Emissions reduction opportunities

Review of decarbonisation innovations for the wine industry

Nisha Choudhary
Sustainability Specialist, thinkstep-anz

Photo: Stewart Watson, Excio

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Summary

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Summary

We identified a number of cost-effective long-term sustainability solutions to decarbonise the wine industry in New Zealand.

- **Digitalisation** through robotics and artificial intelligence. When combined with **optimising energy consumption** and focusing on **renewable sources of energy** it can future-proof the wine industry.

- **Sustainable fuel technology** offers the greatest opportunity to reduce emissions. This includes battery-electric autonomous tractors (compatible with various other smart farming tools). Vehicles on vineyards were identified as the highest contributor to emissions in 2021 (diesel).

- **Smart farming** is a large market with many suppliers globally. There are opportunities to combine and customise monitoring and mitigating solutions as needed. For example, combining *thinkwater* subsurface irrigation system with *croptide* monitoring of water requirement in a field can help provide a complete package to preserve yield and conserve water.

Summary

- Energy-efficient ways to produce wine will require investment of cost, time and resources to reduce fossil fuel consumption and transition to renewable energy sources. Adoption of temperature and humidity control, reclaiming heat from low carbon natural refrigerants and having a centralised cloud platform to monitor any fluctuations are the most efficient solutions to optimise energy consumption.

- There are some additional potential solutions such as upcycling of waste, lightweight bottling and low carbon methods of transportation & distribution as available in local/international markets that can be adopted in NZ.

- The market is expected to grow quickly with different suppliers coming into the market. however, the trend on how to decarbonise is consistent.

- This study provides an initial research and guidance for detailed investigations on a case-by-case basis. Different solutions will be applicable for individual growers and wineries. A detailed cost-benefit analysis from a carbon and economic point of view as well as a feasibility will have to carried out.

Project Scope & Approach

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Scope

- Desktop research and identification of international emission reduction opportunities that might have potential for the New Zealand Wine industry.
- Provide a foundation to guide an initial reduction strategy for SWNZ.
- Detailed analysis of available solutions and cost abatement curve calculation is out of scope in this initial high-level review.

Approach

- For a high-level research study into decarbonisation innovations, we have considered the top five areas of concern which account for 94% of industry emissions as reported in National GHG Emissions and Energy Use Report 2021.
- These have been addressed with three strategic solutions
    - Optimisation,
    - Electrification/Digitalisation and
    - transition to Renewable sources of energy.
- Findings have been researched for three focus areas
    - Fuel at Vineyard,
    - Smart Farming and
    - Energy Efficiency at Winery.
- Innovative solutions based on local/international markets and current international decarbonisation trends have been identified.
- A high-level indicative comparison of cost, emission reduction and energy-saving potential has been done wherever the data was available.
- Additional areas of concern have been summarised in other solutions – waste, bottling, transportation and distribution.

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Background

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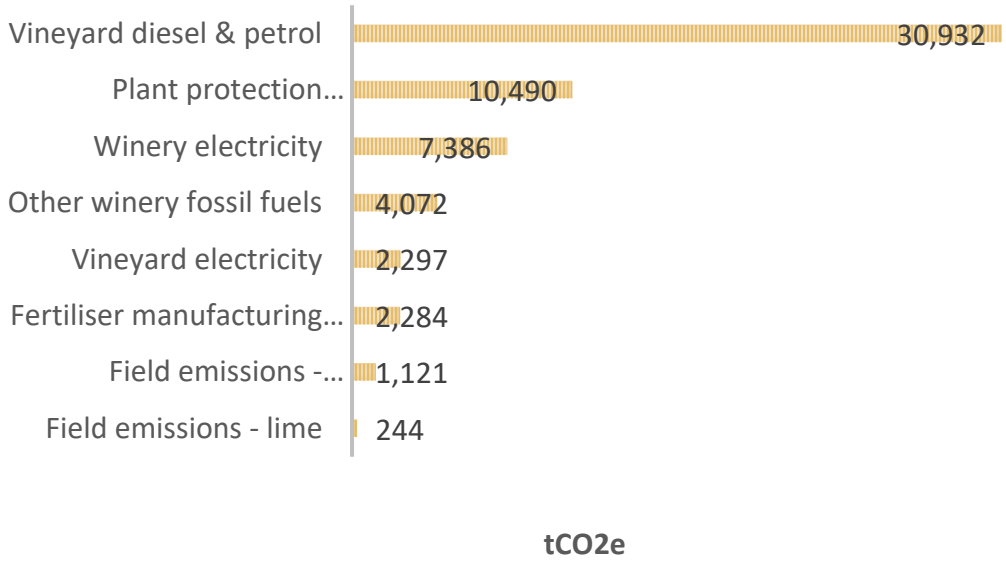
Greenhouse gas emissions

Top five sources of GHG emissions for NZ wine industry reported by SWNZ in 2021

- Vineyard Diesel/Petrol
- Agrichemical manufacturing
- Winery electricity
- Winery other fuels
- Vineyard electricity



Source : Sustainable Winegrowing NZ - National Greenhouse Gas Emissions and Energy Use Report 2021

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Strategy

Strategy

Optimise consumption of fuel, energy and agrichemicals

Electrify/Digitalise the technology

Renewable source of energy

→ address 94% of 2021 reported emissions

Note:
Agrichemical manufacturing emissions are indirect emissions for wine industry and fall outside EECA mandate.

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Focus area 1 : Fuel at Vineyard

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Fuel at vineyard

Diesel

source tractors

62%
of total vineyard emissions

53%
of total industry emissions

Note:
Petrol contributes very little towards vineyard emissions and will be covered as part of the innovative solutions discussed in further slides.

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Sustainable fuel technology at vineyard

Four potential approaches:

- Electric (new)
- Hydrogen (new)
- Use of renewable fuel
- Retrofit

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Oxin

Characteristics

- NZ’s first indigenous autonomous, multi-functional tractor.
- Cofounded by MPI.
- 24 hrs sensor navigation (day and night vision).
- Optimize energy consumption by multitasking (mowing, spraying, trimming and mulching) in one single pass.
- Clever rubber track design reduces ground pressure and allows vineyards to be worked even after rain, without compacting soil.
- Capability to sync with vineyard management software and help review real-time data for quick decision making.

Challenges

- Upfront cost
- Renewable source of energy
- Vineyard layout in NZ (slope or narrow passes)
- Adaptability

Link Source

Oxin

Market

Local Innovation

Oxin, NZ’s first autonomous tractor

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Loxely Innovation

Characteristics

- A local kiwi innovation in the field of **Retrofit battery electric tractors.**
- Optimizing the use of existing diesel assets by replacing internal combustion engine with electric motor.
- Cost effective transition.
- Reduces the waste generated by disposing existing tractors.

Challenges

- No additional benefits of digitalization such as remotely controlled mechanism with sensors or real time data collection.
- Number of passes remain the same (no multitasking) thus no optimization.

Link Source

_ Loxely

Market

- Local innovation

Loxely innovation’s retrofit tractor and its founders

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Autoagri

Characteristics

- Autonomous electric drive.
- Guided by GPS, radar and other sensors making it operational for 24 hrs.
- Low weight compared to conventional tractors thus reducing soil compaction.
- Multi tasking in single pass.
- Limited series – company is looking to collaborate with first few buyers.

Challenges

- Upfront cost (including shipping)
- Renewable source of energy
- Vineyard layout in NZ (slope or narrow passes)
- Adaptability

Link Source

Autoagri

Market

- Available in Norway (limited series)

Autoagri – autonomous electric tractor

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Amogy

Characteristics

- **Retrofit with "ammonia powered system".**
- Ammonia gas supplied gets converted to hydrogen in a reactor and powers **hydrogen fuel cell.**
- Prototype demonstrated on John Deere diesel tractor in May 2022.
- Power generated is more than diesel
- Cost of refuelling is comparable to diesel. ()
- Ammonia-handling health & safety guidelines are in place.

Challenges

- Emerging technology with yet to be realized market potential.
- Health and safety is a concern with ammonia-based system.
- Upfront cost is uncertain.

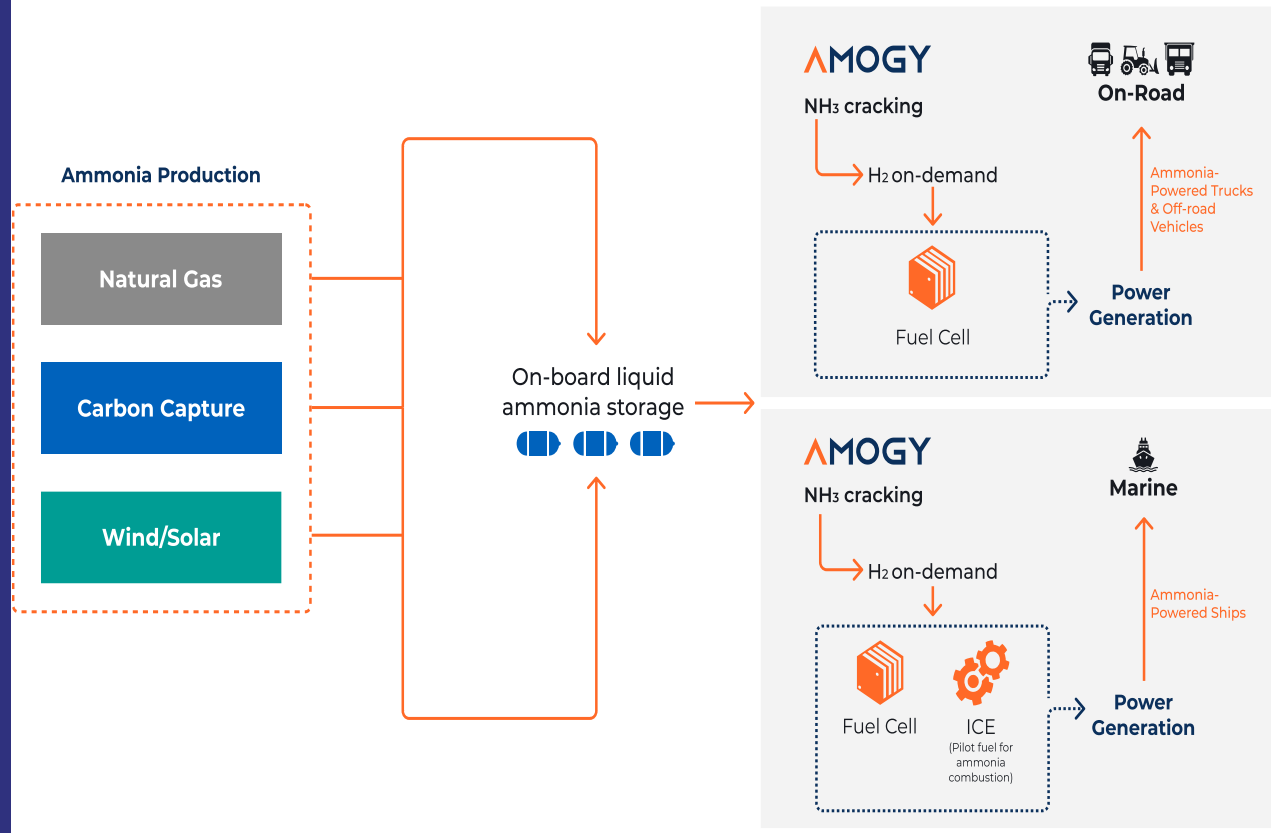
Link Source

Amogy

Market

- Under development

The science behind Amogy



Neste MY Renewable Diesel

Characteristics

- Compatible with existing assets.
- No upfront investment on assets.
- Can be blended with crude diesel.
- Use waste cooking oils (palm, canola, soyabean).
- 90% reduction in carbon emissions compared to conventional diesel (depending on the production pathway).

Note – there are various other production pathways for renewable diesel in research/pilot.

Challenges

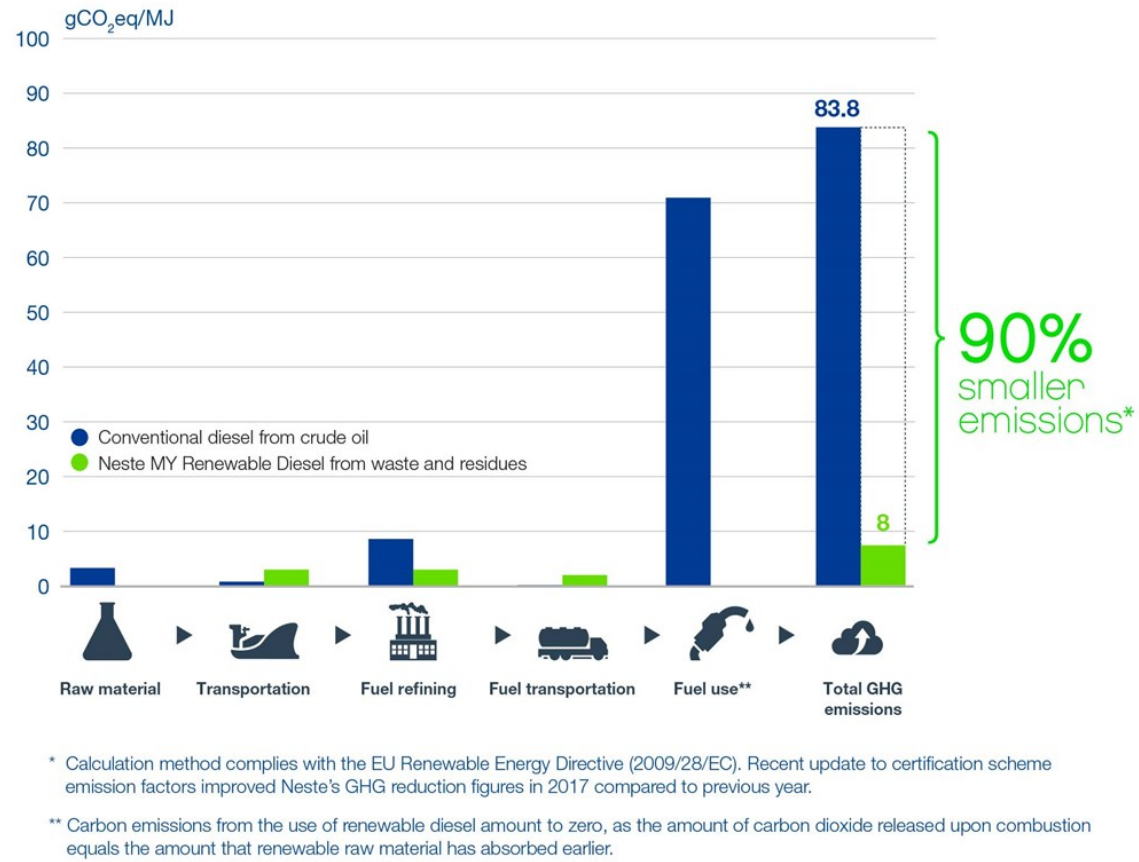
- Indirect impact on land use (depending on production pathway).
- Single provider in market.
- Ambiguity around long-term supply.
- Current operational cost is comparable to diesel.

Link Source

Neste

Market

- Local availability



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Other highly-rated solutions

Product	Type
Monarch Tractors	Electric tractor
John Deere	Autonomous electric tractor
Agxeed Agbot	Autonomous electric tractor

Monarch electric tractor, California

Fuel technology comparison

Fuel Type	Life cycle emission reduction	Operational cost benefits
Electric	***1/2 (Due to 18% non-renewable source of energy in the grid in NZ)	$$$$
Retrofit	**** (using existing assets)	$$$$
Hydrogen Fuel Cell	***** (green hydrogen)	- (Note:1)
Renewable fuel	**** (depending on production pathways)	- (Note:1)

Note:
Current cost of running a heavy vehicle on hydrogen or renewable fuel is higher than fossil fuel therefore there are no cost benefits. The cost of production will reduce as production capacity and demand increases.

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Summary – Sustainable fuel technology at vineyard

- **Market** - National and global market has multiple products available to reduce carbon footprint specific to a vineyard such as Electric, Retrofit (battery), Hydrogen Fuel Cell (upcoming) and Renewable fuel.
- **Operational costs** - For electric and retrofit tractors it is expected to be relatively lower compared to hydrogen fuel cell or renewable fuel.
- **Future proofing** - Retrofit and renewable fuel saves upfront cost (capex) however, these are not long-term solutions to achieve sustainability with existing challenges of incompatibility with digital technologies within vineyard or current scrutiny on land impact respectively.
- **Energy optimisation** - With retrofit, the number of passes through the field for various tasks is higher and thus more energy consumption compared to multi-tasking autonomous tractors (assuming similar energy efficiency of the two). This will add unwanted load on solar panels or additional cost for sourcing renewable energy from grid.
- **Upfront Cost** - With upcoming sources of hydrogen gas within NZ, hydrogen fuel cell technology can be a promising solution in near future. However, the operational cost and initial investment on asset is higher compared to all other solutions.

Recommendation - Sustainable fuel technology at vineyard

- Transition to battery electric fuel technology with adaptation of locally available autonomous electric tractor – Oxin as a long-term sustainable solution for wine industry.

- Renewable fuel can be an interim solution until the source of electricity for fuel is 98% renewable (expected in 2030) or hydrogen is available at large scale. Further research on supply chain will be required.

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Focus area 2 : Smart Farming

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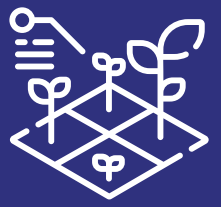
Smart Farming at vineyard

Agrichemical manufacture

- Second largest source
- Indirect emissions



Smart/precision farming

- Optimise consumption of inducers
- Improves energy efficiency
- Adapt regenerative agriculture

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Monitoring solutions

Agri Optics (now Vantage)

A complete package for a vineyard including but not limited to

- Soil surveying
- Spot-spray system
- Crop sensors
- Moisture probes
- Precision nutrient management
- Irrigation scheduling
- Yield monitor

Cropsy tech

AI-driven monitoring system using drone or satellite

- Early detection of pests and diseases to target spray decisions
- Manage crop loss
- Estimate yield to improve supply chain
- Find underperforming and dying vines early for precision replanting

terraview

A fully integrated suite with

- Yield estimation
- Automated irrigation system
- Reliable disease forecasting for risk mitigation (reduce crop loss by 10%)
- Identify nutrient deficiency to reduce impact
- Manage canopy cover
- Daily weather forecast
- Track work and provide real time alerts

Note:

Other software platforms available in market – Evineyard, Croptide

Mitigating solutions - Robotics/Drone technology

Aerolab

A drone/robotics customized for agricultural use. It helps with

- Farm mapping, precision surveying
- Vineyard spot spraying – precisely where required
- Data analysis and risk mitigation

DJI Agras T30 also assists in mapping and precise spraying of agrichemicals on the field

Naio technologies

Ted is the first robot dedicated to vineyard. It helps with effective and precise mechanical weeding without herbicides which respects your soil and crop.

Jo is an autonomous crawler for narrow vines with compact U-turn path. Based on a well-known vineyard crawler design, Jo can carry the same tools as the ones you already use

Farmdroid

- Automatic sowing and weeding.
- Solar panels fitted on roof provides energy enough for 24-hour operations

UV_C robot for Integrated Pest Management (IPM)

Willamette Valley Vineyards (US) is the first in the world to use a robot to apply ultraviolet-C (UV-C) light to fight powdery mildew, an ongoing threat to vineyards, gardens, and other plants around the world.

Mitigating solutions

Smart irrigation
thinkwater
Drip irrigation and sub surface irrigation combined with irrigation sensors such as croptide can provide a complete solution in optimising water levels and quality at vineyard

Sub-surface irrigation has been trialled by Cust Dairy in central Otago partnered by MPI. Benefits look promising, they anticipate data collection and analysis against conventional methods.

Electric Frost Fans
AGI frost fans with real-time data monitoring
Aria (Italy) electric frost fans

Cover crops
They not only help control erosion, but they also provide key nutrients. Cover crops can alleviate soil compaction issues, assist in weed control, and boost moisture retention to transform your pasture into the regenerative farming system and reduces the need of mowing (tractor passes) and consumption of agrichemicals

Low carbon synthetic fertilizers
Nanostructures can be used to deliver fertilizers and pesticides to the agricultural system. Nanoparticles have a high surface area and high sorption capacity, and their release can be directed to targeted sites, making them a part of a “smart delivery system”

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Summary – Smart farming at vineyard

- **Optimisation** - Smart farming solutions aim at digitalisation to make the most of reducing agrichemical consumption and guaranteeing the quality of products.
- **Environmental benefits** - Precision technology helps reduce agrichemical consumption and thus pollution.
- **Cost Effectiveness** - Solutions require initial investment, but higher energy efficiency and lesser consumption of agrichemicals reduce operational costs for producers
- **Future proofing** - Many experts believe autonomous solutions will become more beneficial through different stages of value chain while reducing emissions in the industry.
- **Resistance** – There can be resistance to adopting new technologies.
- **Customisation** - Complete end-to-end solutions or as few as needed are possible.

Aerolab – agricultural spraying drone

Ted – autonomous agricultural robot

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Recommendation – smart farming at vinyard

Digitalisation has already started transforming various sectors at high rate and provides numerous opportunities within the wine industry.

However, considering the large investments in skills, capital and time it will be a slow transition.

Focus area 3 : Energy efficiency at winery

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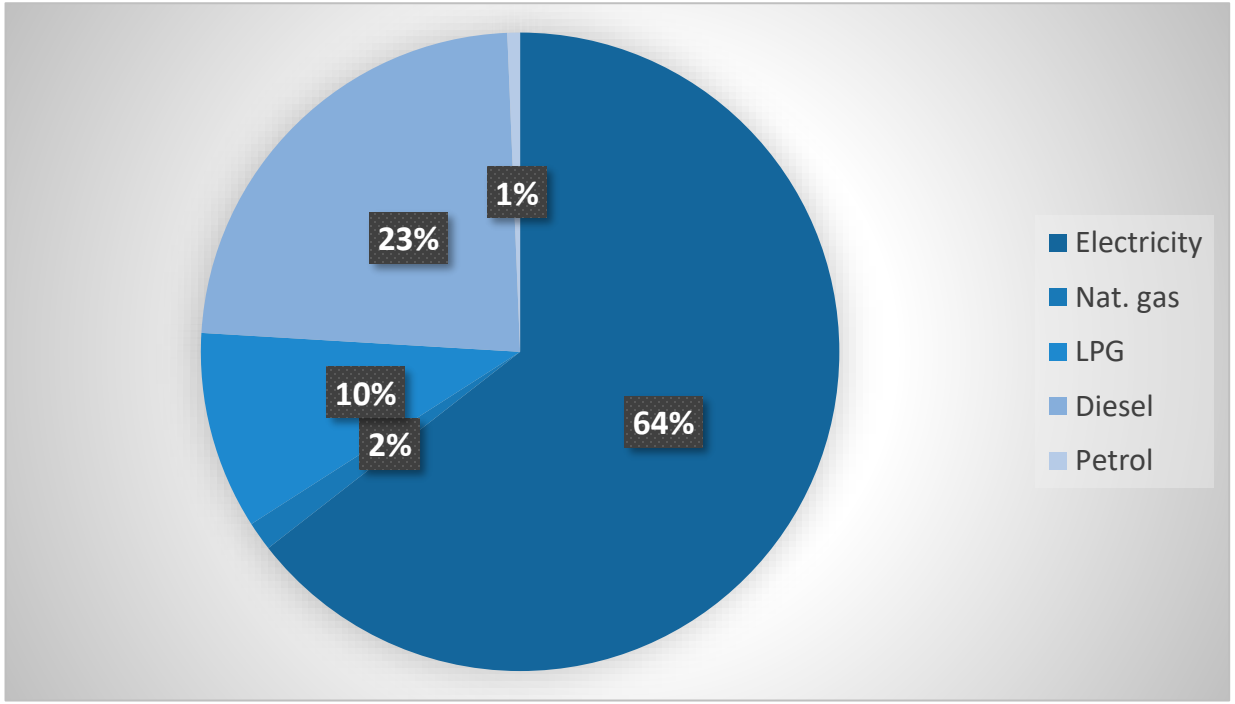
Energy efficiency at winery

- Optimise wine making processes
- Reduce reliance on fossil fuels
- Tap into renewable source of electricity



Source : Sustainable Winegrowing NZ - National Greenhouse Gas Emissions and Energy Use Report 2021

Optimisation through monitoring and/or modifying

Benefits:

- Use of a sensor-based online system or software to monitor/evaluate the fermentation process.
- Monitor fluctuation in temperature/humidity, light, ageing and improves energy efficiency.
- Automate repetitive activities, minimise the chance of catastrophic failures to improve wine quality and reduce loss of production.
- It provides transparency through real-time analysis for decision-making.
- Switch from historical processes to advanced new technologies such as humidification, process heat etc.
- Energy-efficient products combined with digitalization in wine making process will further reduce energy consumption and loss of production by spoilage or infection.
- Climate-controlled systems, building insulation, and natural refrigerants.

Literature source : https://www.oiv.int/public/medias/8593/digital-trends-applied-to-the-vine-and-wine-sector.pdf

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Monitor

Solution	Characteristics
Spark IoT Bridge	NZ based cloud-based platform to automate data collection, visualise data outputs in real-time.
Spark IoT Temperature and Humidity monitor	Dashboard to provide 24x7 visibility into the temperature and humidity of your assets with exception alerts of potential problems.
VinWizard	Automate repetitive activities, minimize chances of catastrophic failures and increase business sustainability.

Modify

Solution	Product & Characteristics	Comparative analysis
Temperature and humidity control	**Ultrasonic humidification system** A low energy system combined with air heat reclaim system to utilise ambient heating and cooling wherever possible. Mt Difficulty, Otago has demonstrated 99% saving in energy consumption compared to conventional steam system	**Energy Savings** - +++++ **Emission reduction** - Yes (To be quantified) **Cost benefits** - $$$$$
	Pulse Cooling David Gill (WinWizard) conducted trial at Bragato for pulse cooling against conventional continuous cooling. While pulse cooling took double the time to reach a set temperature compared to continuous cooling, there was a 30-50% energy saving observed from the former. It has been stated that Aside from some instances during fermentation, the extra time the pulse cooling took outweighed the continuous cooling when you consider the substantial energy savings. It has been trialed at Treasury Wines	**Energy Savings** - +++ **Emission reduction** - Yes (To be quantified) **Cost benefits** - $$$
	Smart Fog The 4.2 micron droplets created by Smart Fog systems evaporate completely into the air before reaching any surface. System conserves energy and water both to generate precise humidity compared to other technologies. Additional cooling effect maintains required temperature reducing the cost of additional cooling equipment.	**Energy Savings** - ++++ **Emission reduction** - Yes (To be quantified) **Cost benefits** - $$$$
	Climate Wizard Creates controlled environment (temperature and humidity) for wine barrel storage. Appropriate for achieving energy efficiency in hot and dry climates. Internationally accepted solution by number of wineries in Australia and South Africa. All these wineries have experienced reduction in energy usage by more than 50% while controlling humidity	**Energy Savings** - +++ **Emission reduction** - Yes (To be quantified) **Cost benefits** - $$$

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Modify

Solution	Product & Characteristics	Comparative analysis
Pulse electric field technology (PEFT)	**ELEA Pulse technology** PEFT brings benefits to three treatment processes within vinification – mash treatment, lees treatment and wine treatment. It improves the quality of wine, reduce processing time and increase energy efficiency in wineries.	**Energy Savings** – Yes (To be quantified) **Emission reduction** - Yes (To be quantified) **Cost benefits** – Yes (To be quantified)
Alternative refrigerants	**Natural refrigerants** To increase the energy efficiency and reduce GHG emissions (<1 GWP) from refrigerants, it is recommended to retrofit existing refrigeration systems with low charge ammonia (NH3) based refrigerants. Safety guidelines yet to be determined. https://climate.ec.europa.eu/eu-action/fluorinated-greenhouse-gases/climate-friendly-alternatives-hfcs_en https://www.scantec.com.au/technologies/low-charge-ammonia	**Energy Savings** - +++ **Emissions Reduction** - ***** **Cost benefits** - $$$ (Exclusive of upfront investment)
	Transcritical CO2 refrigerant Fluid (CO2) goes through subcritical and supercritical states to become an undefined gas (neither liquid nor gas) and works as the most cost-effective and sustainable refrigerant. It is a future proof solution implemented by Countdown and Foodstuffs in NZ. • One of the important benefits is in reclaiming heat and routing to other areas of operation such as hot water boilers thus transforming and circulating one source of energy into another.	**Energy Savings** - ++++ **Emissions Reduction** - ***** **Cost benefits** - $$$$ (Exclusive of upfront investment)
Smart buildings	• In their strategy to be sustainable in their wine-making process by improving energy efficiency, Mt Difficulty Wines have insulated their wine storage tanks to reduce heat gain from surrounding air and have achieved significant differences. • Tablas Creek's cellar has an automatic louver system that opens to cool night air • At Languedoc's biodynamic Château Maris, the winery is constructed from double-walled brick made of lime, waste straw from hemp production, and a molasses-based fixer.	**Energy Savings** – Yes (To be quantified) **Emission reduction** - Yes (To be quantified) **Cost benefits** – Yes (To be quantified)

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Reduce reliance on fossil fuels

Along with monitoring and digitalisation, it is recommended to reduce reliance on fossil fuels, which account for 36% of emissions at wineries. This can be looked at by adapting to new processes as outlined below.

Process heat for cleaning and sanitisation

- Solar water heater are widely adopted solution by wineries for generation of process heat
- **Reclaim refrigeration heat** and use it for hot water boilers**.** Transcritical CO_2 (alternative refrigerant) is proven to discharge more heat than conventional refrigerants which can be reclaimed and rerouted for process heat. While conventional refrigerants (HFC or CFC) have higher emissions, this alternative source reduce not only carbon emissions to negligible but also reliance on fossil fuels for process heat. An example of Montreal warehouse retrofitting with Transcritical CO_2 as refrigerant
- **Upcycle crop residue** (waste) to source heat for boilers. It has been widely adopted as part of the solution by wineries. For example, Yealands Wines using 10% of pruning waste for heating water /
- Fuel cell electric boilers running on renewable energy generated from winery wastewater. Bio-energy (hydrogen) generation from winery wastewater has been demonstrated in the laboratory by converting 1L winery wastewater to generate 1Wh power for hydrogen fuel cells.
- Many uses of hydrogen indicated by Bloomberg NEF in fulfilling industrial heat requirements and powering material handling equipment.

A combination of two or more solutions should help in eliminating reliance on fossil fuels at winery depending on the size of consumption

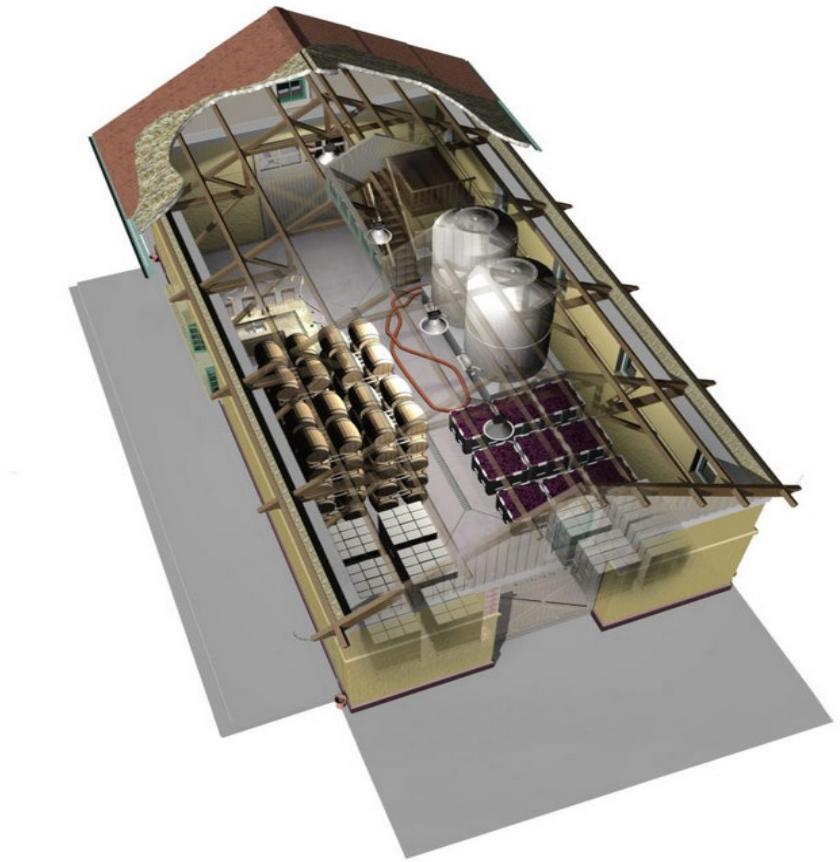
Decarbonisation

Tap into renewable sources of energy (electricity) for winery operations

- expected 96-98% renewable grid (2030)

Summary – Energy efficiency at winery

- **Energy optimisation** - The impact of increased energy consumption through digitalisation is expected to be mitigated by means of optimisation.
- **Cost effectiveness** - Most of the solutions are cost-effective with return on investment.
- **Pioneering solutions** - Some of the innovative solutions provide SWNZ to lead the change towards sustainable operations and be the pioneer of technology such as bio-energy generation from wastewater.
- **Customization** - Not all solutions fit everyone! Solutions need to be customized depending on emissions profile and focus area.



Amador cellars model, integrated structures with smart building systems

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Recommendation - Energy efficiency at winery

Customise multiple solutions under optimisation, digitalisation, decarbonisation to lead sustainable wine operations.

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Other Solutions

Other solutions

Waste

- **Generate power** – convert winery wastewater to hydrogen and generate power that can be circulated within winery.
- **Upcycle wine waste** – grape marc into healthy nutrient or supplements with high levels of flavonoids, antioxidants which promotes healthy bacteria in gut. Example Wellvine
- **Compost** – stems, skins and seeds with manure from animal farm and other amendments and spread it in vineyard following harvest.
- **Packaging** - pruning waste to cellulose for packaging boxes and labels.
- **Biosurfactants** - vineyard pruning waste as an alternative carbon source to produce novel biosurfactants.
- **Process heat** – us vine shoots to make pallets or use directly as fuel for boilers.

Bottling

- Juliet Eco-Magnum – Bag-in-box packaging is fully recyclable and 84% low carbon emissions compared to traditional glass bottle.
- Frugal bottle – 94% recycled paperboard and food grade pouch inside. Lowers carbon 6 times compared to traditional bottle.
- Garcon wines – Lightweight and shatterproof bottles made from 100% recycled PET.
- Green Bottle – reuse of refillable glass bottles to reduce emissions by 95%.
- **Glassware made from wine waste** – trialled by Budweiser in India, hasn't been reported anywhere.

Transport and distribution

- Wineworks – bulk transport in different container sizes.
- Reliance on electric or hydrogen fuel cell fleet for distribution within NZ.
- Reduce distance between vineyard and wineries for distribution of raw material – grapes by having winery within a certain proximity of the source material. This also mitigates supply chain risks impacted by climate change.

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Next Steps

Next Steps

- **Data completion** - Emphasise on completion of data including emissions from all (direct and indirect) sources (packaging, transportation etc).
- **Stakeholder engagement** - Engage with stakeholders to assess GHG inventory based on GHG protocol (Scope 1, 2 & 3) and reporting requirements.
- **Plan and Target** – Science based targets across the industry will assist in the development of emission reduction plans.
- **Emission reduction plan** - Create a near-term (5-7 years) and long-term (10-15 years) emission reduction plan based on production size.
- **Customise and adopt** - Analyse and customise different solutions for wineries, based on current energy consumption and future expansion plans.

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