Carbon sequestration in soils and vegetation in PEF analyses, credible carbon credits?

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1 Summary

On behalf of Vinventions, CE Delft and Sevenster Environmental have reviewed the final draft Product Environmental Footprint Category Rules (PEFCR) for wine (version 04) on one specific aspect, the compulsory inclusion of biogenic carbon sequestration in vegetation and soil as additional information in PEF reports for wine and the methodology that should be applied when determining the amount of carbon sequestered.

We conclude that the methodology that should be applied when determining the amount of carbon sequestered contains several methodological flaws, both with respect to LCA methodology and with respect to the scientific calculation rules laid down in the report:

- Temporary carbon storage in vegetation cannot be included in the PEF, not even under additional information. The approach suggested in the draft PEFCR is not conform PEF pilot guidance on biogenic carbon. Only temporary carbon storage in products may be calculated as additional information, according to the relevant protocols. Moreover, the method described in the draft PEFCR does not actually assess the effects of storage, rather it sets an inappropriate time boundary beyond which (re) emissions are not counted.
- Carbon sequestration in soil might be reported as part of the PEF but a clear time boundary between temporary storage and permanent sequestration needs to be distinguished. This is not described in the draft PEFCR.
- The appointed methodology prescribes simplified accounting for biogenic carbon dioxide emissions (Option 2 according to (Schryver, et al., 2016)) but also chooses to assess carbon storage and sequestration under additional information. In light of the latter, a choice of full biogenic accounting (Option 1) would be more consistent and would allow inventory according to the ILCD handbook with emissions and removals in vegetation, soil and products beyond a scope of 100 years included as a separate category.
- If carbon sequestration in soils were to be taken into account, the resulting net sequestration should be allocated between the various outputs of the multifunctional cultivation system, notably for cork oak forests. Allocation has been elaborated in a negligent way in the draft PEFCR and other products from land use such as meat, wool and payments for environmental services and landscape preservation have been ignored.
- The fact that in the PEFCR report for intermediate paper products very different choices are laid down for:
  - the time scope for what is considered temporarily and permanently sequestered; and
  - the reporting obligations for temporarily sequestered carbon;

  may indicate that the choices appointed in the PEFCR report for wine are not obvious.
- The appointed calculation methodology based on the Hénin-Dupuis model is not substantiated, has been included erroneously and incomplete (land management factor P, erosion) and has been included without a proper guide for background information and calibration.
- The two other appointed calculation methodologies for calculating carbon sequestration in soil and vegetation are meaningless and erroneous as long as the issue time frame has been dealt with unsatisfactory and as long as no relation is made with the management of areas with perennial crops and the cyclic nature of such a management.

It is unclear – even with access to the LCI datasets – how background reports mentioned in the PEFCR draft have been used and are correlated with the results presented in Figures A and B in Annex I. This is in contradiction with the aim of the PEF policy under development and with the aim of an LCA: transparency.

We suggest that following adaptations are made:
- temporary carbon sequestration in vegetation (above and below-ground biomass) is deleted from the PEFCR;
- carbon sequestered in soil should be more uniform approach for different product groups and sectors;
- deficiencies in current reporting and calculating methodology (reference land use, allocation, no reporting on long term emissions, etc.) need to be corrected.

Calculating future amounts of biogenic carbon in vegetation and soils comes with significant uncertainties, especially if no guide is given for calibrating the models with which to calculate this. With the occurring changes in the climate, these uncertainties will only increase.

2 Introduction

2.1 Background

The Comité Européen des Entreprises Vins is one of several product groups and sector organisations that volunteers in developing product group specific calculation rules for calculation of Product Environmental Footprints (PEFs) under the EU Sustainable Production and Consumption policy.
The development of the calculation rules for wine is managed by the 'Technical Secretariat of the PEF pilot on Wine'. This secretariat has very recently published a fourth and final draft Product Environmental Footprint Category Rules (for) Wine and is giving opportunity for review and consultation of this PEFCR draft report until September the 9th, 2016. This is the last opportunity for stakeholder consultations on this document.

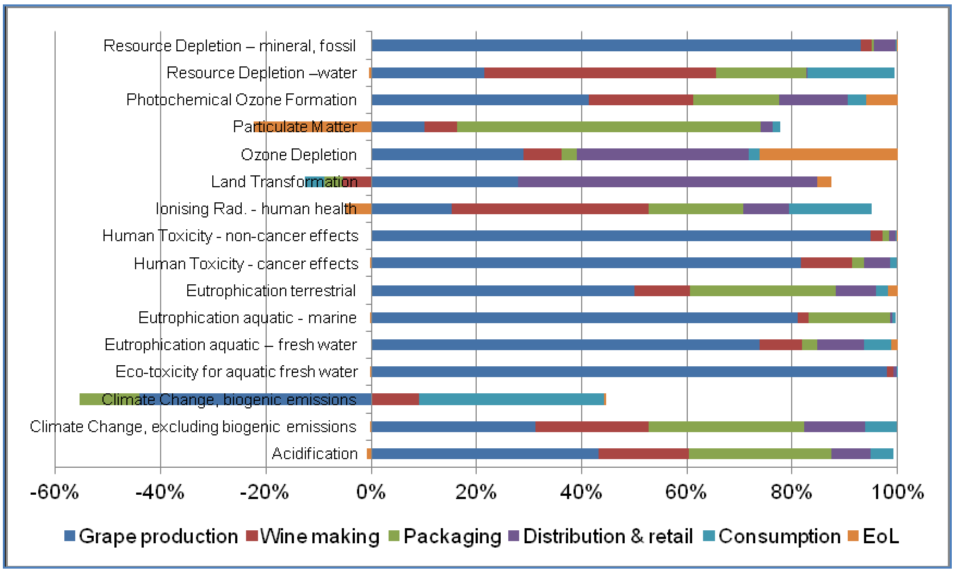
This final draft PEFCR report for wine requires inclusion in the environmental footprint of long-term storage of carbon for all processes in the life cycle of wine as 'additional environmental information'. Additional environmental information concerns information 'considered necessary to be reported' as part of the product environmental footprint of a product. Both LCA-based data and the additional environmental information prescribed by the PEFCR give a description of the significant environmental aspects associated with the product. Categories of long-term carbon storage that should be included for wine as 'additional environmental information' concern:
- carbon sequestered as soil organic carbon at the vineyard;
- carbon sequestered in vines;
- carbon sequestered in soil and vegetation in cork oak forests.

For climate change the fourth draft report has defined a benchmark contribution per ¾ litre of wine of 1.4 kg CO_2 equivalent for still wine and 1.7 CO_2 equivalent for sparkling wine.

However, the draft report also includes the results of a screening study performed by the WINE TS, which indicate a net negative greenhouse gas emission per functional unit of wine if storage of biogenic carbon in soils, vines and in cork oak forest vegetation are taken into account in accordance with the calculation rules defined in the PEFCR report (see Figure 1 copied from the draft PEFCR).

Vinventions strongly questions the correctness of the methodological choices and defined calculation rules for including storage of biogenic carbon in soils and vegetation in the PEF profile for wine and has asked CE delft to review the draft report with regard to these aspects.

Figure 1 **Relative contributions of chain links to environmental themes for still wine**



2.2 Requirements defined in the PEF Guide (EU, 2013) and interpretation of these in the (final draft) PEFCR report for Wine

Requirements

According to the text of the PEF Guide p.27 (EU, 2013) “all resource use and emissions associated with the life-cycle stages included in the defined system boundaries shall be included in the Resource Use and Emissions Profile”.
With respect to biogenic carbon, the text of the PEF Guide p.27 and 28 (EU, 2013) includes the following section: “The raw material acquisition and pre-processing stage starts when resources are extracted from nature and ends when the product components enter (through the gate of) the product’s production facility.
Processes that may occur in this stage include:

- …….
- “Photosynthesis for biogenic materials;
- Cultivation and harvesting of trees or crops.”

The PEF Guide (2013, p.23) also lays down that “additional environmental information may be included in the PEF” if the additional information concerns “relevant potential environmental impacts of a product” that “go beyond the widely accepted life-cycle-based EF impact assessment models”.
Additional environmental information shall be “based on information that is substantiated and has been reviewed or verified in accordance with the requirements of ISO 14020 and Clause 5 of ISO 14021:1999”.

Temporary storage or permanent sequestration of carbon in products may be included as additional environmental information. Temporary carbon storage happens when a **product** "reduces the GHGs in the atmosphere" or creates "negative emissions", by removing and storing carbon for a limited amount of time. In addition, subparagraph 'Accounting for temporary (carbon) storage and delayed emissions' states: "Credits associated with temporary (carbon) storage or delayed emissions shall not be considered in the calculation of the default EF impact categories. However, these may be included as 'additional environmental information'." Moreover, these shall be included under 'additional environmental information' if specified in a supporting PEFCR.

Carbon emissions or removals related to direct land use change and emissions of CH_4 and N_2O related to direct land use change should be included as part of the greenhouse gas balance. In the addition, guidance regarding biogenic carbon emissions (Schryver, et al., 2016) the option of simplified accounting of biogenic emissions and removals is given, however, which means that emissions and removals of biogenic CO_2 do not have to be explicitly covered in the inventory.

Interpretation in the PEFCR report for Wine

In the final draft PEFCR report for wine, the guidelines and definitions included in the PEF Guide (EU, 2013) have been interpreted as that all flows of biogenic carbon through the production system or temporarily or permanently sequestered in vegetation and soil in vineyard/grape cultivation and in cork oak landscapes and forests shall be reported:

- "Long-term carbon storage for all processes in the life cycle of wine" "shall be included in the Environmental Footprint of wine" "where it occurs (e.g. in the soil of vineyards). Biogenic carbon removals and emissions shall be included" (Section 4.6).
- "Organic residues (mainly leaves and stocks) deposited in the vineyard soil contribute to increase its permanent organic carbon stock. In addition, vines contribute to carbon sequestration in their permanent structure during long periods. Both effects should be taken into account and calculated as part of additional environmental information. In the same way, carbon permanently stored in the soil and tree biomass of cork oak forests should be taken into account, as tree live for more than 100 years and sequestered CO_2 during their lifespan" (Annex XI).

Next to this "The biogenic carbon content at factory gate shall always be reported as meta-data" (line 347).

For determining the amount of carbon stored for a long term in soil, the PEFCR report allows two methodologies:

- one based on an adjusted and extended variant of the Hénin-Dupuis model;
- one based on the IPCC Stock-Difference Method.

Storage in aboveground and belowground vegetation (vines, cork oaks) is to be determined with the gain-loss method, without accounting for the effect of delayed re-emission.

The time scope for defining long term or permanent sequestration is not specified explicitly. The PEFCR report mentions a period of "Year 100 or behind".

2.3 Discussion paper structure

In this paper we review the methodological choices and defined calculation rules for including storage of biogenic carbon in soils and vegetation laid down in the PEFCR final draft report.

Consecutively following aspects are considered in three subsequent chapters:

1. Methodological issues: how to assign sequestered CO_2 to cork products and wine:
   - Standard methods are available for calculating carbon footprints, such as the PAS 2050 and ISO standards. What do they say about carbon sequestration and how to take it into account in a carbon footprint?
   - Applied allocation methodology.
   - If there is indeed carbon sequestration in natural cork, vines and soil, how should this be allocated across all the different natural cork products (stoppers, flooring, shoe soles, etc.) and wine making products?
   - The way in which the aspect time is taken into account, especially in view of the useful life of a cork oak of 150-200 years.
   - Is there a risk of the CO_2 sequestered in cork oak forests or vineyards being claimed not only by cork producers, but also by national states (e.g. when cork oak forest development and maintenance are partly subsidized by national boards/bodies)?

2. The amount of CO_2 sequestered in cork oak forests and vineyards as presented for 'virtual products':
   Is the amount of CO_2 fixed in cork oak landscapes and vineyards calculated correctly?

3. Quality of the report and text:
   - Transparency of the draft report - e.g. is it transparent which sources have been used and how they have been used.
   - Quality of applied information, e.g.: representativeness of considered geographical regions.
   - Completeness of the defined methodology – e.g., if calculation rules or a calculation methodology is defined, are sufficient resources and standardized datasets made available for applying these rules of methodology.
   - Applied definitions of the considered life cycles and their system boundaries.

3 Methodological issues

3.1 Caveat

The PEF Screening study and the three PEFCR Supporting studies are confidential and only (to be) assessed by the EC and the Reviewers.
With the extremely limited information provided in the Draft Report and none of the information in the form described in PEFP guidance Annex D.5, it is not possible to verify whether choices are justifiable.

For instance, from the Draft Report it is not clear how the 'materiality' approach (PEFP guidance Annex E.1 and E.2) has been applied in the selection of data quality requirements for hotspots (life cycle stages, processes, elementary flows). Given that the screening report and choice of representative product have been endorsed by the European Commission at this stage in the pilot process, this review does not address any issues with those.

3.2 Proposed methodology for assessing long-term carbon storage reviewed on the basis of authoritative LCI-protocols

Long-term carbon storage is positioned outside the main PEF, to be evaluated and listed as mandatory additional environmental information. Paragraph 4.6 states: "Long-term carbon storage for all processes in the life cycle of wine where it occurs (e.g. in the soil of vineyards). Biogenic carbon removals and emissions shall be included."

The fact that carbon storage is excluded from the main PEF is in line with all existing protocols, although the ILCD Handbook does allow for taking it into account in very specific circumstances which do not apply here. Allowing for carbon storage to be reported as additional information is also in line with recent protocols such as ISO 14067 and PAS 2050:2011.

A very important deviation from all existing protocols, however, is to allow for reporting of carbon storage outside the product. All protocols allow only for carbon stored in the product or in goods to be added as additional information (ISO 14067 6.4.9.6, ILCD Handbook 7.4.3.7.4, PAS2050:2011 item 5.5 (and see Note 4)). ISO 14067 (6.4.8) is very explicit in stating that all emissions and removals other than from use phase or end-of-life phase have to be calculated as if released/removed at the beginning of the assessment period.

In the case of grapes/cork, this means only the carbon in the grapes/cork itself should be counted as carbon storage, but clearly these can't be considered long-lived products except possibly for very exclusive wines. PAS2050:2011 5.1.1 Note 4 states that trees [or vines] older than 20 years should be treated as soil carbon but subsequently clause 5.7 excludes soil carbon change other than due to land use change. Forest management activities resulting in additional carbon storage are also explicitly excluded (PAS2050:2011 5.5 Note 4).

It is arbitrary and inconsistent that the carbon stored in oak barrels is not counted as such, as this would potentially be the only long-lived biogenic product in the life cycle.

Conclusion 1:
The approach to long-term carbon storage is not conform existing protocols.

Even if, despite all this, one would accept this approach as a valid part of the PEFCR, there are several issues with the calculation methodology, primarily to do with allocation and time aspects.

3.3 Allocation

Just as all other processes, inventory data for long-term carbon storage should be allocated between the outputs of the process or system. While one could argue that the carbon storage in the vines can be entirely allocated toward grape production, this is not the case for carbon storage in cork oaks. Cork oak forests and savannas typically are very multi-functional, used not only for cork harvesting but also for animal husbandry, firewood collection, nature conservation, et cetera.

As reported by CE Delft in 2013, in production systems in Tunisia the value of cork represents only 10% of the total value generated. In Spain, cork represents about 80% of value generated per hectare in Spanish cork oak woodland. The fraction of value generated by cork as one of the products will vary considerably between countries and even specific regions. There is no justification to disregard allocation in this context and the calculation guidance in XI.II(b) should be adapted accordingly.

It is possible that the choice of assessing only carbon stored in the stem and prunings of the cork oak trees is regarded as 'subdivision' or as reflecting underlying physical relationships. This is not self-evident, however, and would require proper description and justification. Given the crucial role of cork oaks in e.g. the dehesa system it is unlikely that either can be justified for all potential cork production systems.

Conclusion 2:
Multi-functionality of cork production systems is not addressed properly.

3.4 Time aspects

Time aspects are not normally part of LCA, but increasingly important in the realm of climate change. When topics like carbon storage and sequestration are addressed via LCA, it is essential to make explicit choices regarding time. First and foremost, a time boundary has to be defined that either separates short-term and long-term interventions (e.g. ILCD Handbook (EC, 2010)) or that is an absolute boundary to the inventory, in other words defines a strict assessment period (e.g. PAS2050:2011). A common choice for this boundary is 100 years, but ISO 14067 does not prescribe an assessment period.
This protocol instead requires any carbon footprint assessments to define the time boundary as appropriate for the system. In the context of cork production, this would mean that at least the entire life cycle of a cork oak tree should be covered. (But even if there was a net carbon uptake over that period, it cannot be reported as carbon storage, not even as additional information.)

The second choice is regarding assessing the effect of a difference in timing between uptake and (re-)emission. Other than in the case of permanent sequestration, the carbon will be released to the atmosphere at some point as a 'delayed' emission. This choice is separate from the first choice, and both are theoretically separate from the choice of time horizon for the assessment of the global warming potential except when using dynamic modelling.

In state-of-the-art practice regarding these issues, there are four options:

- PAS2050:2011 prescribes a 100-year assessment period. If re-emission occurs before that time boundary, it is fully included in the inventory as if occurring at t=0. If it occurs after that, it is excluded from the inventory and hence the carbon uptake becomes identical to sequestration.
  As additional information, the effect of delayed emissions may be reported separately and quantified via a two-tier linear decrease in effective GWP from 1 to 0 over 100 years
- The ILCD Handbook prescribes distinguishing emissions before and after 100 year time boundary, but only permanent sequestration can give a negative contribution in a foot print. The default perspective of LCA is infinite and the time boundary is primarily set to aid interpretation of results. According to Paragraph 7.4.3.7.4 (Long-term storage of potential emissions beyond 100 years), three different situations are distinguished, for which greenhouse gas emissions or should be reported as separate categories:
  - The quasi-permanent storage of CO_2 and generally of potential emissions in dedicated long-term storage forms (e.g. injection into former natural gas fields) is accounted for by inventorying no emissions, if the respective storage form can “guarantee” according to current scientific knowledge, and under independent external and qualified expert review, that the substance is not emitted for at least 100,000 years (number set by convention).
  - (Partial) emissions before that time but beyond the first 100 years after an activity has been initiated (e.g. end of life of a cork oak) are inventoried as long-term CO_2 emission elementary flows.
  - Emissions and removals within the first 100 years are inventoried as normal CO_2 emissions occurring at t=0.

  The effect of delayed emissions may only be quantitatively assessed if required by the goal of the study and in that case a linear decrease in effective GWP from 1 to 0 over 100 years has to be used.
- ISO 14067 does not prescribe an assessment period but requires definition and justification in the CFP study. The effect of delayed emissions arising from use phase or end-of-life phase may be reported separately if occurring more than 10 years after the product has been brought into use. The effect should be quantified via a method that needs to be described and justified in the CFP study report.
- At the forefront of modelling of the true effects of temporary carbon storage or delayed emissions is dynamic modelling (see e.g. Levasseur, et al., 2013). In this approach, carbon emissions (removals) as well as their global warming effects are calculated with full time resolution over a period that covers e.g. several centuries. One time boundary can then be defined that applies to the integrated effects, rather than to the inventory and impact assessment separately. This approach might be applied in studies following ISO 14067 (see above).

The approach outlined in the Draft PEFCR Annex XI.II(b) does not follow any of this best-practice guidance. There is no clear choice of time boundary, only an implicit mention between brackets of a “100 year assessment period” in the section title. This is not an acceptable way to present such important information in a PCR document. Moreover, the subsequent equations use a ‘t1’which is defined as “year 100 or behind”.

As a PCR, the choice of t1 should probably be prescribed, or more guidance should be given as to how to choose this in an appropriate manner.
Assuming t0 can be established (for cork oak forests there may not be such uniform stands, but this is outside our expertise), the period t0 to t1 should span at the very least a period that is longer than the average life of a tree.
It would be preferred, however, to fix t1 for cork oaks and vines, respectively.

Within the time period t0 to t1, the equations in XI.II(b) do not address the effects of delaying emissions. All carbon removals and emissions are counted as if occurring at t=0. This is contrary to all existing protocols and seems to defeat the purpose of separating out carbon storage in the first place.
Without an adequate assessment period and without consideration of dead organic matter and methane emissions from decay, in short without considering end of life of trees and vines, the equations are far too simplified to yield meaningful results.

The first term of the equation in line 1348 also gives double-counting of carbon uptake in e.g. the cork bottle stopper itself, given the instructions in 4.5. End-of-life emissions are implicitly corrected for carbon uptake at plant cultivation stage[1]. By counting this uptake again under the additional information, it is counted twice. This is precisely because the equations in XI.II(b) do not address effects of delayed emissions and do not deal with timing aspects properly.

In the draft PEFCR for Intermediate Paper Products (30 May 2016) a time horizon of 300 years is defined as the boundary between temporary and permanent storage. Any (re-)emissions occurring before that horizon have to be counted as if occurring at t=0. This 300 year horizon is conform the general guidance on biogenic carbon modelling by (Schryver, et al., 2016).
The approach taken to carbon storage in the draft PEFCR for Intermediate Paper Products (see details in Paragraph 3.5) should be taken as an example for the wine PEFCR, as it follows best practice in clearly defining the time boundary, at a time scale appropriate for the forestry systems involved.

Conclusion 3:
Timing aspects relevant to calculating effects of carbon storage are not described adequately and are not in line with state-of-the-art practice.
The guidance in XI.II(b) is ill considered and inadequate.

3.5 Temporary and permanent biogenic carbon sequestration (or losses) in other PEFCRs and PCRs

Draft PEFCR report for Intermediate Paper Products (EC, JRC, 2016)

According to the draft PEFCR report, greenhouse gas emissions related to removal and emission of biogenic carbon and associated greenhouse gases (CH_4, N_2O) are to be included as a separate indicator as part of the overall PEF: “Sub-indicator 2: Climate change – biogenic”.

[1] Doing this implicitly is moreover not allowed according to the PEFP guidance (see Annex F.1.4) and might cause inconsistencies when using background data that satisfy the requirements in that Annex. In that case, the background data would include removal, but the PEF study might not address re-emission.

This indicator covers GHGs removals and emissions to air (CO_2, CH_4 and N_2O) originating from the oxidation and/or reduction of biomass by means of its transformation or degradation (e.g. combustion, digestion, composting, landfilling) and CO_2 uptake from the atmosphere through photosynthesis during biomass growth, i.e. corresponding to the carbon content of product and possible biofuel. Following the PEF guide, credits from temporary carbon storage are excluded. The term 'storage for a limited amount of time' needs more clarification for consistent modelling. It is decided that biogenic carbon emitted within three centuries after its uptake is considered as temporary carbon storage and these emissions shall be modelled without temporary resolution (cumulated over time, as in ISO14067).Similar emissions (or sequestrations) related to land use change are to be reported under an additional indicator (Sub-indicator 3: Climate change – land use and land transformation).

Draft PEFCR for Olive Oil, (13 November 2015)
This first draft PEFCR only prescribes reporting of soil carbon flows as additional environmental information. There is no apparent definition of a time horizon between temporary and permanent storage. Paragraph 5.3.1 mentions that CO_2 removals by crops and vegetation shall not be included.

International EPD PCR2010:07 on Virgin Olive Oil and its Fractions
The guidance in this PCR is somewhat convoluted but Paragraph 10.2.1 addresses carbon storage and allows for carbon stored in crops and weeds for more than 100 years to be counted as storage[2], regardless of whether it is part of the product or not. This guidance is taken from the general EPD programme instructions without further specification for olive trees. In the most recent version of the general EPD programme instructions only carbon stored in the product may count as sequestration if not re-emitted within the 100-year assessment period.

3.6 Carbon storage in the Renewable Energy Directive

Annex V of directive 2009/28/EC on the promotion of the use of energy from renewable sources gives calculation rules for the assessment of greenhouse gas emissions associated with the production of biofuels and bio liquids.
The directive states that the capture of CO_2 in the cultivation of raw materials shall be excluded, but emission savings from soil carbon accumulation via improved agricultural management can be included. There is no specific guidance on how to calculate the soil carbon accumulation.

3.7 Land use and land use change: role of subsidies

As already elaborated in (CE Delft, 2013) subsidies play an important role in conservation of cork oak landscapes or establishment of new coral oak landscapes or cork oak plantations. Some examples given in this report are:
- Between 1975 and 1995, the area occupied by cork oak in Portugal increased by approximately 10% (from 657,000 ha to 713,000 ha) because new plantations were subsidized by Common Agriculture Policy (CAP) (Sauro, 2006).

[2] Presumably 'sequestration'.

– A significant part of Spain's cork oak forests is part of the national park 'Los Alcornocales' (literally 'the cork oak groves') in southern Andalusia. Landscape management in the national park is partly paid for by public funds, which are aimed at reducing the risk of forest fire and destruction of the typical cork oak landscape .

For vineyards similar subsidies with an explicit aim of conserving certain types of land use or provision of certain specific ecosystem services do not seem to exist yet. Rather, under the European Wine Regulations subsidies were provided for grubbing up less competitive vineyards and a limit has been imposed on the planting of new vineyards in view of the surplus of wine produced in the EU.
On the other hand, payment support schemes and compulsory distillation of surplus wine[3] could also be considered a subsidy for conservation of vineyard areas as these measures resulted in less productive vineyard, producing wine of lower quality remained operational (see e.g. (Meloni & Swinnen, 2013)).
A new development on this subject is wine growers in more hilly regions searching for subsidies for conserving their estates[4].

As stated in the CML handbook for LCA's subsidized performances and ecosystem services[5] such as conservation of biodiversity or reduction of fire risk are products as well and should be taken into account by allocation.

This aspect is, however, completely ignored in the PEFCR report. Instead, all carbon that is sequestered in vegetation, soil and products is only allocated to agricultural products and semi-manufacturers.

3.8 Overall impression

All in all, this very important annex does not look well considered and in its current form is entirely inadequate for the purpose it is meant to achieve.
No data quality requirements are listed for this additional inventory.
A more elaborate discussion of the extent to which the approach in XI.II is in line with existing protocols is essential, given that this additional information has the potential to annul the climate change impact of a PEF according to the LCA results shown in Annex I.

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3 In the past three decades every year on average 20 to 40 million hectoliters of wine have been destroyed (through distillation) – representing 12 to 22% of EU wine production.

4 See: www.decanter.com/wine-news/winemakers-seek-eu-subsidies-for-hillside-vineyards-2495/

5 See (Guinnee, 2001)[5], page 24:"If subsidies are given for a specific performance, this performance may be defined as a product. An example is that of subsidies for nature conservation measures in agriculture, where, for instance, farmers in the Netherlands may be paid for each successful nest of meadow birds. "Meadow birds" is the a co-product sold to the government, with its own clear share in the total proceeds of the farm."

4 Soil carbon sequestration calculation rules

In this chapter the different calculation rules for calculating the dynamics of carbon in soil and vegetation are reviewed.

As results are given only as relative percentages in the PEFCR report and transparency of the PEFCR report is limited, it is not clear how these rules have been utilized in the calculation of the PEF's for the virtual products defined in Annex I of the PEFCR report. Therefore reflection on the calculation must remain mainly restricted to the calculation methodology.

Obviously, the comments referring to the aspect time, mentioned in previous chapter are of relevance for the calculation methodologies discussed in this chapter.

4.1 Approach (a) for calculating soil organic matter dynamics, modified Hénin-Dupuis model

The approach included in the PEFCR report as a first option for estimating the amount of carbon sequestered in soil during viticulture concerns utilization of the model formulated by Hénin and Dupuis in 1945 and adjusted and extended by others to include climatic aspects, soil characteristics and soil management aspects.
The model assumes first order kinetics for soil organic matter formation and logarithmic kinetics for degradation and considers only one soil compartment with only one type of organic matter.

A first remark is that the formulae for calculation of SOM formation and degradation has been copied incomplete: the management factor P referred to by (Bosco, et al., 2013) and elaborated in e.g. (Bosco, et al., 2011) and (Bechini, et al., 2011) has been forgotten or ignored. As mentioned on page 977 of the article (just below Table 1):"A dimensionless correction factor of the mineralisation coefficient (P), as proposed by Mary and Guerif (1994) and (Bechini, et al., 2011), was used to include farm soil management."

The difference is illustrated below:

- Degradation of soil organic matter has been defined in the PEFCR report as $SOM_0 \times e^{-k_2 \cdot t}$ with SOM_0 being soil organic matter available at t=0 and $e^{-k_2 \cdot t}$ representing the logarithmic decline of it in time with k_2 being the mineralisation factor.
- The actual formulae referred to by (Bosco, 2013) is $SOM_0 \times P \times e^{-k_2 \cdot t}$ in which P represents a factor describing the influence of irrigation and intensity, frequency and depth of tillage.

As factor P can vary more than 100% for different soil management strategies, this factor can have a significant effect on the net amount of organic matter sequestered in in the soil calculated with this approach (see also (Bosco, et al., 2013).

Another aspect concerns the completeness of the Hénin–Dupuis model.
For example:

- The humification factor k1 describing the conversion of part of the annual organic matter inputs[6] into soil organic matter in the Hénin–Dupuis model is just as well a function of temperature and – not considered in the Hénin–Dupuis model – water availability in the soil. Assuming a constant value for the humification factor across all European and global types of climate (and soil) relevant for viticulture will result in underestimation or overestimation of the humification factor in comparison to the actual value for a specific climate and soil.
- The approach for the carbon balance on one hand and for the N- and P-balances on the other hand are inconsistent: erosion is included in the N- and P-balances, but is ignored in the carbon balance.

More generally, the PEFCR report fails to discuss why this Hénin–Dupuis model should be applied and not e.g. a more authoritative model such as RothC.
The choice for a specific model should be substantiated with an assessment on how well the selected model can reproduce actual carbon dynamics in different soils under different soil management systems and for different climates.
Such a review has been conducted for example in (LNE, 2006) and other studies underlying the Flemish 'Carbon Simulator' and Ares model and in the projects conducted as part of the development of the Fullcam carbon model for the Australian Department of the Environment.
The argumentation in (Bosco, et al., 2013) for choosing the Henin-Dupuis model is that it requires less information than more complex models, but this argument is disputable in our perception[7].

Next to this the PEFCR report provides no guidance on how to calibrate the model for a specific field, specific climate and specific for management aspects. Also, no guidance is given in Annex XI.II where relevant site specific information concerning climate or soil can be found or with which standards soil organic carbon content and bulk density should be determined.
Part of the information can be found elsewhere in the report or in the references. Unfortunately, the reader is not guided towards these[8] sections and the essence of references is not mentioned in the main text
(e.g. instructions for soil sampling can be found in The Earth Partners report).

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6 These include (i.e. fractions of organic matter originating from grapevine (leaves and pruning residues), natural grass cover (above-ground and below-ground biomass), cover crops (above-ground and below-ground biomass) and manure.

7 As illustrated in studies underlying Fullcam or the 'Carbon Simulator', the RothC model also requires temperature and clay content, while instead of limestone content in soil, the RothC model requires monthly precipitation and evapotranspiration rates as can be found on the FAO website (Climwat database). Precipitation information is also required for N- and P-balances.

8 For example, in Annex XII.V the reader can find a reference to the "EU-JRC 2010 Thematic Data Layers for Commission Decision of 10 June 2010 on guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC", which gives some of the information required for utilizing the Hénin–Dupuis model. But the reader is not made aware of this in Annex XI.II. Another example are the carbon contents and clay contents in different soil types, as mentioned in Table XII.X.1. and Table XII.X.2.

In all, though a model approach would be a good way for describing organic matter dynamics, the choice for the Hénin-Dupuis model in the PEFCR report is not substantiated and is not necessarily the most obvious choice. The way it has been included in the report in a little bit clumsy way. It looks as if this model was selected because it has been utilized before in studies on soil organic matter dynamics in vineyards.

4.2 Approach (b) for calculating carbon sequestration in soil organic matter, IPCC Stock-Difference Method

A second approach for estimating/taking into account possible changes in soil organic carbon in vineyards and cork oak landscapes allowed by the PEFCR's for wine is the so-called Stock-Difference Method, called 'stock based approach' in the PEFCR report.

In this approach carbon stock change in a given carbon pool between two moments in time is annualized by dividing the difference in pool size by the period of time between both points.
As indicated in the (IPCC, 2000) 'Land Use, Land-Use Change and Forestry': "this method is limited, insofar as it provides only a "snapshot" of the carbon fixed: The values will vary depending on the often arbitrary decision of when to account for the project's benefits".
In this case 'project' refers to viticulture practices. Logical time points would be the moment of establishment of the vineyard and grubbing-up again of the obsolete vine stalks before a new cycle of vineyard establishment is started. The drawback of such an approach would be that management choices during establishment, exploitation and end of live of the vineyard will have an impact that exceeds the period of time considered and will not show in this approach.

If soil carbon is included, it should also cover normal oak forests for the production of barrels, using the same approach as for the other systems.

4.3 Biogenic carbon stored in plant structures

As dictated in the PEFCR report, biogenic carbon sequestration in aboveground and belowground vegetation in vineyards and cork oak landscapes should be calculated with the gain-loss method. The time points for calculation should the year of stand establishment as starting year and a rather unspecified time point at stand age of 100 years or behind as end point.

It is unclear how this calculation rule should be applied for grape vines:
- average lifespan of grape vines in commercial vineyards amounts to 20–30 years according to (Bosco, et al., 2013);
- according to the AgriBalyse dataset for grape cultivation (variety mix) at vineyards in Languedoc-Roussillon, "the temporal border of the inventory corresponds to the life cycle of the vine (32 years)".

The above also implicates that the whole exercise of calculating carbon sequestration in vegetation is effectively futile.
When it is assumed that the area remains in use for growing grapes, net carbon sequestration in vegetation will be effectively zero: the stand is established, is utilized and finally 'grubbed-up' several times during the surveyed period of 100 years or more. Carbon sequestered in grape vines (and undergrowth) on the considered plot will vary from zero at establishment, a climax value just prior to grubbing-up and to zero again just after grubbing-up.

For cork oaks vegetation dynamics will show a similar pattern, although the time scale of the pattern is obviously significantly longer (150–200 years per cycle).

4.4 Carbon sequestration in utilized sources

There seems to be a discrepancy between the PEFCR final draft report and almost all sources used in the draft PEFCR report or sources that should be utilized as background data in case of Situations 2 and 3 for information availability:

- In the AGRIBALYSE database carbon sequestration in either vegetation or soil is specifically not included.
    - Several flows were not taken into account by AGRIBALYSE®:
        - Carbon sequestration in the wood of permanent crops (grapevines and trees): it is difficult to evaluate the fate of the wood (storage or short cycle), the amounts of CO_2 involved are low, in accordance with the calculations carried out by CITEPA for national data sets (CITEPA, 2011).
        - Changes in biomass and soil carbon stocks after land use change (LUC) in France:
        - although two methods were developed for taking account of the changes in soil carbon stocks (Salou et al., 2012: Appendix E), this source/sink of emissions was not included in the data sets in the database.
    - After assessing the various possibilities, the methodology proposed in IPCC 2003 was considered to be the most appropriate and easiest to implement in the framework of the AGRIBALYSE program and its constraints. Access to data on changes in crop production practices over the past 20 years was, however, a major obstacle to implementing the method. It was estimated that this data, when it was available, was not easy to use. It would be necessary to start by collecting this information but this did not fit into the AGRIBALYSE program schedule and there were insufficient resources available.
      In view of this, it was decided not to take account in AGRIBALYSE of changes in soil carbon stocks for land management changes.
    - Changes in soil carbon stocks were not taken into account for permanent crops (grapevines and trees). The areas concerned and the representativeness of the Teruti-Lucas data were considered insufficient for these products. Moreover, for grapevines, it was difficult to define reference carbon stocks because of the nature of the land usually used for grapevines. The carbon stocks for crops and grapevines are very different and the method defined by the IPCC is not suitable as it overestimates the actual flows.
- (Bosco, et al., 2013) only considers soil organic matter dynamics in vineyards: "CO_2 emissions/removal caused by C-stock changes in vine biomass were not included, since its C pool is considerably smaller (<1 % the size) than that of the soil (Keightley, 2011), and the corresponding vine biomass C pool is removed at the end of the vineyard production period."
- In (Demertzi, et al., 2015) and (Dias & Arroja, 2014) only the carbon content of the cork bottle stopper itself are considered, not carbon temporarily or permanently sequestered in vegetation or soil.

The only exception is (Rives et al., 2012) that was reviewed extensively in CE Delft (2013). The main conclusions from that report are:

- The amount of CO_2 fixated in cork oaks according to (UAB, 2011) is an overestimation. Scientific studies on cork oak growth suggest that the total carbon that is fixated in cork oaks is four to five times lower than mentioned in (UAB, 2011).
- In (UAB, 2011) the gross fixed amount of carbon is calculated.
- No indication is given of the actual net fixed amount of CO_2.
- The chosen allocation in (UAB, 2011) is arbitrary and assigns more impact (or CO_2 benefit, in the case of carbon sequestration) to the cork stoppers compared to other cork products.

It is unclear why the 'Technical Secretariat of the PEF pilot on Wine' would want to go beyond the scope of the utilized literature sources, that give clear arguments for not including temporary sequestration in vegetation and is not substantiated in the final draft report.

4.5 Possible alternative approach

Conserving or improving soil organic matter is in itself an important aspect of sustainable agricultural practices as the organic matter content of the soil is important for e.g. soil water holding capacity and capacity for nutrient retention. From this perspective it is commendable that so much attention is given to this subject in the PEFCR report.

But using a model for describing SOM dynamics may be challenging and calculation results may be uncertain, for example in view of future changes in climate. A model has to be calibrated, requires more information (e.g. climate data) and may not be sufficiently advanced to take into account the fact that with further degradation of organic material, the remainder tends to become less degradable – as the remainder is enriched with increasing levels of lignin.

In view of the above, perhaps a simpler approach could be used. For example, in an approach promoted by the Dutch 'Kennisakker' organisation in which annual SOM degradation is estimated as a simple percentage and SOM formation is estimated as the product of organic material given to the land (crop residues, manure, compost and cover crops) and the humification coefficient of the different organic materials. Viticulture can be considered sufficiently sustainable as long as in this broad approach SOM degradation and SOM formation are on par.

5 Quality of the report and text

5.1 Transparency

It is understood that the supporting studies are confidential, but the information provided in Annex I and II is extremely limited. As stated before, it is impossible to assess whether conclusions and assumptions of 'materiality' (PEFP guidance Annex E.1 and E.2) are appropriate. The findings regarding allocation do not seem to be interpreted any further even though there is enough reason to do so (see below).

5.2 Relation between Annex XI and Annex XII.V

Both annex XI.II (Additional environmental information: carbon storage) and annex XII.V (Emission to air – Carbon dioxide (CO_2) from land occupation and transformation) relate to carbon sequestered in soil and vegetation.
Just how both aspects and the approaches appointed for taking into account carbon storage and CO_2 emissions from land occupation connect to each other is completely unclear.

According to annex III land transformation results in a carbon deficit of 1.69 kg/functional unit for still wine, 2.86 kg/functional unit for sparkling wine. Assuming a grape yield of 9,000–10,000 kg of grapes per hectare and a grape consumption of 1.2 kg/functional unit, these deficits amount to a CO_2 emission of 49 and 83 tonnes/ha respectively. These values cannot be related to e.g. (Bosco, 2013) and the AGRIBALYSE database. Just what they represent is completely unclear.

5.3 Quality: allocation

Allocation is only described for by-products of winemaking processes (Draft PEFCR, 5.9), i.e. pomace/marc and lees. While these are probably the central multifunctional processes in the wine life cycle, other processes such as recycling of packaging materials as well as multifunctional use of agricultural land may be important. Multifunctional use of vineyards is not common but does exist. Multifunctional use of cork oak forests or savannas is very common and given the attention given to carbon storage in cork oak forests, allocation should be given the same attention (see Paragraph 3.3).

Choosing mass as the default allocation seems a poor option and is unlikely to really reflect causality. However, in the corresponding PCR of the international EPD system (PCR2010:02, PCR2014:14) allocation by mass, as well as by economic value, seems to play a role.

The choice of allocation by alcohol content for the winemaking co-products is a justifiable one at first sight, but at the point of separation alcohol content should be expected to be either zero (white vinification) or similar, and not indicative of the ultimate potential for alcohol content as a marketable product. Alcohol content is not an intrinsic parameter of these materials, as e.g. protein or fat content might be in other crops. Sugar content or sugar and alcohol content might be a better choice but still does not reflect the high value of e.g. grape seed oil. Economic allocation using long-term average prices is considered an acceptable way to even out variability while still reflecting potential longer term trends in changes in causality in value chains. Economic allocation is selected as the allocation option for co-products of olive oil production, according to the first draft PEFCR of November 2015.

It is not correct to describe allocation based on alcohol content as ‘physical’, because this would seem to imply this option ranks higher in the ISO hierarchy but alcohol content is only a proxy, just as mass or economic value are. True physical relationships between inputs and outputs do not exist for joint production such as this (see UNEP/SETAC 2011).

The table on page 47 (Annex II) show ranges for the three identified allocation methods, but without any further information as to the underlying data being used. The mass allocation column shows figures that cannot be correct (for 5% allocation to pomace there is no way to make a total of 100%).
More importantly, though, the table shows that the variation in economic allocation is not very significant (97-100%) as long as one is only interested in the main product wine. The result of mass allocation is also significantly different and would seem to pass on too much of the impacts to by-products. All in all, the description and justification of allocation choices should be improved.

5.4 Quality: impact assessment categories

Without the normalised and/or weighted results for reference it is very hard to assess the validity of the choice of impact assessment categories. We do note that the description of equal weighting should have been included in the reporting.

The category ‘land use’ seems to be missing from the LCA of the Representative Product, instead there is a result for ‘land transformation’ that is dominated by ‘distribution & retail’. Given that the normalisation factors in Annex VI are in fact identical to those in PEFP guidance Annex A, it seems that land use is erroneously called land transformation. This needs to corrected. The ILCD method includes land transformation as part of the category ‘land use’ and results should be reported as such. It is moreover inconceivable that grape cultivation would not dominate the land use and, therefore, we suspect that the results as shown in the figures on page 43 are not correct, regardless of the terminology used. In the corresponding PCR of the International EPD system (PCR2010:02, PCR2014:14), land use is a mandatory category.

5.5 Quality: DQR definitions and geographical representativeness

Grape production is identified as one of the most relevant life cycle stages (5.1) and it is clear from the figures on page 43 that this is certainly the case. This means that a DQR <= 3 should be applied even in ‘Situation 3’.
That would be in line with the intention of PEFP guidance D.3. This Annex D.3 strictly speaking links minimum DQR to “most relevant processes” but in the case of grape production is is clear that process inventory across all impact categories is relevant. The Draft PEFCR only identifies five “most relevant processes” (p.44), one per life cycle stage, that seem highly unlikely to satisfy the criteria outlined in that PEFP guidance Annex D.3.

Besides, conflicting instructions are given in Annex IX. There, it is suggested that for situation 2&3 for grape production, all PEF are to use background data specific for Languedoc-Roussillon. This is entirely contrary to the notion that the PEFCR would be appropriate for any production region. Given the importance of grape production in the over-all life cycle, data specific to the country of production has to be used. Besides, this approach in Annex IX is inconsistent with the PEFCR draft methodology itself, that prescribes a DQR of 1 or 2 for Situation 2 (Paragraph 5.3). Requirements regarding geographical representativeness thus are inconsistent and not strict enough.

Finally, it is not clarified what the function of the “most important elementary flows” is for parties implementing the PEFCR. According to the PEFP guidance, those elementary flows may require higher data quality, but this is not specified in the Draft PEFCR.

Next to this the PEFCR report provides no guidance on how to calibrate the model for a specific field, specific climate and specific for management aspects.
Also, no guidance is given in Annex XI.II where relevant site specific information concerning climate or soil can be found or with which standards soil organic carbon content and bulk density should be determined.
Part of the information can be found elsewhere in the report or in the references. Unfortunately, the reader is not guided towards these[9] sections and the essence of references is not mentioned in the main text (e.g. instructions for soil sampling can be found in The Earth Partners report).

9 For example, in Annex XII.V the reader can find a reference to the “EU-JRC 2010 Thematic Data Layers for Commission Decision of 10 June 2010 on guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC”, which gives some of the information required for utilizing the Hénin – Dupuis model. But the reader is not made aware of this in Annex XI.II.

6 Conclusions and recommendations

In this review, the draft Wine PEFCR has been scanned for consistency with existing protocols for carbon footprinting and life cycle assessments as well as with best practice. In order of priority, we consider the following items to be significant drawbacks of the current draft PEFCR :

- Including carbon embedded in cork oaks and grapevines is very uncommon and contrary to all relevant protocols. The implementation is arbitrary and unscientific. There is no clear definition of the necessary time boundary. There is a risk of double counting of carbon storage in cork product in the current implementation.
- Including soil carbon stock changes other than from land use change is in line with e.g. ISO 14067. However, the calculation methods appointed in the final draft PEFCR report are:
  - In case of the Hénin-Dupuis based approach, a selection that is not substantiated and which has been included incorrectly (compared with Bosco, 2013) and without guidance.
  - In case of the Stock-Difference Method, is meaningless and erroneous as long as the issue time frame has been dealt with unsatisfactory and as long as no relation is made with the management of areas with perennial crops and the cyclic nature of such a management.
  - In general soil carbon assessments are widely considered as too uncertain to include in standard calculations. ISO 14067 itself does not include it as a mandatory element of the carbon foot print though it recognizes it “should” be part of the assessment.
- Identification of hotspots in the range of cross sections as required by the PEFP guidance is very minimal and not used to justify subsequent methodology and data quality requirements.
- Multi-functionality is not addressed for cork production systems and in general the reporting regarding allocation lacks clear justification.
- Insufficient guidance is provided for PEF involving viticulture outside Europe (France). It is not appropriate to claim that the methodology is suitable for all global wine production systems.
- Data quality requirements are not adequate and inconsistent, both internally and with general PEFP guidance. This also applies to the described requirements regarding the inventory of carbon removal and re-emission from biogenic sources (Paragraph 4.5 of the draft PEFCR).
- There are potential mistakes in the reporting regarding impact category land use.

It is recommended that all the above points are addressed thoroughly before finalizing this PEFCR.

Regarding the first point, temporary carbon storage outside the product should not be taken into account even when reported as additional information. PAS2050:2011 (BSI, 2011) and ISO 14067 (ISO, 2013) have to be guiding and both allow only for carbon storage in the product to be reported as additional information. From the results of the screening study it is clear that the current approach leads to gross distortion of the product foot print and such results should not be used in PEF communications.
Carbon storage in (potentially) long-lived products, i.e. wooden barrels, could be included as additional information when properly accounting for the effect of delayed emissions. In the main PEF, a time boundary between temporary and permanent storage of 300 years has to be used according to the guidance on biogenic carbon (Schryver, et al., 2016) as implemented in the e.g. draft PEFCR for Intermediate Paper Products (EC, JRC, 2016).

It would make sense to use the same time boundary for calculations of the effects of temporary carbon storage, making an inventory of all relevant removals and emissions over a 300-year assessment period. This would be an appropriate assessment period for removals and emissions in (cork) oak forests, as intended by ISO 14067, covering presumably a full tree life cycle. Emissions after 100 years should be included as '(potentially) long term', in line with the guidance of the ILCD Handbook. Overall, using full accounting of removals and emissions of biogenic carbon (Option 1 in (Schryver, et al., 2016) would be more appropriate when claiming potentially significant temporary carbon storage in the life cycle, even if this is only 'additional information'.

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