WSET® LEVEL 4 DIPLOMA IN WINES
D6 | INDEPENDENT RESEARCH ASSIGNMENT

JULY 2022: SUSTAINABILITY

INTRODUCTION

In his contribution to the Encyclopaedia Britannica, James Meadowcroft defines sustainability as an ethical attitude in which our **present environmental and economic behaviour** does not 'diminish the opportunities of **future persons** to enjoy similar levels of **wealth**, **utility**, or **welfare**' (2015). As such, sustainable development takes **environmental**, **economic**, **societal** and **cultural** factors into account (UNESCO, 2021).

Sustainability is a hot topic, inspiring the design, development and implementation of new processes, products and technologies. But we must bear in mind that 'green' solutions also **consume energy and resources** to come about: people's time and attention, electricity, materials, chemicals and water used in production processes or to clean machinery and facilities. Additionally, new technologies tend to make **older equipment redundant**, resulting in functional hardware being discarded to end up as waste in landfill or industrial incinerators.

Sustainable technologies should therefore not be produced and implemented thoughtlessly. If we want to create a truly sustainable wine industry, we need to base decisions on **independent research**, **analysis** and **measurable data**. **Good intentions** and a **feel-good factor** serve as an important motivator and should not be overlooked. Nevertheless, our key actions should be guided by **scientific fact** and take the **full lifecycle** and **energy balance** into account.

SECTION 1: HOW CAN ENVIRONMENTAL SUSTAINABILITY IN A WINERY BE IMPROVED IN RELATION TO WATER AND ENERGY USE?

WATER

Agriculture is the largest water consumer worldwide, accounting for 69% of water withdrawals (UNESCO, 2019). The **impact of viticulture** is significant, with an astounding 870,000 litres needed to produce 1000 kilograms of grapes and turn them into wine (Mekonnen & Hoekstra, 2011). In the winery, each tonne of grapes also generates 3000 to 4000 litres of **wastewater** (Maicas & Mateo, 2020), mainly from **washing operations** during **grape reception**, **pressing**, **fermentation** and **cleaning** equipment and bottles (Deowan, et al., 2015).

WATER MANAGEMENT

Because activities in the winery, the vineyard and treatment of wastewater are interconnected, an **integrated approach to water management** is needed to improve a winery's environmental sustainability. If **water usage** and **wastage** are reduced, and the winery achieves **cleaner production processes** overall, less **treatment** is needed to reuse wastewater, e.g. for irrigation (Wine Australia, 2021). A so-called **'fit for purpose' analysis** shows wineries which types of wastewater are useful for which processes, and which treatments are required to do this safely (Grape and Wine Research and Development Corporation, 2011, p. 48).

To reduce wastage in the winery, it is important to first analyse how water is used. This can be done by installing **flow meters** in strategic places to detect leaks and to identify where the largest amounts of water are consumed. Sustainable Winegrowing New Zealand, for example, has been championing water conservation for many years. By now, 92% of their wineries **measure and record** their water usage; 71% have **leak detection programmes** and almost half **recycle cleaning water** (New Zealand Wine, 2020a). In the US Pacific Northwest, sustainability certification organisation LIVE requires sustainable water management in all aspects of the winery, from **wastewater measurement**, **monitoring**, **recording** and **analysis** to effectively **reducing water use** and **handling wastewater** in accordance with Salmon-Safe protocols (LIVE, 2022).

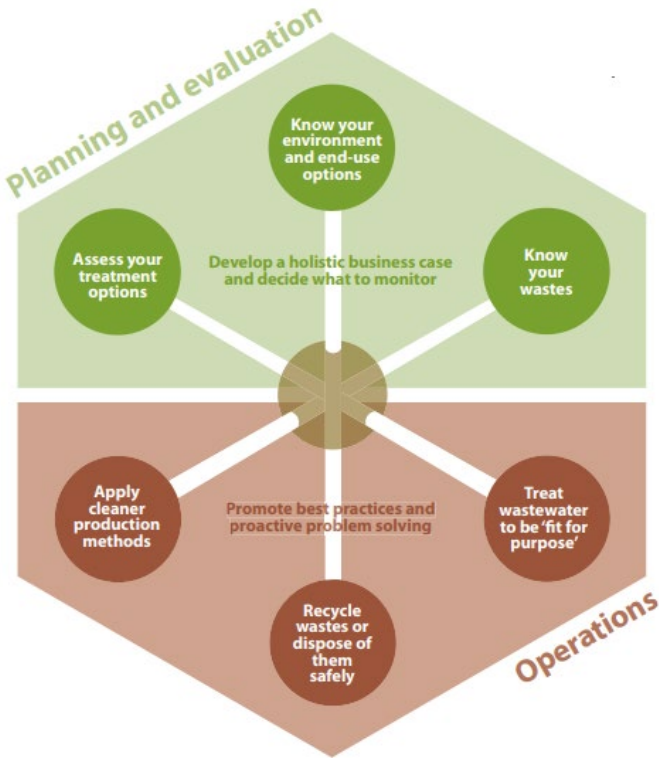

Figure 1 - Key factors in winery wastewater management and recycling (Grape and Wine Research and Development Corporation, 2011, p. 8)

WATER CONSERVATION

Tracking and analysing water usage reveals 'low-hanging fruit' measures that are cheap and easy to implement yet add up to make a difference, such as using **water-reducing hose nozzles** for cleaning or maintaining cellar hygiene with regular **cleaning equipment** rather than hosing floors down (California Sustainable Winegrowing Alliance, 2014). These initiatives work for small as well as large wineries. For example, the world's biggest wine producer, E. & J. Gallo, started by **measuring flow rates** of their hoses and involving employees via **'water walks'**, to build **awareness** of water expenditure throughout the winery. They managed to conserve water straightaway by **switching nozzles**, using **pressure washers** and **steam** for cleaning instead of open hoses, **pre-rinsing dirty barrels** with used water, and installing **drain covers** so grapes would not clog up the pipes and require additional water to be cleared (Rauber, 2015).

Other solutions involve **large investments**. These range from underground **tanks to collect rainwater** from the roofs of winery buildings, via water-saving **bottling lines** using **ultraviolet light** (Rieger, 2022) to dedicated **wastewater plants** to filter and treat water before reusing it (Howell & Myburgh, 2018). In Argentina's Uco Valley, Domaine Bousquet is working on a **biofilter** project to recycle its winery wastewater (Harpers Wine & Spirit, 2022). Stonecroft Winery in Hawke's Bay, New Zealand, already purifies all its 'grey water'[1] in a **treatment plant** and **reuses cooling water** in the winery (New Zealand Wine, 2020b). In California, O'Neill Vintners and Distillers built an installation where **worms filter wastewater** and turn it into an eco-friendly, soil-improving substance (O'Neill Winery & Distillery, n.d.).

Because wine businesses differ widely in size, location, ethos and resources, there is no 'one size fits all' solution. Wineries need to evaluate and implement measures that are feasible for them and share these as inspirational **best practices**. As an example, Cakebread Cellars in Napa Valley even

[1] Grey water is an industry term for wastewater which does not contain serious contaminants.

built their winery parking lot according to sustainability standards. It is planted with native trees, drought-tolerant grasses and landscaped with permeable pavers and a drainage system with bio-swales[2] (Napa Valley Vintners, 2022).

These **water-saving solutions** contribute to **energy conservation** as well, because of the substantial energy costs embedded in water transport, heating and treatments (Brittain, 2021).

ENERGY

A sustainable energy management strategy for wineries should start with **measuring and mapping** energy expenditure and focus on 2 important steps: **energy conservation in all sections of the winery** and opting for **renewable energies**.

ENERGY CONSERVATION

IN WINERY OFFICES

A 2016 study in office buildings showed energy savings up to 41% from simple measures such as using window blinds, adjusting thermostat settings and switching lights and equipment off when leaving (Sun & Hong, 2017). Energy can also be incorporated in the choice of **marketing materials**, **employee travel** and **transport options**.

IN PACKAGING

A winery can improve its energy sustainability by choosing **eco-friendly packaging**, such as **recycled wine boxes**, which take less energy to produce than new cardboard (The Institute of Masters of Wine, 2021b). In 2010, Comité Champagne introduced **lighter bottles**, saving energy and 8000 tonnes in CO_2 emissions annually (Comité Interprofessionnel du Vin de Champagne, 2021). Depending on wine style, ageing requirements and market segments, **bag-in-box** is more environmentally sustainable, with 60 to 90% less lifecycle impact than single-use glass (Ferrara & De Feo, 2020). **Aluminium cans** and **bottles** require less energy to produce, transport and recycle[3] (The IWSR, 2021). Similarly, **paper wine bottles**, made from 94% recycled paperboard (Arthur, 2020) and **kegged wines on tap** in hospitality or tasting rooms[4] have much lower energy and water footprints.

Wineries increasingly participate in **bottle reuse** projects, with bottles collected from hospitality and retailers. Styria, Austria, pioneered this in 2011, with reuse processes requiring only 0.09 kWh of energy per bottle, compared to 1.1 kWh to produce a new one (Eales, 2019).

IN WINE PRODUCTION

Studies show winemaking is energy intensive (Malvoni, et al., 2017), with **refrigeration** as the biggest culprit, followed by **lighting**, **compressed air** and **processing** (Styles, et al., 2014). In cool climates **heating**, **cooling** and **ventilation** totalled 44% of energy use; lighting 22% (Smyth & Nesbitt, 2014).

UC Davis professor Roger Boulton recommends **comprehensive energy management** for wineries, focusing on **energy-efficient passive buildings**, **insulation, refrigeration, generating renewable energy** and providing **storage systems** (Boulton, 2019).

[2] Bio-swales are channels which capture and purify storm water and allow it to recharge ground water tables.
[3] However, they are not yet collected in every region or country, and not all waste processing plants are able to recycle them at this point in time.
[4] Especially in areas with a strong brewery, pub and fill-up tap-room culture, this is an ongoing trend, eliminating the need for many hundreds of thousands of glass bottles in places such as Colorado (Carboy Winery, 2020) and the wider Seattle-Puget Sound area in Washington State (Perdue, 2014).

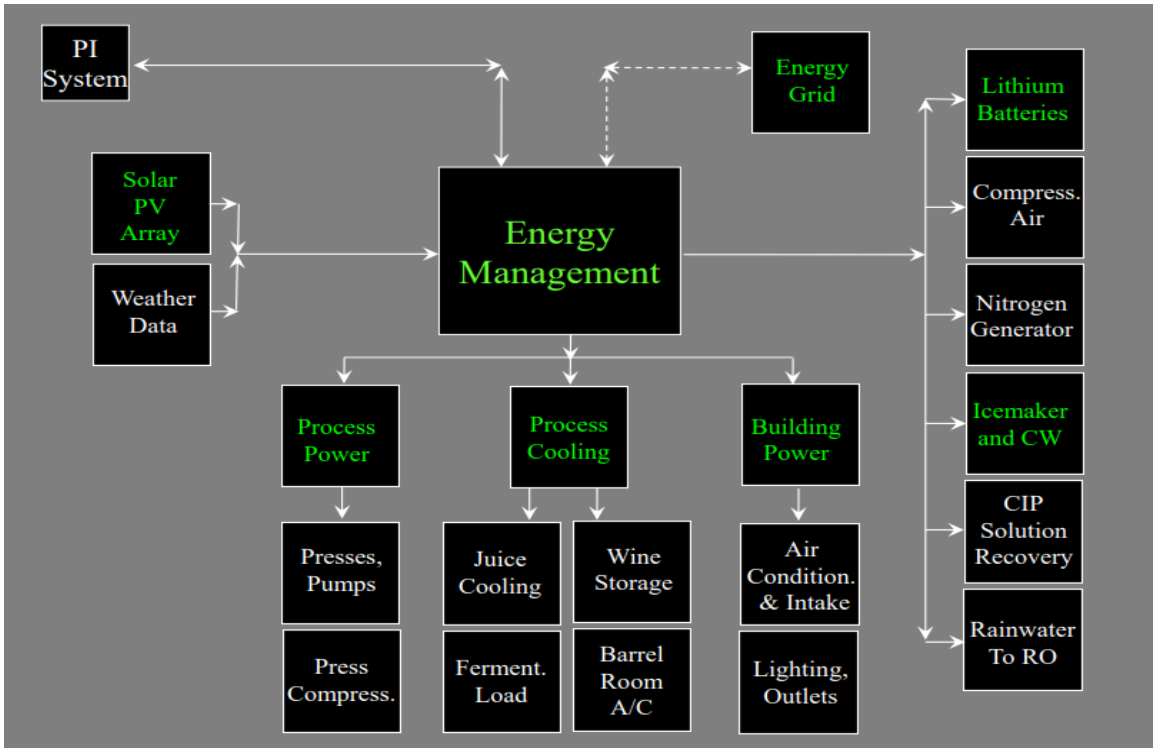

Figure 2 – Energy management in UC Davis' sustainable winery - passive building performance (Boulton, 2019)

Where possible, wineries should take advantage of **natural conditions**. Underground **chalk quarries**, for example, retain **stable temperatures and humidity levels**. Champagne Ruinart's *crayères* only require power for energy-efficient LED lighting (Ruinart, n.d.). New cellar spaces are increasingly constructed **underground**, such as Château Smith Haut Lafitte's *chai furtiff*[5] in Bordeaux, which operates without electric cooling (McCoy, 2020). Refrigeration operates more efficiently at lower surrounding temperatures, so chilling liquids or wine at **night** and conducting cold stabilisation in **winter** conserve energy (The Australian Wine Research Institute, 2011).

Numerous **technological measures** are available to wineries, depending on their needs and circumstances. J. Lohr cut energy expenditure in their winery in hot and arid Paso Robles simply by installing two **high-speed roll-up doors**. Previously, doors were left open during production hours for easy access, which caused big energy losses. The new doors save over 32,000 kWh each year, equivalent to a three-person household's consumption[6] (California Sustainable Winegrowing Alliance, 2013a). Asti Winery in Cloverdale uses natural daylight and **energy-efficient lighting** with **motion sensors**. Combined with other measures, from **insulating 93 wine tanks** to installing **variable speed drives**[7] which adjust the speed of compressors and fans, they save 1.6 million kWh annually (California Sustainable Winegrowing Alliance, 2013c). A 2020 trial in New Zealand showed that **pulse cooling** tanks, where coolant is pumped through refrigeration jackets in intervals, drastically lowers

[5] Translates from French as 'stealth storeroom'.
[6] Based on the 2020 figures of the U.S. Energy Information Administration, the average annual electricity consumption for a U.S. residential utility customer was 10,715 kWh (U.S. Energy Information Administration, 2021).
[7] Variable speed drives (VSD) are converters, installed between the electrical supply and equipment such as motors, air compressors, fans and pumps, reducing their speed wherever possible, e.g. for partially-filled equipment. Because much winery equipment uses compressed air for crushing and pressing grapes, heating, cooling, filtration, micro-oxygenation and bottling; VSD air compressors alone can deliver energy savings between 15 and 40% (Chicago Pneumatic, n.d.).

energy expenditure. Although it took twice as long to get to the 8°C target, only 30% of the energy of conventional methods was used (Bragato Research Institute, 2020).

RENEWABLE ENERGIES

Wineries can further improve their environmental sustainability by **procuring energy from renewable sources**. The focus should be on truly sustainable solutions, factoring in the material, environmental and energy costs of harnessing and transporting energy[8], and social or geopolitical implications[9] of outsourcing environmental costs to developing countries.

SOLAR ENERGY

Solar and photovoltaic panels[10] are suitable for wineries, since most are located in medium to high solar radiation areas, and there is a seasonal match between peak energy consumption in the winery and higher radiation times (Perdigones, et al., 2021, p. 46). Concha y Toro, for instance, fulfils all its energy requirements in Chile with 21 solar photovoltaic plants (Viña Concha y Toro, 2020).

Because solar energy is an intermittent source, depending on sunshine, it is often combined with complementary technologies. Salcheto in Montepulciano, Tuscany, for example, blends **photovoltaic**, **geothermal** and **wood biomass** solutions (Alimonti & Pecci, 2022).

FUEL CELLS

In Napa and Sonoma, Trinchero Family Estates and Stone Edge Farm combine **solar energy** with **fuel cells**: electrochemical **energy-conversion devices** that can work on **hydrogen**[11] (California Sustainable Winegrowing Alliance, 2013).

GEOTHERMAL ENERGY

In the cool-climate Finger Lakes, Sheldrake Point Winery relies on a **geothermal installation**, in which **water** and **methanol** are pumped through wells and loops deep **underground**, where the temperature is a constant 50°C. In the winery, compressors extract or discharge heat for warming and cooling the building and the glycol used in tank chilling jackets (Sheldrake Point Winery, 2020).

BIOFUELS

Waste disposal is an environmental concern, so turning **biomass** such as grape stems, pomace and lees into value-added **biofuels** provides several environmental benefits (Bharathiraja, et al., 2020). Some larger wineries and co-operatives such as Caviro, owner of Italy's biggest wine brand Tavernello, built their own **biorefinery** (Gruppo Caviro, 2020).

---

[8] Because these technologies rely on freely available, natural resources, such as the sun, wind, flowing water or heat contained beneath the earth's crust, they are easily seen as innately eco-friendly and free. However, the materials used to construct solar panels, wind turbines and batteries rely on metals and minerals, which are finite resources and need to be mined, processed, transported and – at the end of their lifecycles – disposed of (Church & Crawford, 2018).

[9] Because much of the hardware is manufactured in developing countries, part of the environmental cost is outsourced to these regions. This not only sustains an asymmetric flow of resources (Riechers, 2012), it can also augment social and political problems (Marín & Goya, 2021), and therefore threaten economic and social sustainability.

[10] Solar and photovoltaic panels respectively convert solar radiation into heat and thermal energy into electricity.

[11] Hydrogen itself can be produced from water via electrolysis. This process does require energy from another source, but fuel cells have a higher fuel-to-electricity conversion efficiency compared to e.g. combustion engines, and only water and heat are produced as by-products (Sazali, et al., 2020).

WIND ENERGY

Despite concerns about visual aspects, impact on wildlife and microclimates, **wind energy** is one of the cleanest renewable energies (Hamed & Alshare, 2022). Wineries can procure wind power via utility suppliers, or install a smaller **wind turbine** themselves. For optimal returns, **location** is key, favouring open plains, hilltops, mountain gaps or water (U.S. Energy Information Administration, 2022). In California's Salinas Valley, for example, with strong winds from Monterey Bay, Scheid Family Wines generates enough electricity to cover its needs and put surplus back into the grid (Bournellis, 2018). Similarly, in Rioja Alavesa, Spain, Bodegas Fernández de Piérola surpasses its own energy requirements with a turbine at 550 metres altitude[12] (Portillo, 2016).

Some of the above-mentioned technologies are not feasible – nor desirable – for small wineries. However, they can factor in sustainability when **selecting water and energy suppliers**. In many regions, providers increasingly include renewable energies in their portfolios.

SECTION 2: HOW CAN A WINE PRODUCER IMPROVE THEIR SOCIAL SUSTAINABILITY THROUGH THEIR EMPLOYEE RELATIONSHIPS?

Social sustainability has many faces. In countries with stable, mature economies and reliable social protection, the focus tends to be on **wellbeing and improving work-life balance**; while in regions where working conditions are still largely unregulated, sustainability needs to address **basic human rights, health and safety** first.[13]

WORKERS' RIGHTS

But even in wine businesses where workers' basic rights are fulfilled, improvements can be made. In its sustainable winery checklist, the Pacific Northwest's certification body **LIVE** states criteria for **community impact, workers' health, safety, education and benefits**, from staff training and policy participation to adequate meal periods, rest breaks and availability of hygiene, sanitation and first-aid facilities. **Remuneration** for members must exceed legal minimum wages, with paid overtime and vacation, **healthcare** and **retirement** benefits (LIVE, 2022). Equally, in South Africa, the **IPW** sustainability guidelines[14] include **staff training, health and safety measures** (Wine & Spirit Education Trust, 2021a, pp. 502, 516).

EMPLOYABILITY

Wineries can also launch own **initiatives** for a socially sustainable workplace. John Williams of Frog's Leap in Rutherford, for example, invested in **year-round employment** and benefits for immigrant

[12] Their €400.000 investment produces 250.000 kWh per year, amounting to annual energy savings of €50,000. The calculation is based on the current average wholesale energy price in Spain, reported in June 2022 as 187.16 euros per megawatt (Statista, 2022).

[13] To illustrate this chasm: a 2020 study in Austria and Germany identified job satisfaction factors among wine sector employees, such as remuneration, career opportunities, recognition by colleagues and managers, quality of the wines and alignment with the business' philosophy (Regel, et al., 2020). In contrast, a 2021 research report by OXFAM revealed large-scale exploitation of immigrant workers in wine regions around the world, ranging from excessive working hours, below-minimum wages and lack of insurance, to forced labour, abysmal housing conditions and health and safety hazards (Gore, et al., 2021). International investigations even linked some seasonal-labour agencies to organised crime groups involved in human trafficking (Europol, 2019).

[14] Integrated Production of Wine. Meeting these requirements is needed to obtain the 'Integrity and Sustainability' seal. 95% of South African growers and wineries currently subscribe to them.

workers (Gilinsky, et al., 2016). He involves employees in **decision-making** and continues to **lower the spread between the lowest- and highest-paid jobs** (Fox, 2020). O'Neill Vintners & Distillers ensure a well-rounded, diverse workforce by offering **university scholarships and internships** to advance the representation of black, indigenous and people of colour (Wine Institute, 2021b). In 2011, Moët Hennessy Louis Vuitton created a **sheltered workshop** for disabled employees, several of which secured permanent contracts at their Champagne houses since (LVMH, n.d.). In Bordeaux, Château Montrose developed **ergonomic tools** for its workers, and Château Anthonic **increases employability** by teaching vineyard skills to low-skilled young workers (McCoy, 2020).

COMMUNITY

Social sustainability can also be improved by contributing to the **local community**, forging bonds with people, organisations and businesses in the region. Companies can recruit, source services or goods locally and support regional tourism and initiatives (Martucci, et al., 2019). When wine producers work constructively within their community, this **raises the brand's image** and strengthens employees' **positive feelings about their workplace**. This boosts employee retention, engagement, motivation, productivity and customer service (Sageer, et al., 2012).

Measures to mitigate negative impact on the community and enhancing **environmental sustainability** also improve employee relationships. As marketing expert Helen Wells asserts:

> Better brand, happier staff. Being perceived as a green company is great for your brand image, and can make staff recruitment and retention easier. People want to work for companies that are part of the solution, rather than part of the problem. (Wells, 2015)

MANAGEMENT

Finally, I want to stress the value of **'enlightened management'** in employee relationships. Socially sustainable businesses should not be run in fear, mistrust and micromanagement. Hiring the right persons for the job, **rewarding** them fairly, providing **meaningful involvement** and **growth and training opportunities**, are the ways forward. Then even staff who leave the business are likely to remain **brand advocates** and can become **trusted contacts or business partners** in their new capacity, which results in a **strong, sustainable social network**.

An example of a wine producer with a strong socially-centred philosophy is Wirra Wirra in McLaren Vale. On their way to the entrance, staff and customers, referred to as the 'Wirra Wirra tribe', pass an installation with the words of the iconic Greg Trott, who revived the winery in the 1960s:

> Never give misery an even break, nor bad wine a second sip. You must be serious about quality, dedicated to your task in life, especially winemaking, but this should all be fun. (Wirra Wirra, n.d.)

SECTION 3: IN YOUR OPINION, DOES SUSTAINABILITY BENEFIT THE CONSUMER, AND TO WHAT EXTENT DOES IT INFLUENCE THEIR BEHAVIOUR?

DOES SUSTAINABILITY BENEFIT THE CONSUMER?

Sustainability certainly benefits consumers, as it balances the interests of **people, planet and profit**. It affects the air we breathe, the water – and wine – we drink, the life we live and the resources available to live it, for us as well as our descendants.

Economic growth has brought us many **benefits**, from reducing poverty to improving human rights and access to education, healthcare, water and sanitation. However, what Ekins & Zenghelis call the **'grow now, clean up later'** mindset, has long ignored externalities[15]: 'this approach has brought human societies to the brink of catastrophe, putting at serious risk all these benefits and, indeed, the continuance of human civilisation itself' (Ekins & Zenghelis, 2021).

Consumers clearly benefit from measures that allow us to continue human civilisation, business, trade and food and wine production. In the short term, however, prices may go up to reflect the full cost of a product. To be **economically sustainable**, prices need to include those expenses that were previously passed on to other parties or future generations. Although price increases may not feel like a benefit to consumers, **fair prices** provide the basis for **continued, sustainable production and consumption**.

Another – less obvious – benefit is that **sustainability success stories** give us **hope**. In these times of negative news, improvements in **environmental, social and economic indicators** motivate us to go on. Hans Rosling called this '**factfulness**: understanding as a source of mental peace'. He warned against losing hope: 'When people wrongly believe that nothing is improving, they may conclude that nothing we have tried so far is working and lose confidence in measures that actually work' (Rosling, et al., 2018, pp. 16, 69).

DOES SUSTAINABILITY INFLUENCE CONSUMER BEHAVIOUR?

Research by wine consumer research organisation Wine Intelligence reveals that wine consumers care about **personalisation**, **experience**, **convenience** and **sustainability** (Halstead, 2019). Sustainably produced wines align with **'ethical consumerism'** and consumers perceive them as innovative, trendy, and offering health benefits (Capitello & Sirieix, 2019).

However, consumption behaviour is not entirely consistent with these positive associations; a phenomenon known as the **green attitude-behaviour gap** or **green purchasing inconsistency**. According to White et al.: 'a frustrating paradox remains at the heart of green business: few consumers who report positive attitudes toward eco-friendly products and services follow through with their wallets' (2019, p. 127).

Wine researcher Juan Park explains this by how our brain uses innate **pain and reward systems** for purchasing decisions (2019). When consumers consider a purchase, their brain weighs what they get out of it, against what it will cost them. If the perceived rewards outweigh the pain, they are likely to buy. Among wine consumers queried by Wine Intelligence, 55% worry about climate. Yet only 40% were willing to endure more 'pain' for sustainable wines, in the form of paying more or giving up convenience. However, when a product aligned with their **self-image** and **beliefs**, or it was associated with **higher standards** and **quality** (= higher rewards), consumers were more likely to buy. **Wine label terms** such as 'natural wine', 'organic', 'environmentally-friendly', 'sustainably-produced', 'preservative-free' or 'fair-trade' increased consumers' willingness to buy; while claims

[15] Externalities is a term used in economics to refer to situations where some costs of the production or consumption of goods or services are not factored into their price. Externalities can be positive or negative. In the case of negative externalities, the producer does not pay for the incurred costs; while in the case of positive externalities, the producer does not receive the benefits.

which confused them, such as ‘sulphite-free’, ‘carbon-neutral’, ‘biodynamic’, ‘vegan’ or ‘vegetarian’, had the opposite effect (The Institute of Masters of Wine, 2021a).

All this suggests consumers **care** about and are **influenced** by sustainability, providing they **understand the rewards**. An Italian study confirmed that responses to sustainability claims are **heterogenous**, but overall, labels addressing environmental aspects **increase sales**. In addition, consumers are willing to pay a **premium** for wines produced by companies that respect **fair working conditions** (Piracci, et al., 2022).

Positive effects of sustainability on consumption behaviour are demonstrated **across consumer segments**, and most of all with **millennials**, provided sustainability claims are well defined and prominently displayed (Pomarici & Vecchio, 2014). A recent study among South-African consumers showed that especially **younger individuals** with **higher incomes**, **higher education levels** and better **knowledge of eco-certification** were willing to pay a higher price for sustainably produced and fair-trade wines (Mihailescu, et al., 2021). For **low-income** consumers, however, higher prices form a **barrier**, irrespective of their attitudes towards environmentalism (Schäufele & Hamm, 2018).

CONCLUSION

When wine businesses want to improve their **environmental, social or economic sustainability**, it is essential they make an in-depth **analysis** of the current situation, which highlights where gains can be achieved. In decision-making to reduce a winery’s environmental impact, the **full lifecycle** of technologies should be considered. Furthermore, by raising **awareness,** improving **working conditions** and **involving employees** in all sections of the winery, more hands and minds are working to achieve the sustainability objectives. And finally, **marketing** and **communication** matter, because clear and prominently conveyed sustainability efforts increase a wine’s **attractiveness to consumers**, boost **employee engagement** and strengthen the **brand image**.

BIBLIOGRAPHY

Alimonti, C. & Pecci, G., 2022. Back Analysis of a Horizontal Geothermal Plant Implemented in a Wine Production Process. *Sustainability,* 14(1), p. 157.

Arthur, R., 2020. *Paper wine bottle can cut carbon footprint by 84%, says Frugalpack.* [Online] Available at: https://www.beveragedaily.com/Article/2020/07/08/Packaging-innovation-Paper-wine-bottle-cuts-carbon-footprint [Accessed 21 June 2022].

Bharathiraja, B. et al., 2020. Critical review on bioconversion of winery wastes into value-added products. *Industrial Crops and Products,* Volume 158, pp. 1-10.

Boulton, R., 2019. *The Design Solutions for a Self-Sustainable Zero-Carbon Winery.* [Online] Available at: https://climatechange-porto.com/wp-content/uploads/2019/03/Session-4-Wineries-of-the-Future-Roger-Boultton-CCL2019.pdf [Accessed 16 June 2022].

Bournellis, C., 2018. *Wind Turbine Electricity Generation.* [Online] Available at: https://winesvinesanalytics.com/features/article/202687/Wind%20Turbine%20Electricity%20Generation [Accessed 19 June 2022].

Bragato Research Institute, 2020. *Pulse cooling as an energy saver in wineries.* [Online] Available at: https://bri.co.nz/2020/10/02/pulse-cooling/ [Accessed 18 June 2022].

Brittain, A., 2021. *Maximizing Energy Efficiency, Saving Money, and Cutting Carbon Footprint.* [Online] Available at: https://www.portoprotocol.com/case-studies/maximizing-energy-efficiency-saving-money-and-cutting-carbon-footprint-views-of-anna-brittain-napa-green/ [Accessed 16 June 2022].

California Sustainable Winegrowing Alliance, 2013a. *J. Lohr Vineyards & Wines.* [Online] Available at: https://www.sustainablewinegrowing.org/docs/J%20Lohr_Case%20Study-FINAL.pdf [Accessed 17 June 2022].

California Sustainable Winegrowing Alliance, 2013c. *Improving Energy Efficiency at Older Facilities.* [Online] Available at: https://www.sustainablewinegrowing.org/docs/Asti%20Cast%20Study%20v4.pdf [Accessed 17 June 2022].

California Sustainable Winegrowing Alliance, 2013. *Using Fuel Cells in Vineyards & Wineries.* [Online] Available at: https://www.sustainablewinegrowing.org/docs/Fuel%20Cells%20Case%20Study%20v7.pdf [Accessed 17 June 2022].

California Sustainable Winegrowing Alliance, 2014. *Sustainable Water Management Handbook for Small Wineries.* [Online] Available at: https://www.sustainablewinegrowing.org/docs/CSWA_Sustainable_Water_Management_Guide_for_Small_Wineries.pdf [Accessed 25 June 2022].

Capitello, R. & Sirieix, L., 2019. Consumers' Perceptions of Sustainable Wine: An Exploratory Study in France and Italy. *Economies,* Volume 7, pp. 1-20.

Carboy Winery, 2020. *Sustainable wines on tap.* [Online]
Available at: https://www.carboywinery.com/about/sustainable-wines-on-tap [Accessed 29 June 2022].

Chicago Pneumatic, n.d. *Compressors and Wineries. The Perfect Blend..* [Online]
Available at: https://compressors.cp.com/en-us/news-and-events/wine-and-compressors [Accessed 16 June 2022].

Church, C. & Crawford, A., 2018. *Green Conflict Minerals: The fuels of conflict in the transition to a low-carbon economy.* [Online]
Available at: https://www.iisd.org/system/files/publications/green-conflict-minerals.pdf [Accessed 18 June 2022].

Comité Interprofessionnel du Vin de Champagne, 2021. *Climate Change Adaptation in the Champagne Region.* [Online]
Available at:
https://www.champagne.fr/assets/files/Developpement%20Durable/dp2021/dossier-climate-change-adaptation-2021.pdf [Accessed 18 June 2022].

Deowan, S., Bouhadjar, S. I. & Hoinkis, J., 2015. Winery Wastewater. In: A. Basile, A. Cassano & N. Rastogi, eds. *Advances in Membrane Technologies for Water Treatment.* s.l.:Woodhead Publishing, pp. 625-642.

Eales, B., 2019. *Ingenious ways to reuse bottles instead of recycling them.* [Online]
Available at: https://www.wine-business-international.com/wine/general/ingenious-ways-reuse-bottles-instead-recycling-them [Accessed 21 June 2022].

Ekins, P. & Zenghelis, D., 2021. The costs and benefits of environmental sustainability. *Sustainability Science,* Volume 16, pp. 949-965.

Europol, 2019. *Bad harvest for Bulgarian-French network exploiting vineyard workers.* [Online]
Available at: https://www.europol.europa.eu/media-press/newsroom/news/bad-harvest-for-bulgarian-french-network-exploiting-vineyard-workers [Accessed 19 June 2022].

Ferrara, C. & De Feo, G., 2020. Comparative life cycle assessment of alternative systems for wine packaging in Italy. *Journal of Cleaner Production,* Volume 259, pp. 1-12.

Fox, C., 2020. *WWC20 - Frog's Leap, Napa Valley.* [Online]
Available at: https://www.jancisrobinson.com/articles/wwc20-frogs-leap-napa-valley [Accessed 20 June 2022].

Gilinsky, A. J., Newton, S. K. & Fuentes Vega, R., 2016. Sustainability in the global wine industry: Concepts and cases. *Agriculture and Agricultural Science Procedia,* Volume 8, pp. 37-49.

Gore, T., Alestig, M., Banerji, S. & Ceccarelli, G., 2021. *The Workers Behind Sweden's Italian Wine.* [Online]
Available at:
https://www.oxfam.se/sites/default/files/the_workers_behind_swedens_italian_wine.pdf [Accessed 19 June 2022].

Grape and Wine Research and Development Corporation, 2011. *Winery Wastewater Management & Recycling: Operational Guidelines.* [Online]
Available at: https://www.wineaustralia.com/getmedia/72627da6-d28a-42f2-b600-28fdd5a6c85c/operational-guidelines.pdf [Accessed 28 June 2022].

Gruppo Caviro, 2020. *Energy and environment, together.* [Online]
Available at: https://www.caviro.com/en/bioenergy-and-compost/ [Accessed 19 June 2022].

Halstead, L., 2019. *The Four Things Wine Consumers Care About.* [Online]
Available at: https://www.wineintelligence.com/the-four-things-wine-consumers-care-about/ [Accessed 11 June 2022].

Hamed, T. A. & Alshare, A., 2022. Environmental Impact of Solar and Wind Energy - A Review. *Journal of Sustainable Development of Energy, Water and Environment Systems,* 10(2), pp. 1-23.

Harpers Wine & Spirit, 2022. *Comaine Bousquet's Biofilter project.* [Online]
Available at: https://domainebousquet.com/en/domaine-bousquets-biofilter-project/ [Accessed 29 June 2022].

Howell, C. L. & Myburgh, P. A., 2018. Management of Winery Wastewater by Re-using it for Crop Irrigation - A Review. *South African Journal of Enology and Viticulture,* 39(1), pp. 116-131.

LIVE, 2022. *LIVE winery checklist 2022.* [Online]
Available at: https://livecertified.org/sites/default/files/documents/2022%20Winery%20Checklist%20Summary.pdf [Accessed 16 June 2022].

LVMH, n.d. *LVMH Disability Inclusion.* [Online]
Available at: https://www.lvmh.com/group/lvmh-commitments/social-environmental-responsibility/lvmh-disability-inclusion/ [Accessed 17 June 2022].

Maicas, S. & Mateo, J. J., 2020. Sustainability of Wine Production. *Sustainability,* 12(2), p. 559.

Malvoni, M., Congedo, P. M. & Laforgia, D., 2017. Analysis of energy consumption: a case study of an Italian winery. *Energy Procedia,* 126(201709), pp. 227-233.

Marín, A. & Goya, D., 2021. Mining - The dark side of the energy transition. *Environmental Innovation and Societal Transitions,* Volume 41, pp. 86-88.

Martucci, O., Arcese, G., Montauti, C. & Acampora, A., 2019. Social Aspects in the Wine Sector: Comparison between Social Life Cycle Assessment and VIVA Sustainable Wine Project Indicators. *Resources,* 8(2), p. 69.

McCoy, E., 2020. *Meet Bordeaux's eco-warriors.* [Online]
Available at: https://www.decanter.com/learn/meet-bordeauxs-eco-warriors-438588/ [Accessed 16 June 2022].

Meadowcroft, J., 2015. *Sustainability.* [Online]
Available at: https://www.britannica.com/science/sustainability [Accessed 11 June 2022].

Mekonnen, M. M. & Hoekstra, A. Y., 2011. The green, blue and grey water footprint of crops and derived crop products. *Hydrology and Earth System Sciences,* Volume 15, pp. 1577-1600.

Mihailescu, R. et al., 2021. Identifying the willingness to pay for eco-certified wine by South African consumers: A comparison of biodynamic, fair trade and sustainably produced wines. *Research in Hospitality Management,* 11(3), pp. 235-240.

Napa Valley Vintners, 2022. *Cakebread Cellars Green Parking Lot Helps to Conserve Water.* [Online]
Available at: https://napavintners.com/d2e/cakebread_cellars.asp [Accessed 14 June 2022].

New Zealand Wine, 2020a. *Water.* [Online]
Available at: https://www.nzwine.com/en/sustainability/focus-areas/water/ [Accessed 13 June 2022].

New Zealand Wine, 2020b. *Recycling water.* [Online]
Available at: https://www.nzwine.com/en/winery/stonecroft/recycling-water [Accessed 13 June 2022].

O'Neill Winery & Distillery, n.d. *Sustainability Initiatives.* [Online]
Available at: https://oneillwine.com/sustainability-initiatives [Accessed 20 June 2022].

Park, J., 2019. *Reward and Pain: How the Brain Decides What to Purchase.* [Online]
Available at: https://www.wineintelligence.com/reward-and-pain-how-the-brain-decides-what-to-purchase/ [Accessed 11 June 2022].

Perdigones, A. et al., 2021. Evaluation of the cost-effectiveness of grid-connected photovoltaic solar energy in wineries. *Ciência E Técnica Vitivinícola,* 36(1), pp. 45-54.

Perdue, A., 2014. Kegs offer a greener way to serve wine. *The Seattle Times*, 21 November.

Piracci, G., Boncinelli, F. & Casini, L., 2022. Wine consumers' demand for social sustainability labeling: Evidence for the fair labor claim. *Applied Economic Perspectives and Policy,* pp. 1-20.

Pomarici, E. & Vecchio, R., 2014. Millennial generation attitudes to sustainable wine: an exploratory study on Italian consumers. *Journal of Cleaner Production,* Volume 66, pp. 537-545.

Portillo, G., 2016. *La primera bodega del mudo autoabastecida con renovables en Rioja.* [Online]
Available at: https://www.renovablesverdes.com/la-primera-bodega-del-mundo-autoabastecida-renovables-rioja/ [Accessed 20 June 2022].

Rauber, C., 2015. *How Californias largest winemaker has cut water use by 25 percent.* [Online]
Available at: https://www.bizjournals.com/sanfrancisco/blog/2015/04/e-j-gallo-wine-drought-jackson-family.html [Accessed 25 June 2022].

Regel, E. A., Forneck, A. & Quendler, E., 2020. Job satisfaction of certified employees in viticulture: A qualitative study. *Work,* 67(2), pp. 467-475.

Riechers, M., 2012. *A conversion of nature's value?.* [Online]
Available at:
https://gupea.ub.gu.se/bitstream/handle/2077/29234/gupea_2077_29234_1.pdf [Accessed 18 June 2022].

Rieger, T., 2022. *Unified Symposium Presents Case Studies for Three Water-Efficient Wineries.* [Online]
Available at: https://www.winebusiness.com/news/article/255379 [Accessed 29 June 2022].

Rosling, H., Rosling Rönnlund, A. & Rosling, O., 2018. *Factfulness: Ten Reasons We're Wrong About the World--and Why Things Are Better Than You Think.* 1st ed. New York: Flatiron Books.

Ruinart, n.d. *Reduce Carbon Footprint.* [Online]
Available at: https://www.ruinart.com/en-ww/sustainability-commitments/carbon-footprint [Accessed 17 June 2022].

Sageer, A., Rafat, S. & Agarwal, P., 2012. Identification of Variables Affecting Employee Satisfaction and Their Impact on the Organization. *IOSR Journal of Business and Management,* 5(1), pp. 32-39.

Sazali, N., Wan Salleh, W. N., Jamaludin, A. S. & Mhd Razali, M. N., 2020. New Perspectives on Fuel Cell Technology: A Brief Review. *Membranes,* 10(5), pp. 1-18.

Schäufele, I. & Hamm, U., 2018. Organic wine purchase behaviour in Germany: Exploring the attitude-behaviour-gap with data from a household panel. *Food Quality and Preference,* Volume 63, pp. 1-11.

Sheldrake Point Winery, 2020. *Sheldrake Point Winery Goes Geothermal.* [Online] Available at: https://sheldrakepoint.com/wp-content/uploads/2020/07/Sheldrake-Point-Winery-Goes-Geothermal.pdf [Accessed 18 June 2022].

Smyth, M. & Nesbitt, A., 2014. Energy and English wine production: A review of energy use and benchmarking. *Energy for Sustainable Development,* 23(December 2014), pp. 85-91.

Statista, 2022. *Monthly wholesale electricity prices in Spain 2019-2022.* [Online] Available at: https://www.statista.com/statistics/1267552/spain-monthly-wholesale-electricity-price/ [Accessed 19` June 2022].

Styles, S., Layous, S. & Crable, S., 2014. *Winegrape Vineyards and Winery Operations. Energy Efficiency/Sustainability and Expansion,* San Luis Obispo: California Polytechnic State University, Irrigation Training & Research Center (ITRC).

Sun, K. & Hong, T., 2017. A simulation approach to estimate energy savings potential of occupant behavior measures. *Energy and Buildings,* Volume 136, pp. 43-62.

The Australian Wine Research Institute, 2011. *Improving Winery Refrigeration Efficiency.* [Online] Available at: https://www.winebusiness.com/content/file/ImprovingRefrigerationEfficiency.pdf [Accessed 18 June 2022].

The Institute of Masters of Wine, 2021a. *Sustainability from the Vineyard to the Glass [Webinar].* [Online] Available at: https://www.mastersofwine.org/events/webinars [Accessed 10 June 2022].

The Institute of Masters of Wine, 2021b. *Economic Sustainability Across the Wine Value Chain [Webinar].* [Online] Available at: https://www.mastersofwine.org/events/webinars# [Accessed 11 June 2022].

The IWSR, 2021. *How is canned wine innovation evolving?.* [Online] Available at: https://www.theiwsr.com/how-is-canned-wine-innovation-evolving/ [Accessed 21 June 2022].

U.S. Energy Information Administration, 2021. *FAQs - How much electricity does an American home use?.* [Online] Available at: https://www.eia.gov/tools/faqs/faq.php?id=97&t=3 [Accessed 17 June 2022].

U.S. Energy Information Administration, 2022. *Wind explained. Where wind power is harnessed.* [Online] Available at: https://www.eia.gov/energyexplained/wind/where-wind-power-is-harnessed.php [Accessed 19 June 2022].

UNESCO, 2019. *The United Nations World Water Development Report 2019.* [Online] Available at: https://unesdoc.unesco.org/ark:/48223/pf0000367306/PDF/367306eng.pdf.multi [Accessed 14 June 2022].

UNESCO, 2021. *Sustainable Development.* [Online]
Available at: https://en.unesco.org/themes/education-sustainable-development/what-is-esd/sd [Accessed 11 June 2022].

Viña Concha y Toro, 2020. *Corporate Sustainability Report.* [Online]
Available at: https://vinacyt.com/content/uploads/2021/08/vina-concha-y-toro-sustainability-report-2020.pdf [Accessed 29 June 2022].

Wells, H., 2015. *Why your SMB should invest in green technology.* [Online]
Available at: https://blog.ext.hp.com/t5/BusinessBlog-en/Why-your-SMB-should-invest-in-green-technology/ba-p/4862# [Accessed 18 June 2022].

White, K., Hardisty, D. J. & Habib, R., 2019. The Elusive Green Consumer. *Harvard Business Review,* 97(4), pp. 124-133.

Wine & Spirit Education Trust, 2021a. *Study Guide D3: Wines of the world.* London: Wine and Spirit Education Trust.

Wine Australia, 2021. *Winery wastewater management and recycling.* [Online]
Available at: https://www.wineaustralia.com/growing-making/winery-wastewater-management-and-recycling [Accessed 13 June 2022].

Wine Institute, 2021b. *Green Medal Awards Acknowledge Growers and Vintners for Sustainability Leadership.* [Online]
Available at: https://wineinstitute.org/press-releases/green-medal-awards-acknowledge-growers-and-vintners-for-sustainability-leadership/ [Accessed 11 June 2022].

Wirra Wirra, n.d. *This Should All Be Fun.* [Online]
Available at: https://wirrawirra.com/pages/about-wirra-wirra [Accessed 24 June 2022].