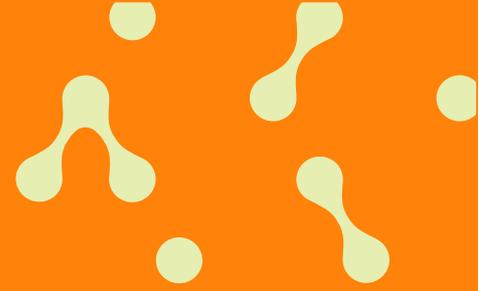
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1. Introduction

The Hills and Fleurieu Landscape Board recently engaged Affinity Labs, the commercial arm of the Australian Wine Research Institute, to undertake an emissions baseline for the Hills and Fleurieu region, specifically focusing on viticultural emissions. As an extension of this regional profiling, the Hills and Fleurieu Landscape Board further engaged Affinity Labs to narrow the focus of the profiling, assessing targeted Scope 1 emissions for vineyards with the intention to forecast regional emissions in line with such forecasting undertaken for other sectors.

The focus of the forecasting is stated to be on Scope 1 emissions. In agriculture, scope 1 emissions are those which are directly resulting from on-farm agricultural activities such as fuel combustion, fertiliser application, and livestock management, each of which are emissions over which producers and land managers have the greatest direct influence. Scope 2 and 3 emissions, related to off-farm energy use and supply chains, are excluded from this analysis and considered the responsibility of other sectors such as industry and energy.

The objectives of this work are to:

1. Estimate current total Scope 1 emissions from vineyards in the Hills and Fleurieu region, leveraging existing regional emissions data generated by Affinity Labs.
2. Forecast total vineyard emissions out to 2050 under a business-as-usual (current practices) scenario, accounting for expected industry trends such as shifts in vineyard area, climate change impacts, and market conditions.
3. Develop two emissions reduction scenarios to 2050:
 - a. Baseline Adoption Scenario – estimating realistic reductions based on the technical mitigation potential and anticipated adoption driven by market forces alone.
 - b. Stretch Target Scenario – modelling the potential for greater or earlier uptake of emissions-reducing practices enabled by improved education, extension services, and pro-active policy support.

This report is intended to serve as both a baseline reference and a strategic tool to inform the region's emission reduction planning efforts. By focusing on Scope 1 emissions from vineyards, it highlights the actionable opportunities available to producers and supports the development of practical, regionally relevant solutions to reduce agriculture's climate impact.

2. Reviewing the Hills and Fleurieu Emissions Profile

Based on the previous emissions profiling undertaken by Affinity Labs, cradle-to-gate greenhouse gas (GHG) emissions baselines for wine grape production across the Hills and Fleurieu Landscape Board's regional geographical indications (GIs) are presented within Table 1 below. This data incorporates the calculated figures for net vineyard emissions for each GI region based on 1 ha of planted vine and 1 year (defined functional unit), multiplied by the known vineyard area for each GI region. This emissions profiling uses existing Sustainable Winegrowing Australia (SWA) datasets to quantify on-farm emissions sources.

Outcomes have been disaggregated by GI zone (Adelaide Hills, McLaren Vale, Langhorne Creek, Currency Creek, Southern Fleurieu), with calculations undertaken through an LCA software platform (SimaPro) for transparency and replicability.

Table 1: Cradle-to-gate GHG emissions baselines for wine grape production across the Hills and Fleurieu Landscape Board's regional geographical indications (GIs).

Emissions Category	Adelaide Hills	Currency Creek	Langhorne Creek	McLaren Vale	Southern Fleurieu
GHG Emissions Intensity (t CO ₂ -e / t crop)	0.267	0.23	0.2	0.16	0.267
Median Yield (t/ha)	5.46	4.54	5.3	5.68	3.44
GHG Emissions per ha (t CO ₂ -e/ha)	1.46	1.04	1.06	0.91	0.92
Vineyard area 2020 (Ha)	3832	1054	6094	7173	488
GI Region Emissions (t CO₂-e)	5586	1100	6459	6519	448
Total Emissions Baseline (t CO₂-e)	20,112				

The direct and indirect emissions contributing to the net vineyard emissions across the regions of the Hills and Fleurieu Board's coverage are detailed in Table 2 below.

Table 2: Net vineyard emissions summary for each GI region based on 1 ha of planted vine and 1 year.

Emissions Category	Adelaide Hills	Currency Creek	Langhorne Creek	McLaren Vale	Southern Fleurieu
GHG Emissions Intensity (kg CO ₂ -e / ha)	1457.82	1044.2	1060	908.8	918.48
Electricity	606.06	281.48	180.2	289.68	209.84
Diesel	480.48	345.04	397.5	306.72	227.04
Irrigation	223.86	258.78	312.7	193.12	147.92
Fertilizer Emissions	38.22	13.62	79.5	45.44	72.24
Synthetic Nitrogen	27.3	72.64	31.8	22.72	192.64
Petrol	21.84	13.62	21.2	22.72	48.16
Input Transport	21.84	0	0	0	0
Grape Transport	10.92	0	0	0	3.44
Natural Gas	5.46	31.78	5.3	5.68	3.44
Urea	5.46	9.08	5.3	5.68	0
Organic Nitrogen	5.46	13.62	0	5.68	0
Crop Residues	5.46	0	15.9	5.68	13.76
Urea Hydrolysis	5.46	4.54	0	0	0
PMS	0	0	0	0	0



2.1 Scope 1 Emissions profile

As previously discussed, Scope 1 emissions refer to direct greenhouse gas emissions that occur from sources that are owned or controlled by the reporting entity, in this instance vineyards within the Hills and Fleurieu region. Based on the Scope 1, 2 and 3 Carbon Footprint of the Australian Grape and Wine Sector 2020-21 which was undertaken as part of the Australian Wine Industry developed Emissions Reduction Roadmap, Scope 1 emissions for vineyards fall under three primary classifications:

- Fuel consumption
 - Direct emissions from the combustion of mobile and stationary fuel
- Nitrogen fertiliser use
 - Direct emissions from the use of nitrogen fertilisers when applied in farms
- Crop residues
 - Direct emissions from crop residues decomposition when left in the fields of vineyards.

Hence, refining Table 2 above, the calculated Scope 1 emissions from vineyards in the Hills and Fleurieu region is presented in Table 3. Represented in Table 4 is a more simplified version, framing Scope 1 emissions into the three categories as above (i.e. Fuel, Fertiliser and Crop Residues).

Table 3: Scope 1 vineyard emissions summary for each GI region based on 1 ha of planted vine and 1 year.

Emissions Category	Adelaide Hills	Currency Creek	Langhorne Creek	McLaren Vale	Southern Fleurieu
Scope 1 GHG Emissions Intensity (kg CO ₂ -e / ha)	556.92	490.32	477	374.88	485.04
Diesel	480.48	345.04	397.5	306.72	227.04
Synthetic Nitrogen	27.3	72.64	31.8	22.72	192.64
Petrol	21.84	13.62	21.2	22.72	48.16
Natural Gas	5.46	31.78	5.3	5.68	3.44
Urea	5.46	9.08	5.3	5.68	0
Organic Nitrogen	5.46	13.62	0	5.68	0
Crop Residues	5.46	0	15.9	5.68	13.76
Urea Hydrolysis	5.46	4.54	0	0	0

Table 4: Categorized Scope 1 vineyard emissions summary for each GI region based on 1 ha of planted vine and 1 year.

Emissions Category	Adelaide Hills	Currency Creek	Langhorne Creek	McLaren Vale	Southern Fleurieu
Scope 1 GHG Emissions Intensity (kg CO ₂ -e / ha)	556.92	490.32	477	374.88	485.04
Fuel use	507.78	390.44	424	335.12	278.64
Nitrogen fertiliser use	43.68	99.88	37.1	34.08	192.64
Crop Residues	5.46	0	15.9	5.68	13.76
Vineyard area 2020 (Ha)	3832	1054	6094	7173	488
GI Region Emissions (t CO ₂ -e) – Scope 1	2134.1	516.8	2906.8	2689.0	236.7
Total Emissions Baseline (t CO ₂ -e) – Scope 1	8,483				



3. Forecasting emissions to 2050 for Hills and Fleurieu Vineyards

To effectively forecast total vineyard emissions out to 2050 under the current emissions scenario, it is essential to establish a comprehensive data framework that captures both historical and projected variables. This includes current and past vineyard emissions data segmented by source, vineyard acreage, and yield, all of which has been presented here previously through the emissions baseline generated.

The forecasting analysis is required to incorporate market trends, with a focus on environmental influences including climate change impacts on grape suitability, water availability, and extreme weather events. Expected trends suggest a nuanced picture. While some regions may see moderate growth due to increased global wine consumption and technological adoption, others may face contraction due to climate stressors or policy-driven emissions restrictions. Scenario modeling has been used to project emissions trajectories, accounting for baseline industry growth or decline, regional climate adaptation strategies, and potential shifts in vineyard practices.

The following subsections detail core guiding factors considered in the forecasting predictions presented within this report.

3.1 Domestic and International Market Trends

The global wine industry is undergoing significant transformation driven by climate change, evolving consumer preferences, and technological innovation. Rising temperatures and shifting weather patterns are forcing traditional wine regions to adapt or relocate, while demand grows for sustainable, organic, and lower-alcohol wines. Markets in Asia, particularly China and India, are expected to lead consumption growth, while traditional markets like Europe may continue to decline. Technology, including AI and precision viticulture, is improving vineyard efficiency and supporting direct-to-consumer sales models, while consolidation among producers and distributors is expected to continue.

In Australia, the wine industry is responding to similar pressures with region-specific adaptations. Climate change is pushing production toward cooler regions like Tasmania, and growers are experimenting with drought-resistant varieties and sustainable practices. Trade tensions, especially with China, have encouraged exporters to diversify into emerging markets, however trade tensions fluctuate and this market has once again become available. The industry is also focused on premiumisation, automation, and environmental responsibility to remain competitive and resilient through to 2050.

The One Grape and Wine Sector Plan, as prepared on behalf of Wine Australia, Australian Grape and Wine, and key industry stakeholders, acknowledges these significant shifts in global market conditions, trade, and environmental pressures, highlighting the urgent need for sector-wide adaptation. To guide some of the conversation to substantiate real-world challenges the wine industry has been facing, which will directly and indirectly impact upon regional emissions outputs, the report details what challenges are being faced and will continue to be faced moving towards 2030 and beyond. Figure 1 below graphically represents some of the broad challenges the wine sector has experienced since 2020 and will continue to experience.

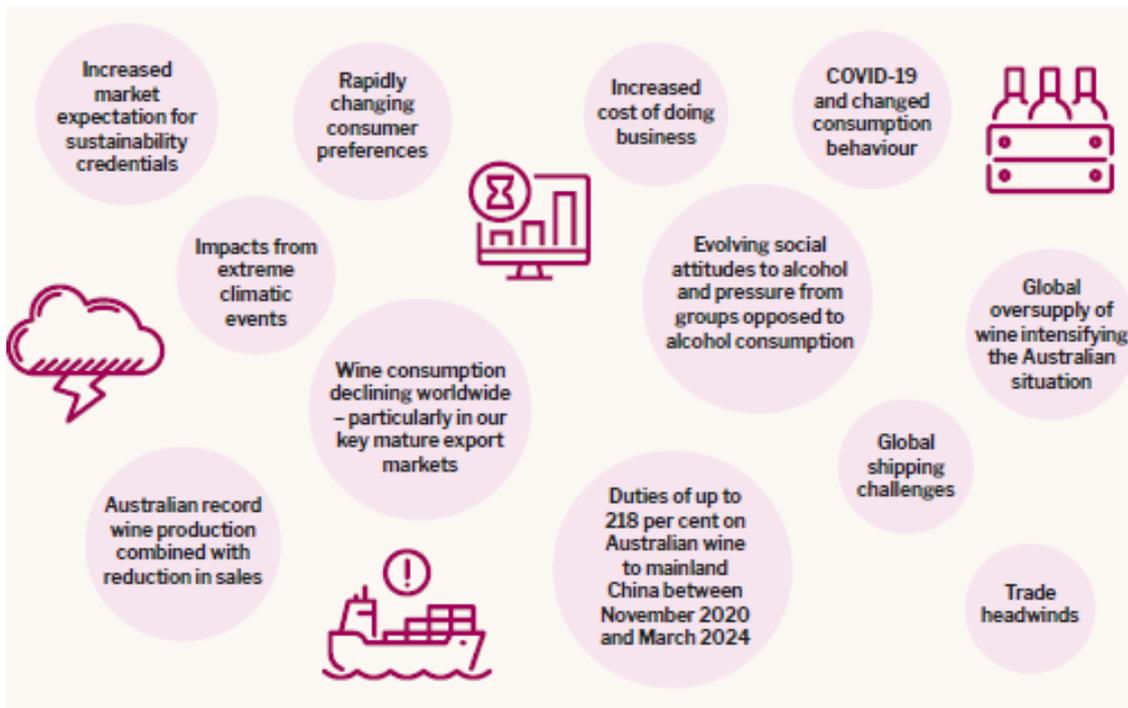


Figure 1: Broad challenges the wine sector has experienced since 2020.

3.2 Vineyard area reduction

A 2023 Market Bulletin from Wine Australia stated that based on current economic and climate outlooks, alongside other contributing factors such as declining red grape prices and reduced grower returns leading to industry exits, Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) has projected a national vineyard area decline from 150,000 hectares to 136,000 hectares by 2027–28. This represents a 10 per cent reduction, or roughly 2 per cent per year, which is significantly higher than recent trends; for example, South Australia’s vineyard area has decreased by just 3 per cent over the past decade up to 2023.

Considering the current challenges, weak market demand, reduced water availability, rising input costs, ageing vineyards, historically low grape prices, and an ageing grower population with many now over 60 years old, this projected decline may appear realistic. However, it's important to note that many growers supplement their income through off-farm activities, which may delay their decision to exit the sector. Additionally, if vineyards are sold to other growers rather than removed altogether, they remain part of the productive base. Only the physical removal of vines will lead to a real reduction in future production potential.



Further to the information below, in 2023 Vinehealth provided data to state historical whole vineyard area removal from SA based growing zones, including data for 2020 – 2023. Figure 1 represents the area of whole vineyards removed by Zone between 2020 and 2023 (Vinehealth 2023).

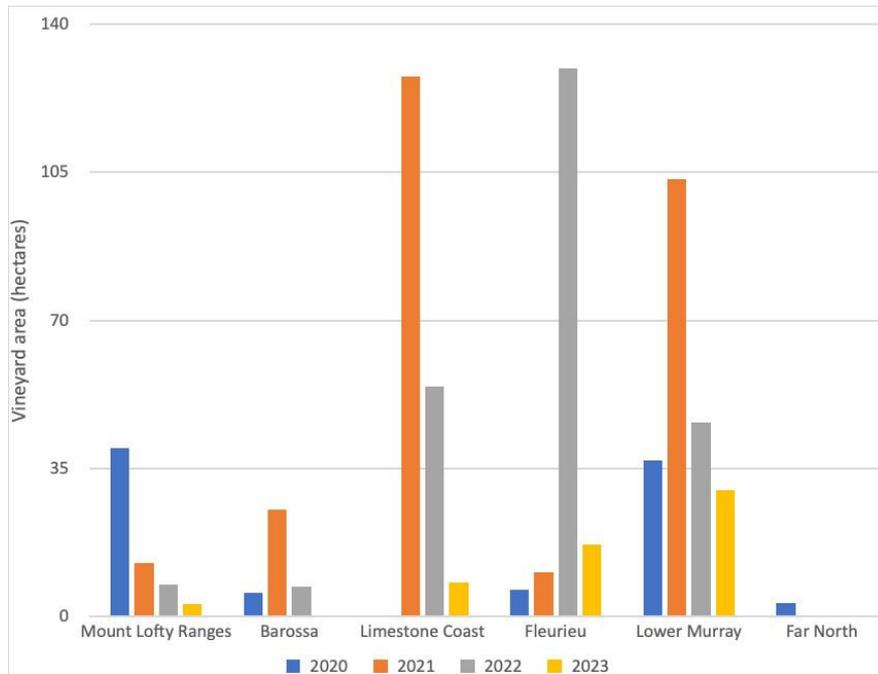


Figure 2: Area of whole vineyards removed by Zone between 2020 and 2023. Data reported is on a calendar year basis with 2023 reported until 30 November.

Whole vineyard removals in SA have been increasing, with 18 in 2020, 29 in 2021 and 32 in 2022, however differences appear to be regionally focused, therefore modelling needs to factor this specificity in.

According to the Register, none of the whole vineyards reported as removed between 2020 to 2023 have been replanted as of 30 November 2023. Given the current industry state, a shift toward premiumization, with a focus on cool climate wines, it is thought national vineyard area will continue to decrease to 2050, however this will remain to have a high regional specificity.

3.3 Environmental Factors

The Wine Australia Climate Atlas is a comprehensive online tool that provides detailed climate data across all of Australia’s Geographical Indications (GIs), with a particular focus on viticultural relevance. It offers a high-resolution, long-term perspective on climate trends by drawing on both historical data (1960–1990, 1997–2017) and future projections (2041–2060 and 2081–2100), using a high-emissions scenario. The atlas reports on key variables such as average growing season temperature, seasonal rainfall, frost risk, heat extremes, and aridity index. Each GI is mapped individually, allowing users to explore shifts in climate conditions spatially and temporally.



The Climate Atlas is particularly valuable in supporting regional greenhouse gas (GHG) emissions forecasting for viticulture. By identifying how climate variables are expected to change in each wine region, the atlas can inform how vineyard practices, and therefore emissions, are likely to evolve. For instance, rising temperatures and declining rainfall are likely to increase reliance on irrigation, which affects both electricity and diesel use, particularly in regions with lower water security. Similarly, shifts in frost risk and heat extremes can influence fertiliser, pesticide, and cooling needs, which all carry an emissions footprint.

In emissions modelling, the atlas helps estimate both total and per-hectare emissions by allowing forecasters to assess where vineyard area might expand, contract, or become less viable under future climates. For example, cooler GIs such as the Adelaide Hills may see growth in vineyard area due to rising temperatures improving growing conditions, while warmer areas may face declining productivity or increased input intensity. These trends, overlaid with emissions intensity data (e.g. t CO₂-e/ha), help produce region-specific emissions forecasts that reflect both climate pressures and industry adaptation.

Due to the nature of the outputs, and recognition of the Climate Atlas by Wine Australia as a tool for the sector, the forecasted emissions for the Hills and Fleurieu vineyard have used the outputs as a trusted reference. Table 5 details computer modelling projections for climate change scenarios as developed through the Climate Atlas, with direct focus on rainfall, temperature, extreme heat and cold events, and aridity.

Table 5: Climate Atlas computer modelling projections for climate change scenarios specific to Hills and Fleurieu Landscape Board viticulture regions.

Region	Climate Indicator	1997–2017	2041–2060	2081–2100	Trend / Insight
Adelaide Hills	Rainfall (Growing Season)	263 mm	296 mm	278 mm	Slight increase mid-century, then slight decline
	Temperature (°C)	17.9°C	19.0°C	20.4°C	Steady warming (+2.5°C by 2100)
	Extreme Heat (EHF)	19.7	22.5	24.9	Increasing heatwave frequency/severity
	Frost Risk Days	0.5 days	0.2 days	0.0 days	Frost risk declining to zero
	Aridity Index	0.51	0.40	0.33	Increasing aridity – drier conditions
Currency Creek	Rainfall (Growing Season)	198 mm	219 mm	205 mm	Slight increase mid-century, then slight decline
	Temperature (°C)	18.5°C	19.4°C	20.7°C	Steady warming (+2.0°C by 2100)
	Extreme Heat (EHF)	19.2	19.9	21.4	Moderate increased heatwave frequency/severity
	Frost Risk Days	0.0 days	0.0 days	0.0 days	No present or emerging frost risk
	Aridity Index	0.36	0.29	0.24	Comparatively drier region, however still increasing aridity – drier conditions
McLaren Vale	Rainfall (Growing Season)	236 mm	230 mm	215 mm	Slight decrease mid-century, then further declining projected
	Temperature (°C)	18.6°C	19.8°C	21.3°C	Steady warming (+2.5°C by 2100)
	Extreme Heat (EHF)	19.5	22.6	25.6	Increasing heatwave frequency/severity
	Frost Risk Days	0.0 days	0.0 days	0.0 days	No present or emerging frost risk
	Aridity Index	0.44	0.34	0.27	Increasing aridity – drier conditions
Langhorne Creek	Rainfall (Growing Season)	171 mm	174 mm	168 mm	Relatively stable growing season rainfall predicted
	Temperature (°C)	19.2°C	20.1°C	21.3°C	Steady warming (+2.0°C by 2100)
	Extreme Heat (EHF)	18.9	20.5	22.1	Increasing heatwave frequency/severity
	Frost Risk Days	0.0 days	0.0 days	0.0 days	No present or emerging frost risk
	Aridity Index	0.25	0.21	0.18	Comparatively drier region, however still increasing aridity – drier conditions
Southern Fleurieu	Rainfall (Growing Season)	227 mm	241 mm	223 mm	Slight increase mid-century, then slight decline
	Temperature (°C)	18.0°C	19.1°C	20.5°C	Steady warming (+2.5°C by 2100)
	Extreme Heat (EHF)	19.0	21.1	23.9	Increasing heatwave frequency/severity
	Frost Risk Days	0.0 days	0.0 days	0.0 days	No present or emerging frost risk
	Aridity Index	0.46	0.35	0.29	Increasing aridity – drier conditions



3.4 Forecast of total vineyard emissions out to 2050 – Hills and Fleurieu

Based on the information above, the emissions forecast presented here is an estimate of what future emissions could be to 2050 if no further actions are taken by vineyards within the Hills and Fleurieu regions, to reduce their emissions. This estimate does not consider any potential greening of supply chains independent of vineyard actions. The variation in emissions over time does incorporate predicted emissions intensity changes in the South Australian electricity grid (i.e. increased uptake of renewables into each states electricity grid or grid decarbonisation). Additionally, the estimate accounts for expected industry trends as detailed here within, including shifts in vineyard area, climate change impacts, and market conditions and the overarching implications this will have on vineyard area (and production) growth rate. Thus, applying business-as-usual (current practices) assumptions that reflect the validations from industry we can formulate the following predictions for each of the subregions:

Table 6: Estimated impact on vineyard area growth rate as a result of market, consumer, and environment trends to 2050.

GI Region	Area Growth Rate (2020–2050)	Reasoning	Timeframes
Adelaide Hills	+10%	Cool climate wines remain in demand despite warming. Premiumization and global recognition.	Growth expected between 2030 - 2040
Currency Creek	-10%	Marginal viability due to heat/aridity	Decline expected from present to 2040
Langhorne Creek	-5%	Stable production. Climate resilience, stable rainfall. Aging population and lower price point fruit.	Decline expected 2030 - 2035
McLaren Vale	0%	Urban expansion and heat stress limiting factors. Mediterranean climate system enables alternate varieties. Premiumization potential.	Decline 2025 – 2035, growth 2035 – 2050 balancing.
Southern Fleurieu	+5%	Expansion opportunity for cool-climate wines.	Steady growth to 2050.

Figure 3 provides a year-by-year estimation of regional emissions forecasting to 2050, with Table 7 reflecting the calculations which substantiate the graph and forecast for the Hills and Fleurieu regions.

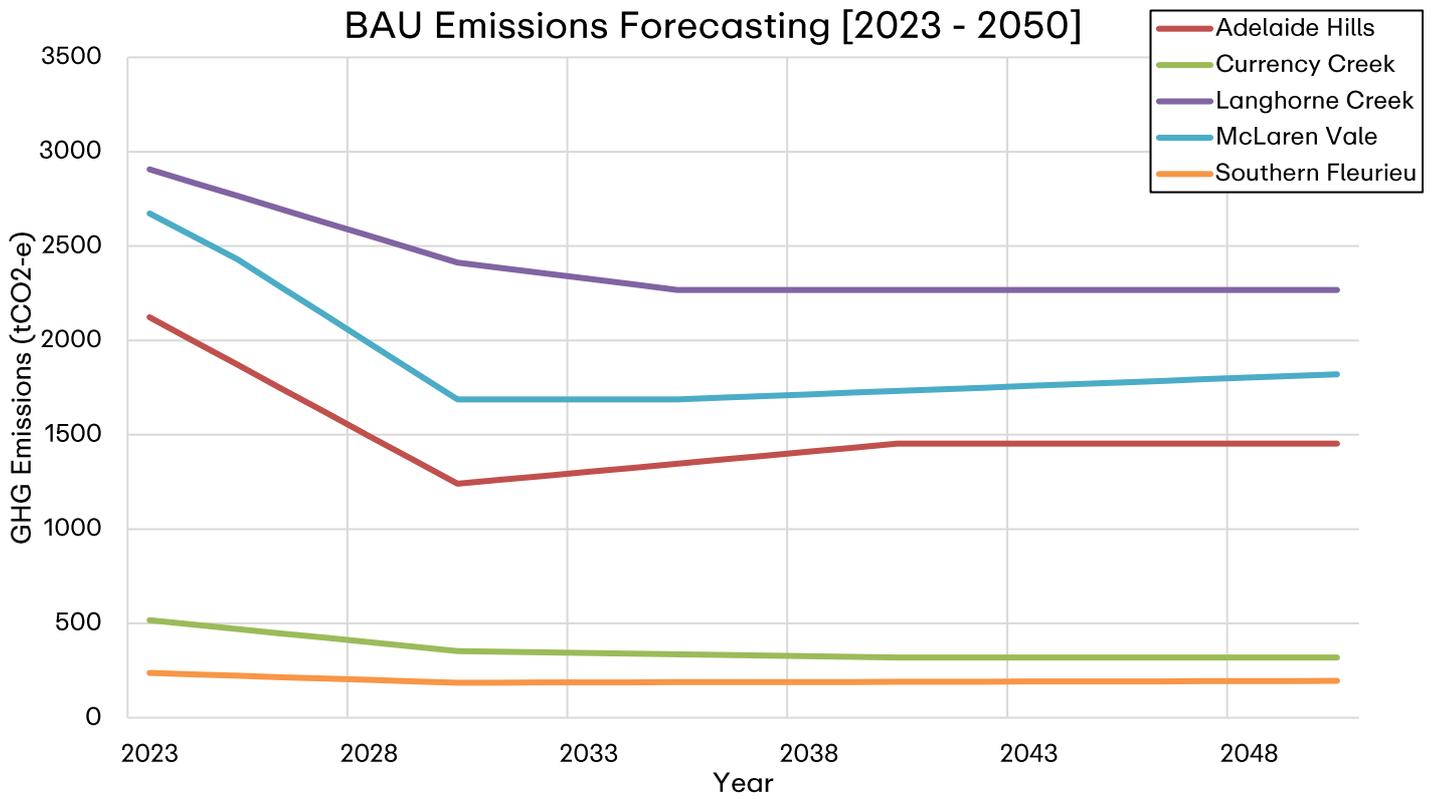


Figure 3: Hills and Fleurieu regions viticulture BAU emissions projection to 2050.



Table 7: Hills and Fleurieu regional business-as-usual (BAU) emissions forecasting to 2050.

GI Region Emissions (t CO2-e)																													
Region	Vineyard area 2020 (Ha)	2023 (Calculated)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Adelaide Hills	3832	2123	1997	1870	1745	1618	1492	1366	1240	1261	1283	1304	1325	1346	1368	1389	1410	1431	1452	1452	1452	1452	1452	1452	1452	1452	1452	1452	1452
Currency Creek	1054	517	494	470	447	423	400	377	353	350	346	343	340	336	333	329	326	322	319	319	319	319	319	319	319	319	319	319	319
Langhorne Creek	6094	2907	2836	2765	2695	2624	2554	2483	2412	2383	2354	2325	2296	2267	2267	2267	2267	2267	2267	2267	2267	2267	2267	2267	2267	2267	2267	2267	2267
McLaren Vale	7173	2673	2551	2429	2281	2132	1984	1836	1687	1687	1687	1687	1687	1687	1696	1705	1714	1723	1732	1741	1749	1758	1768	1776	1785	1794	1803	1812	1821
Southern Fleurieu	488	237	229	222	215	207	200	193	186	186	187	187	188	188	188	189	189	190	190	191	191	192	192	193	193	193	194	195	195
Total	18641	8456	8106	7757	7382	7005	6630	6255	5879	5868	5857	5846	5836	5825	5852	5879	5906	5933	5961	5970	5979	5989	5998	6008	6017	6026	6036	6045	6054



4. Scenario Analysis – Scope 1 Emission Reduction Possibilities

4.1 Scenario Analysis #1: Fertiliser Use in Vineyard

Based on the emissions baseline developed, Table 8 below details the percentage component of fertiliser use on each region’s overall emissions intensity. Across the regions, there is vast variability in the contribution of fertiliser use, with the lowest attributable to Adelaide Hills and Langhorne Creek at around 7.5 – 8%, all the way up to 40% for Southern Fleurieu.

Table 8: Percentage component of fertiliser use per region contributing to emissions baseline.

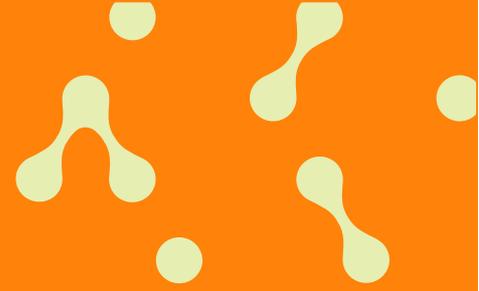
Emissions Category	Adelaide Hills	Currency Creek	Langhorne Creek	McLaren Vale	Southern Fleurieu
Scope 1 GHG Emissions Intensity (kg CO ₂ -e / ha)	556.92	490.32	477	374.88	485.04
Nitrogen fertiliser use	43.68	99.88	37.1	34.08	192.64
Percentage contribution of emissions	7.8%	20.4%	7.8%	9.1%	39.7%

4.1.1 Baseline Adoption Scenario

In the baseline adoption scenario, emissions reductions from fertiliser use are forecast based on the gradual uptake of improved nitrogen management practices that are aligned with current commercial and agronomic norms. Vineyards typically exhibit relatively high nitrogen-use efficiency compared to other irrigated cropping systems, largely due to the precise application of nutrients via fertigation, which delivers nitrogen directly to vine roots and reduces losses to the surrounding soil microbiota. However, even within this relatively efficient system, opportunities exist to further reduce nitrous oxide (N₂O) emissions by improving the timing and method of fertiliser applications.

Under this scenario, the primary driver of adoption is cost-efficiency and vineyard productivity, rather than environmental performance alone. Growers are expected to follow best management practices for fertigation by applying nitrogen during periods of active root growth, typically just prior to flowering and postharvest in Mediterranean climates. Fertiliser applications outside these periods, such as between flowering and harvest, are recognised as contributing to higher N₂O emissions due to reduced nitrogen uptake by the vines. Education around optimal timing is assumed to be already broadly understood, and uptake of these practices is likely to continue at a steady pace where operationally feasible.

The application of organic amendments such as compost is assumed to persist under this scenario, particularly in vineyards focused on soil health and organic certification. However, research indicates that such practices can lead to significant spikes in N₂O emissions following application, particularly when compost is surface-applied. While efforts have been made to mitigate this, such as burying compost in shallow trenches, these methods have not demonstrated consistent success in reducing emissions and are unlikely to be widely adopted without further supporting evidence. Likewise, biochar application remains limited, as its effect on N₂O emissions is inconsistent and not yet sufficiently validated under typical vineyard conditions.



Given current cost pressures within industry, and a likely slow transition of export changes and regulatory change, a basis of assumption of adoption of 50% of Hills and Fleurieu vineyards to adopt precision viticultural practices and optimized fertiliser practices is used. It is further assumed that annual emissions reduction (comparative to BAU) for practices that are adopted organically by industry through market-driven demand, cost savings, and gradual uptake is 1% per year from present status up to 2050. The resulting impact on the emissions forecast is very low as evidenced in Table 9.



Table 9: Hills and Fleurieu baseline adoption scenario for fertiliser use to 2050. Resulting models are in addition to business-as-usual (BAU) emissions forecasting previously determined to 2050 (i.e. inclusive of vineyard area changes and grid decarbonization).

GI Region Emissions (t CO2-e)																													
Region	Vineyard area 2020 (Ha)	2023 (Calculated)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Adelaide Hills	3832	2123	1996	1870	1744	1618	1492	1366	1240	1261	1282	1303	1325	1346	1367	1389	1410	1431	1452	1452	1452	1452	1452	1452	1452	1452	1452	1452	1452
Currency Creek	1054	517	494	470	447	423	400	376	353	350	346	343	339	336	332	329	326	322	319	319	319	319	319	319	319	319	319	319	319
Langhorne Creek	6094	2907	2835	2765	2694	2624	2553	2483	2412	2383	2354	2325	2295	2267	2267	2267	2267	2267	2267	2267	2267	2267	2267	2267	2267	2267	2267	2267	2267
McLaren Vale	7173	2673	2551	2429	2280	2132	1984	1835	1687	1687	1687	1687	1687	1687	1696	1704	1713	1722	1731	1740	1749	1758	1767	1776	1785	1794	1802	1811	1820
Southern Fleurieu	488	237	229	222	215	207	200	192	186	186	186	187	187	188	188	189	189	190	190	190	191	191	192	192	193	193	194	195	195



4.1.2 Stretch Target Scenario

The stretch target scenario represents a more ambitious pathway that assumes the implementation of proactive policies, widespread extension support, and targeted research investment to accelerate the adoption of nitrogen management practices that reduce N₂O emissions in vineyards. Under this scenario, fertiliser-related emissions are mitigated through a suite of coordinated strategies that optimise nitrogen application, enhance plant uptake, and minimise nitrogen losses to the environment.

In this enhanced adoption environment, best practice fertigation timing is universally implemented, supported by industry-wide education initiatives and regional demonstration projects. Growers are provided with tools and training to match nitrogen application closely with vine demand, using crop sensing technologies and decision-support software that integrate soil and plant data. These tools help ensure that nitrogen is applied only when needed and in the precise quantities required, significantly reducing the risk of excessive application and associated N₂O emissions.

A major emphasis in this scenario is placed on increasing nitrogen assimilation through the strategic use of cover crops during the off-season. These cover crops are selected and managed to scavenge residual soil nitrogen, reducing emissions by minimising nitrogen availability for microbial conversion to N₂O. In addition, the adoption of compost application is re-engineered, with further research leading to the development of new compost incorporation techniques that limit exposure to oxygen and soil microbes immediately after application, thereby reducing emissions peaks observed in previous trials. If these methods are proven effective, compost use can support both soil health and emissions reduction goals.

Biochar use is also revisited under this scenario. Supported by targeted research funding and demonstration trials, site-specific guidelines for biochar type, application rates, and integration methods are developed. Where suitable, biochar is deployed to improve nitrogen retention and soil carbon levels, with promising results in select vineyard soil types. Its inclusion in integrated nutrient management strategies helps further reduce fertiliser demand and N₂O release.

Collectively, these practices result in a more efficient and environmentally responsive fertiliser management system. Under the stretch target scenario, vineyard fertiliser-related emissions are forecast to decline by 30–40%, with reductions driven by both improved nitrogen use efficiency and the mitigation of emissions associated with organic inputs. This scenario reflects a future in which environmental performance is an active goal of vineyard management, supported by coordinated extension services, market recognition, and climate-aligned policy incentives.

This scenario reflects a future in which environmental performance is an active goal of vineyard management, supported by coordinated extension services, market recognition, and climate-aligned policy incentives. With these enablers, industry adoption rates rise sharply by 2040, sustained through to 2050. Adoption rates increase from 50% up to 80%, with an assumed annual emissions reduction (comparative to BAU) of 2.5% per year from present status up to 2040.



Table 10: Hills and Fleurieu stretch target scenario for fertiliser use to 2050. Resulting models are in addition to business-as-usual (BAU) emissions forecasting previously determined to 2050 (i.e. inclusive of vineyard area changes and grid decarbonization).

GI Region Emissions (t CO ₂ -e)																														
Region	Vineyard area 2020 (Ha)	2023 (Calculated)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	
Adelaide Hills	3832	2123	1995	1869	1744	1617	1491	1365	1238	1260	1281	1302	1324	1345	1366	1387	1408	1430	1451	1451	1451	1451	1451	1451	1451	1451	1451	1451	1451	
Currency Creek	1054	517	493	469	446	422	399	376	352	349	345	342	338	335	331	328	325	321	318	318	318	318	318	318	318	318	318	318	318	318
Langhorne Creek	6094	2907	2833	2763	2692	2622	2551	2480	2410	2381	2352	2322	2294	2264	2264	2264	2264	2264	2264	2264	2264	2264	2264	2264	2264	2264	2264	2264	2264	
McLaren Vale	7173	2673	2549	2427	2278	2130	1982	1833	1685	1685	1685	1685	1685	1685	1694	1711	1711	1720	1729	1738	1747	1756	1765	1774	1783	1792	1800	1809	1818	
Southern Fleurieu	488	237	228	220	214	206	199	191	184	185	186	186	186	187	187	188	188	189	189	190	190	190	191	191	192	192	193	193	194	



4.2 Scenario Analysis #2: Diesel in Vineyard

Based on the emissions baseline developed, Table 11 below details the percentage component of diesel use on each regions overall emissions intensity. Across the regions, there is vast variability in the contribution of diesel use, with the largest attributable to Adelaide Hills, Langhorne Creek and McLaren Vale at levels above 80%.

Table 11: Percentage component of fuel use per region contributing to emissions baseline.

Emissions Category	Adelaide Hills	Currency Creek	Langhorne Creek	McLaren Vale	Southern Fleurieu
Scope 1 GHG Emissions Intensity (kg CO ₂ -e / ha)	556.92	490.32	477	374.88	485.04
Fuel use (Diesel)	480.48	345.04	397.5	306.72	227.04
Percentage contribution of emissions	86.3%	70.4%	83.3%	81.8%	46.8%

4.2.1 Baseline Adoption Scenario

In the baseline adoption scenario, emissions reductions are modelled based on the realistic uptake of mitigation practices driven primarily by market forces and practical feasibility. Vineyard fuel use (more narrowly diesel use) is closely tied to tractor operations for activities such as agrochemical spraying, mowing, and cultivation. Under this scenario, growers are assumed to adopt practices that offer immediate agronomic or financial benefits without requiring significant capital investment or external support. Improved agrochemical application practices such as selecting appropriate products, applying at correct rates, and achieving adequate spray coverage in a single pass are expected to be widely implemented due to their direct productivity and cost advantages. These refinements can reduce the frequency of spray applications and thus lower tractor use.

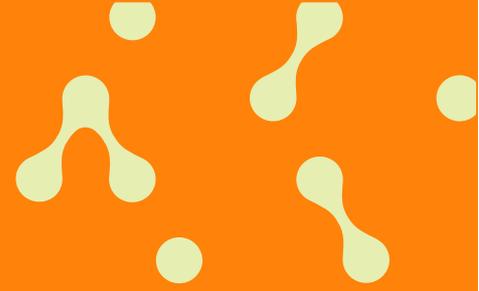
Some uptake of multi-row spray equipment is expected, particularly in larger or more capitalised vineyard operations where the economic return on investment is more compelling. Precision viticulture technologies are anticipated to be adopted at a moderate level, especially in premium wine regions where efficiency gains justify the cost. These technologies allow growers to target specific areas of a vineyard, reducing unnecessary passes and associated fuel use. The integration of livestock, particularly sheep, into vineyard systems during winter is expected to continue growing, as it reduces the need for mechanical weed management and herbicide use.

While drip irrigation is already prevalent across Australian vineyards, further efficiency gains are limited under this scenario. Transitions from mechanised operations to hand labour, such as for pruning or harvesting, are not widely expected in the baseline scenario due to increased labour costs and logistical constraints. Overall, this scenario forecasts a modest reduction of approximately 1.5% per annum in vineyard fuel-related emissions, comparative to BAU, primarily through operational efficiency improvements and minor shifts in vineyard management practices. Adoption would be expected to be ~50% of vineyards, with uptake commencing from 2030 through to 2040 primarily (Table 12).



Table 12: Hills and Fleurieu baseline adoption scenario for fuel use to 2050. Resulting models are in addition to business-as-usual (BAU) emissions forecasting previously determined to 2050 (i.e. inclusive of vineyard area changes and grid decarbonization).

GI Region Emissions (t CO ₂ -e)																													
Region	Vineyard area 2020 (Ha)	2023 (Calculated)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Adelaide Hills	3832	2123	1997	1870	1745	1618	1492	1366	1235	1250	1266	1282	1297	1313	1329	1344	1360	1376	1397	1397	1397	1397	1397	1397	1397	1397	1397	1397	1397
Currency Creek	1054	517	494	470	447	423	400	377	352	347	342	337	332	328	322	318	313	308	305	305	305	305	305	305	305	305	305	305	305
Langhorne Creek	6094	2907	2836	2765	2695	2624	2554	2483	2403	2366	2328	2291	2253	2215	2206	2197	2189	2180	2180	2180	2180	2180	2180	2180	2180	2180	2180	2180	2180
McLaren Vale	7173	2673	2551	2429	2281	2132	1984	1836	1680	1672	1665	1658	1650	1643	1645	1646	1647	1649	1658	1667	1676	1685	1693	1702	1711	1720	1729	1738	1747
Southern Fleurieu	488	237	229	222	215	207	200	193	185	185	185	185	185	184	184	184	184	184	185	186	186	187	187	187	188	188	189	189	190



4.2.2 Stretch Target Scenario

The stretch target scenario represents a more ambitious pathway for emissions reduction, enabled by comprehensive support through education, extension services, pro-active research translation, and policy incentives. Under this scenario, the adoption of low-emissions technologies and practices is accelerated across the sector. Multi-row and autonomous spray equipment become more widely deployed, supported by co-investment from government programs and industry partnerships. These technologies significantly reduce the number of tractor passes required per season, leading to substantial reductions in diesel consumption.

Precision viticulture technologies are assumed to be integrated as standard practice, supported by training programs and user-friendly digital tools that improve decision-making. Livestock grazing is more broadly adopted across suitable vineyard sites, encouraged through extension support and infrastructure development, such as fencing and rotational grazing systems. Disease-resistant cultivars and rootstocks are promoted through coordinated industry programs, enabling reduced reliance on pesticide sprays and fewer tractor operations.

Emerging technologies are fast-tracked for commercial adoption through dedicated R&D funding and field demonstrations.

This integrated approach delivers a systemic shift in vineyard fuel use, whereby overall, this scenario forecasts a reduction of approximately 2.5% per annum reductions in vineyard fuel-related emissions compared to BAU, primarily through operational efficiency improvements and minor shifts in vineyard management practices. Adoption would be expected to be ~70% of vineyards, with uptake commencing from 2030 through to 2040 primarily (Table 13).



Table 13: Hills and Fleurieu stretch target scenario for fuel use to 2050. Resulting models are in addition to business-as-usual (BAU) emissions forecasting previously determined to 2050 (i.e. inclusive of vineyard area changes and grid decarbonization).

GI Region Emissions (t CO ₂ -e)																													
Region	Vineyard area 2020 (Ha)	2023 (Calculated)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Adelaide Hills	3832	2123	1997	1870	1745	1618	1492	1366	1226	1233	1241	1249	1257	1265	1273	1281	1289	1298	1319	1319	1319	1319	1319	1319	1319	1319	1319	1319	1319
Currency Creek	1054	517	494	470	447	423	400	377	349	342	335	328	321	314	307	300	293	287	283	283	283	283	283	283	283	283	283	283	283
Langhorne Creek	6094	2907	2836	2765	2695	2624	2554	2483	2389	2339	2289	2240	2190	2140	2119	2098	2078	2057	2057	2057	2057	2057	2057	2057	2057	2057	2057	2057	2057
McLaren Vale	7173	2673	2551	2429	2281	2132	1984	1836	1667	1649	1632	1614	1597	1579	1570	1562	1553	1544	1553	1562	1571	1580	1589	1598	1607	1615	1624	1633	1642
Southern Fleurieu	488	237	229	222	215	207	200	193	183	182	181	181	180	179	178	177	176	175	176	176	177	178	178	179	179	180	180	180	181