REDUCING THE CARBON FOOTPRINT OF WINEGROWING

In 2021, the EU adopted its first European climate law as part of the European Green Deal. This law set Europe's climate neutrality targets for 2050, as well as a target to reduce greenhouse gas (GHG) emissions by 55% by 2030, compared to 1990. Following the Climate Act, in February 2024 the Commission also recommended an additional intermediate target of reducing emissions by 90% by 2040, thus confirming the direction taken[1]. The aim of this strategic vision is to achieve an economy with net-zero greenhouse gas emissions[2]. How can the wine sector become part of this carbon-neutral approach? What are the main methods within crop management practices to reduce the carbon footprint of vine growing? This didactical sheet will outline some of the answers.

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WHAT IS CARBON NEUTRALITY?

Carbon neutrality refers to a balance between anthropogenic GHG emissions and the sequestration (or storage) of biogenic CO_2 (soil, biomass). Carbon neutrality is thus based on offsetting emissions by sequestering carbon in soils and living biomass through photosynthesis. There is an array of sequestration mechanisms, and they can only be accounted for if they are long-term: storage in wood (hedges, tree plantations, etc.), storage in the soil via organic matter. However, it should be considered that any increase in soil or biomass carbon stock is reversible if the practices are stopped, cancelling out the beneficial effect of the storage. Therefore, offsetting emissions by sequestration is no substitute for reducing the emissions generated.

Launched at COP 21, the '4 per 1000' initiative is based on the principle that increasing the organic carbon content of soils by 0.4% each year would make it possible to offset global GHG emissions linked to human activities. The idea is to consider GHG emissions linked to human activity. Soil contains around 2,400 Gt of carbon, while annual emissions from human activity amount to 9.4 Gt.

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1. Site web de la Commission Européenne, « Le pacte vert pour l'Europe » : https://ec.europa.eu/stories/european-green-deal/
2. Communication de la Commission Européenne, « Une planète propre pour tous : une vision européenne stratégique à long terme pour une économie prospère, moderne, compétitive et neutre pour le climat » [COM(2018) 773 final].

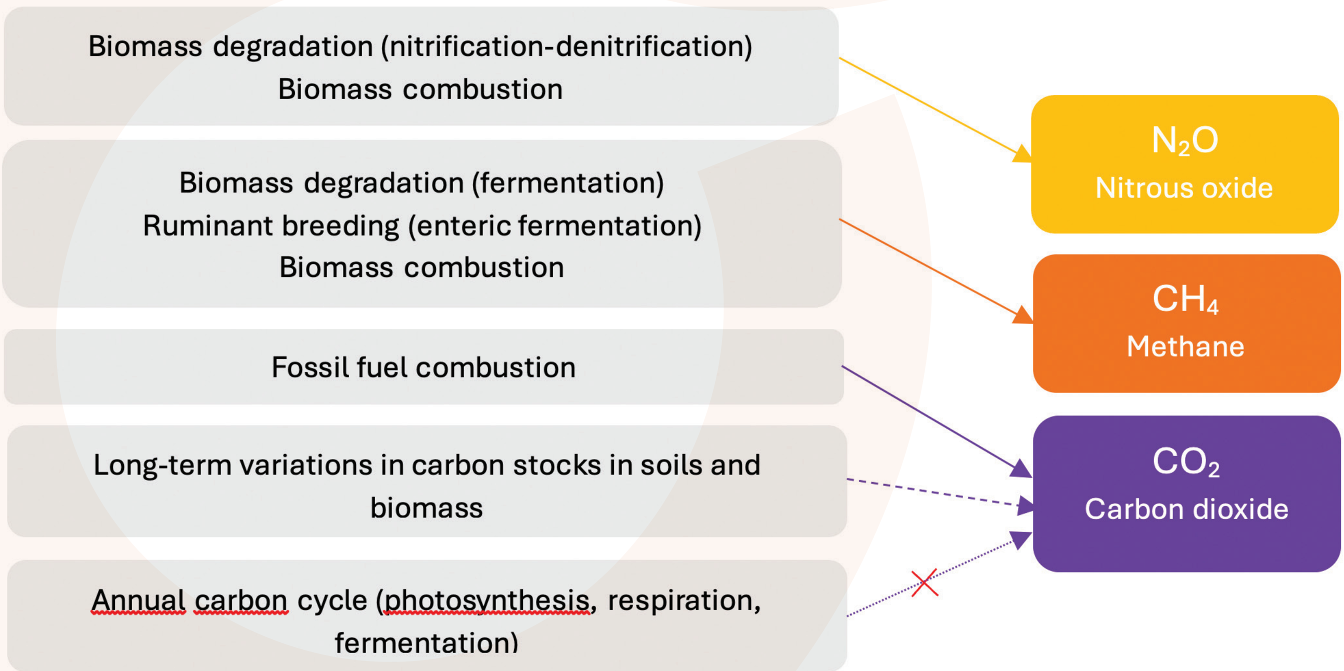
However, a collective INRAE study known as the '4 per thousand study'[3] showed that there is limited potential for additional carbon storage in French agricultural soils. Even with the widespread use of agricultural practices that favour carbon storage — assuming a constant climate, atmospheric CO_2 concentration and land use — the gain would only be 29.9 Mt CO_2e/year, or 6.5% of national emissions in 2016, which corresponds to an accumulation rate of +1.8‰/year. This figure is still well below the global target of +4‰/year.

In viticulture, while storing carbon in the soil is an interesting method, it is not enough on its own. It thus needs to be part of a wider strategy, combining the storage and direct reduction of emissions (energy, inputs, transport, etc.).

WHAT ARE THE MAIN GREENHOUSE GASES EMITTED BY THE WINE INDUSTRY?

The various greenhouse gases that we count do not all have the same effect on climate change. The warming power of gases depends on whether they absorb infrared radiation and how long they remain in the atmosphere. These two factors are expressed by their 100-year global warming potential (GWP). The 100-year GWP expresses the warming power of a gas emitted into the atmosphere over a period of 100 years. The GWP is constructed as a standard, with CO_2 taking the value of 1. The main greenhouse gases found in the viticultural carbon footprint are: carbon dioxide (CO_2) (GWP = 1), nitrogen dioxide (N2O) (GWP = 273) and methane (CH4) (GWP = 28).

This means that 1 kg of N2O emitted into the atmosphere corresponds to 273 kg of CO_2 emitted. The same applies to methane: 1 kg of CH4 corresponds to 28 kg of CO_2. This is why a carbon footprint is expressed in kg CO_2e[4] ('kg of CO_2 equivalent').

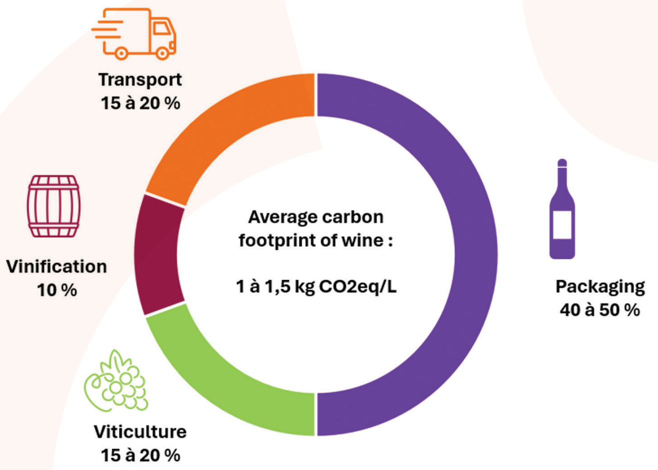


Main greenhouse gases produced by the wine industry and how they are emitted (Adoir and Luzi, 2024).
Solid arrow = emissions, dotted arrow = sequestration, crossed-out arrow = flows not considered in the carbon footprint (zero net balance)

3. Pellerin, Bamière et al., Stocker du carbone dans les sols français, Quel potentiel au regard de l'objectif 4 pour 1000 et à quel coût ? Rapport scientifique de l'étude, INRA (France), 2020, 540 p.
4. Emilie ADOIR, Hugo LUZI, L'empreinte carbone des entreprises du vin, Les Entretiens du Beaujolais et les Assises de l'Agroecologie en Beaujolais- Edition 2024. Le carbone, ça detonne !, 2024.

WHAT ARE THE MAIN SOURCES OF EMISSIONS IN THE WINE SECTOR?

Work carried out in France by the French Wine and Vine Institute (IFV) shows that the wine industry footprint is structured as follows: packaging accounts for 40% to 50% of emissions; viticulture 15% to 20%; transport 15% to 20%; vinification around 10% (IFV, unpublished). Packaging includes indirect emissions linked to the manufacture of dry materials, in particular bottles, which represent the main source of emissions. The carbon footprint of the viticulture stage mainly includes fuel consumption and fertiliser production. As far as transport is concerned, only emissions linked to the use of fuel are taken into account. Finally, winemaking is mainly responsible for electricity consumption, the carbon footprint of which remains relatively low in France. It should be noted that, even if exports are included, the share of transport in the total carbon footprint remains relatively small. The order of magnitude of the carbon footprint of wine over its entire life cycle (from grape to shelf) is 1 kg to 1.5 kg CO_2eq/L of wine.



Breakdown of the carbon footprint of wine by major life cycle stage (Adoir and Luzi, 2024)

Several ways of reducing greenhouse gas emissions can be suggested post-harvest: changing the type of glass, avoiding clear glass; reducing bottle weight by refining the glass; setting up deposit systems; using other containers such as aluminium cans or bag-in-box; transporting the wine in bulk; developing wineries with gravity systems, etc.

WHAT ARE THE BIGGEST SOURCES OF EMISSIONS AT THE VITICULTURE LEVEL?

The order of magnitude of viticulture's carbon footprint is in the order of 1 to 3 tonnes of CO_2e/ha/year; as mentioned above, it represents 15% to 20% of the carbon footprint of the wine life cycle.

Using the GES&Vit tool, IFV has calculated the carbon footprint of a vineyard plot in a high-yield production context. This calculation considers management practices involving mechanical pruning; high nitrogen inputs of around 80 kg of nitrogen per hectare per year (40 kg applied to the soil in organic form; 40 kg in mineral form applied fractionally by fertirrigation); plant cover in all the inter-rows, with alternating green manures and permanent grass cover; and the use of a decision-making tool for plant protection. In this context, the four main emission items identified are:

- **Fuel**, linked to the manufacture and combustion of the off-road diesel used on the plot, accounts for around 30% of the plot's emissions. Tractor use is a significant item, particularly because of the energy required for the various tasks carried out (tilling the soil, pruning, shredding, etc.);
- **N_2O emissions in the field** also account for around 30% of plot emissions: N2O, known as nitrous oxide or dinitrogen monoxide, is released as a result of nitrogen inputs (nitrogen fertilisers, organic fertilisers and soil improvers, the spreading of animal waste, etc.) and through managing plant cover, such as mowing or termination, which activate nitrification-denitrification reactions. Nitrous oxide is one of the main greenhouse gases produced by agriculture. This is a major source of emissions for vineyards where yields are high due to the high level of fertilisation and the regular management of plant cover through ploughing;
- **the manufacture of fertilisers/soil improvers** accounts for around 10% of emissions from the plot: like N_2O emissions, this element is even more significant for high-yield vines, as is the case in this example;
- **setting up the plot** also accounts for around 10% of emissions from the plot itself; this involves planting and trellising and is amortised over the life of the plot[5].

5. Camille Guilbert, Clara Gérardin et Hugo Luzi, Réduction de l'empreinte carbone d'un Vignoble Innovant Ecoresponsable. Scénarii et leviers évalués avec l'outil GES&Vit, 2023

HOW CAN EMISSIONS BE REDUCED IN WINEGROWING?

For a plot of land that has already been planted, several relatively simple methods can be implemented to reduce emissions or increase carbon storage in the short term.

- **Nitrogen fertilisation** is a particularly interesting area to explore. By reducing mineral nitrogen inputs, we reduce both indirect emissions linked to the manufacture of fertilisers and direct emissions of nitrous oxide. Each unit of mineral nitrogen not used saves around 12 kg CO_2e[4]. Replacing mineral nitrogen with organic nitrogen has the advantage of reducing direct emissions and increasing the carbon stock in the soil, although emissions are also associated with organic fertiliser production. For example, the composting process of some organic fertilisers can generate significant methane and nitrous oxide emissions, which can reduce the expected benefits.
- **Fuel consumption** is also a significant item, accounting for around a quarter of emissions. Every litre of off-road diesel saved reduces the carbon footprint by 3.14 kg CO_2e[4]. There are several ways to optimise this consumption: reducing the number of passes, combining operations, choosing suitable tools and tractors, eco-driving, better organisation of work sites and bringing equipment closer to the plots. The introduction of measurement protocols also makes it possible to target the most energy-intensive work. Viable alternatives to diesel, such as electricity and, in the longer term, hydrogen and animal traction, are being developed, but full studies of their overall environmental impact are still needed. Electric tractors are already available for some vineyard operations and are particularly cheap when the energy is produced on the farm, for example with photovoltaic panels on the cellar roof.
- **The choice of trellising materials** also has a significant impact: using wooden stakes instead of metal ones saves an average of 100 kg CO_2e/ha/year[4].
- **Grass cover**, when it replaces mechanical or chemical weeding, may temporarily increase emissions because of the increase in fuel consumption, but in the medium term, it allows better carbon sequestration in the soil. A recent study showed that inter-row permanent cover with grass resulted in a net reduction of 300 kg CO_2e/ha/year[4] compared with mechanical weeding.
- **Returning vine prunings to the soil,** rather than burning them, is another relevant method. Despite the need for an extra tractor pass, this practice results in carbon storage that more than offsets the emissions generated, with an estimated environmental gain of around 400 kg CO_2e/ha/year[4], while also reducing fine particle emissions.
- **Planting hedges:** hedges are one of the most effective ways to store carbon in the biomass of the hedge, as well as in the soil, which they enrich with organic matter. It is not common to plant trees or hedgerows in and around vineyards, due to space exploitation. But there are several advantages to be considered (see Didactical Sheet on agroforestry in viticulture). One solution is to opt for small shrub hedges around the perimeter of the plot. For example, by planting 90 linear metres of hedges per hectare, it would be possible to store around 200 kg CO_2e/ha/year (averaged over 25 years)[6], i.e., almost 10% of the emissions from the plot in our case study of high-yield vines. It should be remembered, however, that this storage is reversible if the hedgrows are grubbed up.

There is thus a wide range of options to reduce the carbon footprint of viticulture. These must be chosen based on their environmental effectiveness, as well as their agronomic, economic and social feasibility.

TO FIND OUT MORE

- Pellerin, Bamière et al., Stocker du carbone dans les sols français, Quel potentiel au regard de l'objectif 4 pour 1000 et à quel coût ? Rapport scientifique de l'étude, INRA (France), 2020, 540 p.: https://www.inrae.fr/sites/default/files/pdf/Rapport%20Etude%204p1000.pdf
- GES&VIT, a tool for GES emissions estimation and reduction in viticulture (video): https://www.youtube.com/watch?v=qbH_yIY_uGM&ab_channel=CLIMED-FRUIT
- Emilie ADOIR, Hugo LUZI, L'empreinte carbone des entreprises du vin, Les Entretiens du Beaujolais et les Assises de l'Agroecologie en Beaujolais- Edition 2024. Le carbone, ça detonne !, 2024 : https://www.vignevin.com/wp-content/uploads/2024/05/Le-Carbone-ca-detone.-Entretiens-du-Beaujolais-et-Assises-de-lAgroecologie-2024.pdf
- Réduction de l'empreinte carbone d'un Vignoble Innovant Ecoresponsable. Scénarii et leviers évalués avec l'outil GES&Vit : https://www.vignevin-occitanie.com/empreinte-carbone-vie/
- 4p1000: https://4p1000.org/discover/?lang=en

6. Storage values calculated on the basis of Label Bas Carbone figures – méthode haies and the ADEME Carbocage project.

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