# Public report presenting the main improvement strategies

## ACTION B4

Anthesis Lavola

LIFE PRIORAT +MONTSANT | IMPROVING THE SUSTAINABILITY OF GRAPE AND WINE PRODUCTION AT THE PRIORAT REGION

LIFE15 ENV/ES/000399

# Table of contents

Table of contents 2

1. Introduction and objectives 3

2. Collected data 3

3. Identification of best practices 5

3.1. Best practices detected 5

3.1.1. Water efficiency best practices 5

3.1.2. Energy efficiency best practices 7

3.2. Set of improvement actions for Priorat and Montsant wineries 9

4. Efficiency measures assessment 10

4.1. Costs reduction with measures application 10

4.1.1. Reduction of water associated costs 10

4.1.2. Reduction of energy associated costs 12

4.2. Baseline environmental impacts calculation 14

4.3. Environmental impacts reduction with measures application 15

5. Conclusions 17

References 18

# 1. Introduction and objectives

This report summarizes the action B4 on the LIFE Priorat + Montsant project. After delivering a set of individual reports to each winery participating in this project in a confidential way, where the environmental performance of the wineries is described, this report gives an overview of average values for all these wineries. Thus, this report gives answer to the action B4 of the project, which is focused on the efficiency of the energetic and hydric resources of the wineries when producing wine.

In action B4, 19 wineries have been selected and data has been collected for years 2014, 2015 and 2016. This data is accounted as the starting point or baseline for each winery, from which improvement potentials are later identified and environmentally assessed too. The information that wineries provided, such as production data, energy consumption, waste production, distribution and other inventory data, helps to carry on a Life Cycle Assessment to estimate the environmental baseline profile. Once the best practices and improvement actions are identified, their environmental assessment is also performed through LCA methodology, so at the end, the environmental benefits are also estimated with these improvement scenarios.

Thus, the different energetic and hydric consumptions arisen on the wineries are considered, to assess their respectively environmental impact due to the production of wine. Once the current environmental impact is calculated, it's possible to determine which are the best actions and best practices carriable in order to decrease this environmental impact related to the wineries, leading to a lower environmental footprint of the winemaking.

The set of best practices and improvement actions has been elaborated with specific expertise in water and energy efficiency measures within the wine sector and has been narrowed down to the most appropriate ones for the Priorat and Montsant regions. In this document this set of best practices and improvement actions is also shown and assessed both from the environmental point of view as well as from the economic standpoint.

# 2. Collected data

## 2.1. Baseline scenario data (2014-2016)

The baseline data collected is presented below as average values for the 19 wineries and for the years 2014-2016 (average values). It also shows the deviation value among all wineries in order to see variability of results.

The values presented are related to a reference value useful for comparisons and interpretation of results, both for the environmental as well as for the economic assessment. In the LCA methodology this reference value is also represented as "functional unit". In this case this value is set as "the production of a bottle of 0.75l of wine". Thus, all the values presented are referred to the functional unit as well as the environmental impact results.

It can be observed from the table that the average value of total energy consumption for Montsant wineries is 0,21 kWh/bottle of wine, whereas for the Priorat wineries it is 0,31 kWh/bottle. However, for both groups, standard deviation is higher than the difference between the average values, thus it can be concluded that for the whole region a similar profile for the energy consumption in wineries is presented, with a slighter difference in average values.

The energy consumption has been split into different uses/processes: 1) energy for winemaking; 2) energy for ageing and 3) energy for cleaning operations. The contribution of the energy by process is higher for the winemaking, both in Priorat and Montsant wineries. On the second place, for Montsant wineries, there is the consumption for ageing, whereas for Priorat is the energy for cleaning operations.

Regarding water consumption, both Montsant and Priorat wineries have the same average value of 2 liters per bottle of wine. Montsant wineries present a lower standard deviation among them than Priorat wineries.

Water consumption has also been split into the same processes as wine production. The top contributor in this case is the cleaning operations, for both Montsant and Priorat wineries, followed by winemaking and ageing.

| Parameter | Units | Montsant Wineries average | Montsant standard deviation | Priorat Wineries average | Priorat standard deviation |
|---|---|---|---|---|---|
| Total energy consumption | **kWh / 0,75L wine bottle production** | **2.05E-01** | **1.92E-01** | **3.13E-01** | **3.20E-01** |
| **Energy consumption for winemaking** | kWh / 0,75L wine bottle production | 7.88E-02 | 1.30E-1 | 6.39E-02 | 9.89E-02 |
| **Energy consumption for ageing** | kWh / 0,75L wine bottle production | 7.50E-02 | 1.72E-01 | 1.26E-04 | 3.43E-04 |
| **Energy consumption for cleaning operations** | kWh / 0,75L wine bottle production | 5.87E-03 | 8.39E-03 | 1.10E-03 | 2.04E-03 |
| Total water consumption | **$m^3$ / 0,75L wine bottle production** | **2.03E-03** | **1.60E-3** | **2.00E-03** | **3.43E-03** |
| **Water consumption for winemaking** | $m^3$ / 0,75L wine bottle production | 2.90E-04 | 6.47E-04 | 2.57E-05 | 6.19E-5 |
| **Water consumption for ageing** | $m^3$ / 0,75L wine bottle production | 2.42E-04 | 2.62E-04 | 4.83E-06 | 1.32E-05 |
| **Water consumption for cleaning operations** | $m^3$ / 0,75L wine bottle production | 9.45E-04 | 1.73E-03 | 2.89E-04 | 8.49E-04 |

# 3. Identification of best practices

## 3.1. Best practices detected

Best practices in water efficiency and energy efficiency, in general terms and also specific for wineries, have been detected, listed and classified, along with a quantitative approach on how much savings this best practice can achieve on average.

### 3.1.1. Water efficiency best practices

Best practices identified and recommended include actions to prevent and/or minimize at origin the use and pollution of water during the process of winemaking, or to increase the efficiency of direct or indirect water use. Other production phases of winemaking are also included. These actions can enhance environmental efficiency of daily operations for the wineries and it is considered that its implementation can be useful, low cost and with short-term results.

Table 1 contains all actions detected in literature [1] [2] [3], classified by stage of the wine production: storage facilities, winepress and filtering, equipment and surfaces cleaning, and wine bottling. The action is described along with its improvement objective. Also, the influence on the water footprint is identified, whether it affects the blue water footprint (related to water consumption, both direct and indirectly), the grey water footprint (related to water pollution and wastewater, both direct and indirectly). Finally, an estimation on how much water is directly saved on the winery premises has been reported, also affecting proportionally to water associated costs. These values have later been used for the savings estimations and the environmental impact calculation.

*Table 1. List of detected best practices on water efficiency for wineries*

| **Generic facilities** | | | |
|---|---|---|---|
| Action | **Improvement objective** | **Influence on water footprint** | **Direct water consumption and cost reduction (%)** |
| **W1 Inspections about facilities and equipment** | Inventory of processes and equipment's' consumptions in the centre where they consume or pollute water | It allows identifying quickly action prioritization | 10% of total water [1] |
| Winemaking - Winepress and filtering | | | |
| Action | **Improvement objective** | **Influence on water footprint** | **Direct water consumption and cost reduction (%)** |
| **W2 Collection and treatment of wastewater from the process [2]** | If the water quality allows it, apply primary and secondary treatments to reuse water for watering/irrigation of crops or other hydric requirements | Reducing blue water footprint (due to less consumption) and grey water footprint (due to less wastewater) | 10% of water used in general cleaning |

| | | | |
|---|---|---|---|
| **W3 Install systems that maintain adequate water pressure on the press** | Optimizing press efficiency and consuming less water. | Reducing blue water footprint (due to less consumption) | 50% of water used in the press [3] |
| **W4 Use of more efficient filtering plates** | Reducing water consumption given that more efficient plates are less prone to clogging | Reducing blue water footprint (due to less consumption) | 25% of water used in the filter [1] |
| **W5 Rainwater collection [2]** | Collecting water from the rain to use it as cleaning or for crop irrigation, if its quality allows it | Reducing blue water footprint (due to less consumption) | 10% of water used in general cleaning |
| **W6 Keep documentation updated related to wastewater permits, physic-chemical characterization of wastewater and legal limits of wastewater in the production zone** | Providing updated information access to perform studies and law compliance | Control of grey water footprint | Only wastewater control (qualitative) |

## Equipment and surfaces cleaning

| Action | **Improvement objective** | **Influence on water footprint** | **Direct water consumption and cost reduction (%)** |
|---|---|---|---|
| **W7 Follow-up of water consumption and wastewater, review periodically used water flows** | Identifying changes in water consumption and wastewater flows | Facilitating water footprint calculation | 10% of cleaning water [1] |
| **W8 Install mesh strainers on the waste pipe** | Avoiding filtration and solid mixture with the wastewater. Facilitating water post-treatment, reducing suspended solids and BOD | Reducing grey water footprint (due to less pollutant load) | Only wastewater quality |
| **W9 Avoid use of biocides such as detergents, and use preferably biodegradable products** | Reducing pollutant load from wastewater flows | Reducing grey water footprint (due to less pollutant load) | Only wastewater quality |
| **W10 Perform the first cleaning dry [2]** | Avoiding excessive use of water by using an air blower or special sponges to perform the first cleaning | Reducing blue water footprint (due to less consumption) and grey water footprint (due to less wastewater) | 25% of cleaning water [3] |
| **W11 Adopting cleaning hoses with a fast opening and closure system** | Avoiding water loss to bad closure of hoses and during usage of hoses | Reducing blue water footprint (due to less consumption) | 50% of water used in hoses [3] |
| **W12 Use cleaning water with variable pressure** | Consume less water since pipes and distribution systems work with different | Reducing blue water footprint (due to less consumption) | 50% of cleaning water [3] |

| | | | |
|---|---|---|---|
| | pressures depending on the cleaning requirement | | |
| **W13 Perform a maintenance plan according to equipment** | Avoiding loss and leakage during processes | Maintaining blue water footprint in the "normal" limits of the winery operation | 10-20% of cleaning water [1] |
| **W14 Establish an equipment cleaning protocol** | Determining the correct detergent dose, the application time, the optimal application temperature for cleaning operations | Reducing grey water footprint (due to less pollutant load) | 10-20% of cleaning water [1] |
| **W15 Automation of chemical substances dosing** | Avoiding overuse of chemical cleaning agents, applying them in the correct concentration | Reducing grey water footprint (due to less pollutant load) | Only wastewater quality |
| Bottling process | | | |
| Action | **Improvement objective** | **Influence on water footprint** | **Direct water consumption and cost reduction (%)** |
| **W17 Optimize cleaning water for the bottles** | Adjust bottle cleaning operations by using an adequate volume of water | Reducing blue water footprint (due to less consumption) | 50% of water used in bottling [3] |
| **W18 Water use optimisation plan for bottles cleaning** | Perform a management plan for bottle cleaning, so that employees can achieve the water reduction targets | Reducing blue water footprint (due to less consumption) | 10% of water used in bottling [3] |

### 3.1.2. Energy efficiency best practices

Energy efficiency best practices have been detected and selected among several sources, also accounting for generic actions which could be implemented in any facility, business or even a house, combined with those specific for wineries.

Here, Table 2 differs a bit from the water efficiency actions. The classification has been made by type of equipment, phases of the winemaking, and groups of similar strategies. Another column describes the action itself, then the estimated energetic savings are expressed in relative terms (%) and an additional information on the years of return of the investment has been pointed out. Estimated energetic savings have later been used for the savings assessment and the environmental assessment.

*Table 2 List of detected best practices on energy efficiency for wineries*

| Consumption equipment | Action | Estimated energetic savings (%) | Return on investment (years) |
|---|---|---|---|
| **Lighting** | E1. Substitution of current lighting (fluorescent, halogen lamp, etc) by LED lighting | 40 - 50% of lighting consumption in area of operation | 3 - 5 years |
| | E2. Install switches/presence detectors/pushbuttons to zone and sectorize lighting and adjust light needs in the space. For outside lighting, the use of an astronomical clock is recommended | 10% of lighting consumption in area of operation | 3 - 5 years |
| | E3. Facilitate natural lighting systems | 10 - 30% of lighting consumption in area of operation | Highly variable |

| Consumption equipment | Action | Estimated energetic savings (%) | Return on investment (years) |
|---|---|---|---|
| **Air conditioning and heating systems** | E4. Substitution of current equipment for high-efficiency equipment | 10 – 30% of heating/cooling consumption | 7 – 10 years |
| | E5. Installation of heat recovery systems, free cooling systems and speed shifter in climate equipment | 15% of heating/cooling consumption | 5 – 7 years |
| | E6. Lagging hot/cold water pipes to reduce thermal losses | 10% of heating/cooling consumption | 1 – 2 years |
| | E7. Optimization and rationalization of cooling systems functioning (real needs studies, automatic start/stop systems, centralized control systems…) | 5 - 10% of heating/cooling consumption | Highly variable |
| | E8. Avoiding insulation and assuring a Good ventilation of cold systems, to facilitate heat dissipation | 1 – 5% of heating/cooling consumption | Immediate – 1 year |
| **Pumps, engines and air compressors** | E9. Current pumps, compressors and/or engines substitution for high-efficiency equipment and with speed shifter | 10% of substituted equipment consumption | 4 – 6 years (overrun) |
| | E10. Reducing engines of big size or substitute them for various smaller engines that can be driven individually to run smaller tasks | 5% of substituted equipment consumption | 4 – 6 years (overrun) |
| | E11. Setting a functioning timer for compressors for them to work by demand | 5 – 10% of compressors consumption | Immediate |
| **Productive process** | E12. Use of more efficient processes and technologies (machinery, oenological processes) | 15% of the process consumption | Highly variable |
| | E13. Technological alternative solutions: stabilization with nano proteins, CMC, co-inoculation, etc. | 15% of the process consumption | Highly variable |
| | E14. Location of the barrel cellar in an underground floor | - | - |
| | E15. Recovering heat from industrial processes (cold equipment, compressors, etc) to obtain heated water for other processes | 10 – 15% of the process consumption | 4 – 6 years |
| | E16. Thermal insulation of refrigerated tanks | 5 – 10% of the industrial cooling consumption | 5 – 8 years |
| **Renewable energies** | E17. Heat generation systems with renewable energy: thermal solar, biomass, geothermic… | Highly variable (5 – 40%) | 10 – 15 years |
| | E18. Installation of renewable electricity generation systems (photovoltaic, small wind power generators…) | Highly variable (5 – 50%) | 8 – 12 years |
| **Enveloping** | E19. Improve thermal insulation on façades, decks and building envelope | 5 -15% of the cooling/heating consumption | 10 – 15 years |
| | E20. Installation of solar protection systems (canopies, decks, photovoltaic shelters) to avoid insolation of deposits or barrels, also offering shadow to waiting spaces | 5 – 10% of the cooling consumption | 5 – 10 years |
| **Management and control** | E21. Implementation of an energetic Audit plan and/or an Energy Management System | Potential of improvement around 20% of the total consumption | 1 – 2 years |
| | E22. Consumption monitoring system installation, with internal counters and a control software | 5% of total consumption | 2 – 4 years |
| **Other aspects** | E23. Training and awareness-raising of employees in energy good practices, avoiding overconsumption due to bad practices | 5 – 10% of consumption which depends on employee's behaviour | 1 year |

| Consumption equipment | Action | Estimated energetic savings (%) | Return on investment (years) |
|---|---|---|---|
| | E24. Implementation of a preventive maintenance plan which guarantees the correct functioning of lighting, electrical equipment, insulation systems, heat and air conditioning systems, etc. | Highly variable according to the current maintenance policy | Highly variable |

## 3.2. Set of improvement actions for Priorat and Montsant wineries

Once the best practices both in water and energy efficiency have been detected, the way to address a set of actions for improvement for Priorat and Montsant wineries has been classifying the wineries by its characteristics and narrow down the most appropriate actions for each group or type of winery detected. This classification and selection of appropriate actions has been consulted with DO Montsant and DO Priorat representatives. The selection of actions has been made according not only to the size and possibilities of each winery type, but also whether they had already implemented or not these measures.

After this classification, water and energy actions have been assigned to these groups. Table 3 shows both the classification system and the list of actions that have been recommended to wineries for DO Montsant wineries, and Table 4 for DO Priorat wineries. It can be observed that most of the wineries are small or very small ones, very characteristic from familiar businesses.

*Table 3. List of recommended best practices for DO Montsant wineries*

| **DO Montsant wineries** | | | |
|---|---|---|---|
| **Winery type (number)** | Description | Water efficiency actions | Energy efficiency actions |
| **Very small wineries (5)** | Small familiar and traditional house, typically one store or garage dedicated to all processes. 1-2 employees. | 1, 3, 4, 10, 14 | 1, 3, 9, 12, 13, 16, 17, 18 |
| **Small wineries (2)** | Rural big house with more than one space dedicated to the business. 2-3 employees. | | 1, 3, 9, 12, 13, 16, 17, 18, 20 |
| **Medium-size wineries (1)** | Several and delimitated spaces for each process, sometimes 2 stories and extra space for storage. 3-4 employees. | 1, 3, 4, 5, 7, 10, 11, 14, 17 | 1, 3, 9, 12, 13, 15, 16, 17, 18, 20, 23, 24 |
| **Big wineries (1)** | Industrial facility, compartmented spaces for each process, several stories and underground ageing space. With wastewater treatment plant. More than 5 employees. | 1, 2, 3, 4, 5, 6*, 7, 8*, 9*, 10, 11, 12, 13, 14, 15*, 17, 18 (all) | 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 20, 21, 22, 23, 24 |

*Qualitative measures or which environmental impact cannot be calculated at this point

*Table 4 List of recommended best practices for DO Priorat wineries*

| Priorat wineries | | | |
|---|---|---|---|
| **Winery type** | Description | Water efficiency actions | Energy efficiency actions |
| **Small wineries (5)** | Rural medium/big house with more than one space dedicated to the business. Sometimes 2 stories. 1-2 employees. | 1, 3, 4, 10, 14 | 1, 17, 18 |
| **Medium-size wineries (5)** | Industrial facility, separate spaces for each process. 3-4 employees. | 1, 3, 4, 5, 7, 10, 11, 14, 17 | 1, 2, 17, 18, 21, 22, 23, 24 |

In the next chapter, the set of actions recommended for wineries is studied from an environmental and economic savings point of view.

# 4. Efficiency measures assessment

## 4.1. Costs reduction with measures application

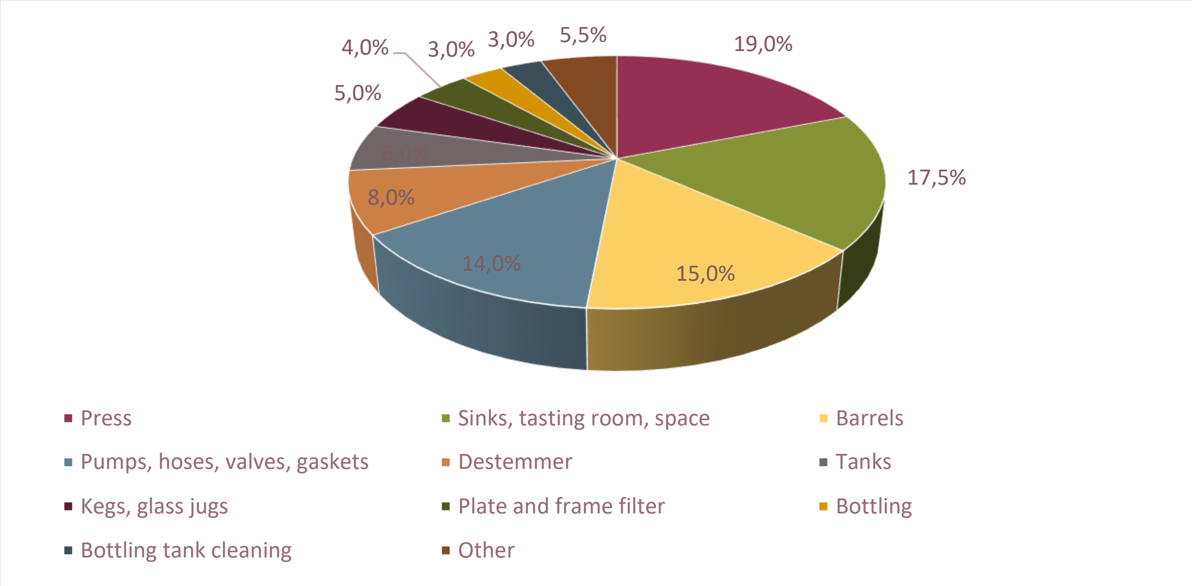
Prior to the environmental impacts' calculation, the estimation of potential savings from water efficiency and energy efficiency best practices must be performed. In this section, the evaluation of water use, and energy use potential savings, along with their associated costs, is performed; and results are shown in quantitative indicators, grouped by DO Montsant and DO Priorat wineries. These estimated savings account for the economical part of the assessment. After that, in 4.3, these potential savings are further used in the environmental impact assessment in order to estimate related benefits in the environmental area.

### 4.1.1. Reduction of water associated costs

Since water from the wineries assessed could not be monitored by stages, or when this has been possible, not all the stages were equally addressed, data from literature [1] [5] has been used to estimate water use distribution in the winery premises. It is known that most consumption of water in a winery is due to cleaning and sanitation processes [2] (around 70%) [5] while the rest is used in the winemaking process or is used for refrigeration. In

Figure 1 the distribution of cleaning and sanitation use of water in a winery is shown.

*Figure 1 Distribution of water use for cleaning and sanitation processes in a winery [1]*




Water potential savings have been calculated taking as a baseline data from 2014-2016 (average values). These data has been grouped by winery type following the classification made in Table 3 and Table 4, since the recommended measures are the same for those groups. By applying the correspondent savings rate shown in Table 1 and the water consumption rate by stage from Figure 2, water savings could be estimated.

Results are shown in Table 5 for Montsant and Table 6 for Priorat wineries. Note that values shown above are the sum of all potential savings if the wineries should apply all measures recommended, thus it is the theoretical maximum savings rate attainable. The hypothesis behind this calculation is that all wineries have not implemented yet any water efficiency measure. Real values will depend on how water efficiency is already dealt inside the winery and where there is room for improvement. In the individual reports for each winery, the set of measures recommended along with disaggregated savings values has been reported for them to decide and prioritize which actions need to be implemented.

It can be observed in the results that for very small and small wineries, the approximate potential of water savings is around 33%, for medium-size wineries, that represents 41% and 47% for big wineries. The bigger the winery, the more list of actions has been recommended since there is the possibility to stablish more protocols, more machinery and automatized processes, also taking into account that is feasible for the bigger ones to have a wastewater treatment plant where water can be reused for cleaning uses or irrigation of crops. However, it is also more likely that bigger wineries already have implemented water efficiency measures thus having relatively less space for improvement.

*Table 5 Estimated potential water savings for DO Montsant wineries*

| Winery type | Water consumption 2014-2016 (m³/year) | Estimated potential water savings | | Associated cost savings (€/year) [6] |
|---|---|---|---|---|
| | | m³/year | % | |
| Very small wineries | 102 | 34 | 33% | 71 |
| Small wineries | 579 | 190 | 33% | 321 |
| Medium-size wineries | 144 | 59 | 41% | 99 |
| Big wineries | 4,764 | 2,225 | 47% | 3,182 |
| Total | 5,589 | 2,508 | 45% | 3,658 |

*Table 6 Estimated potential water savings for DO Priorat wineries*

| Winery type | Energetic consumption 2014-2016 (m³/year) | Estimated potential water savings | | Associated cost savings (€/year) [6] |
|---|---|---|---|---|
| | | m³/year | % | |
| Small wineries | 148 | 49 | 33% | 82 |
| Medium-size wineries | 535 | 219 | 41% | 369 |
| Total | 683 | 268 | 39% | 451 |

Note also that even that the average water consumption per bottle is the same in both Montsant and Priorat wineries, the absolute value of water consumption is different for both groups, since in Montsant there is a large amount of water being consumed by a big winery. Thus, it is concluded that by implementing efficiency actions in bigger wineries will make a more significant impact rather than all the small to medium-size wineries apply all of the measures proposed.

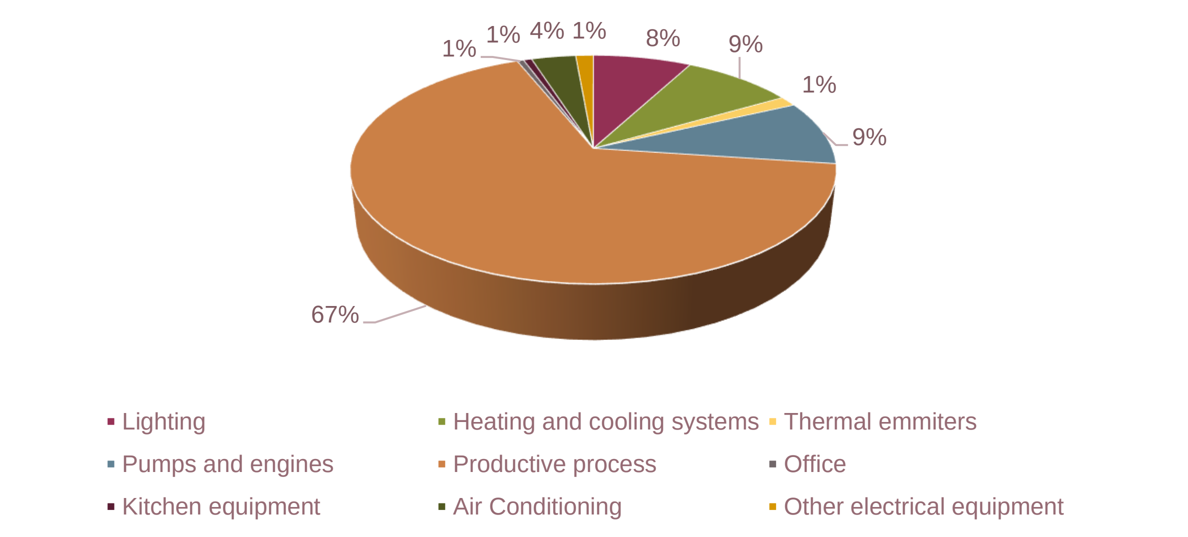
### 4.1.2. Reduction of energy associated costs

To estimate the reduction of energy associated costs of the best practices detected, first of all, an understanding of the energy profile of a winery must be shown. Since each best practice relates to a specific substage of the winery, or to specific machinery or equipment, there is the need to know the energy demand distribution of an average winery. Data from expertise in the Energy Department in Anthesis Lavola has been gathered as well as official data from ICAEN (Catalan Institute of Energy)[1] have been gathered to

[1] http://mapamesures.icaen.gencat.cat/mapamesures/AppPHP/

design an average profile of the energetic demand of a winery. It can be observed that the productive process of winemaking occupies the most part of the energy demand of a winery, followed by pumps and engines, heating and cooling systems and lighting.

*Figure 2 Distribution of energy demand for an average winery*




Estimated energetic savings (%) for each best practice from Table 2 have been applied to the respective substage or equipment energy demand (%) shown here in Figure 2 and multiplied by the total energy demand of each winery (average data from 2014-2016), in order to know the net value in kWh/year of the potential energy reduction. After that, the relative energy savings have been calculated for each measure and for the total of measures in each winery and group of similar wineries. In the individual reports, each winery has received this information disaggregated for each best practice recommended so that they can decide how to prioritize the implementation of best practices. Here in this report, a summary of the total savings is shown for each group of similar wineries.

*Table 7 Estimated potential energetic savings for DO Montsant wineries*

| Winery type | Energetic consumption 2014-2016 (kWh/year) | Estimated potential energetic savings | | Associated cost savings (€/year) [4] |
|---|---|---|---|---|
| | | kWh/year | % | |
| Very small wineries | 8,246 | 3,183 | 39% | 318 |
| Small wineries | 22,520 | 8,793 | 39% | 879 |
| Medium-size wineries | 18,600 | 9,620 | 52% | 962 |
| Big wineries | 332,042 | 244,267 | 74% | 24,427 |

| | | | | |
|---|---|---|---|---|
| Total | 381,408 | 265,863 | 70% | 26,586 |

*Table 8 Estimated potential energetic savings for DO Priorat wineries*

| Winery type | Energetic consumption 2014-2016 (kWh/year) | Estimated potential energetic savings kWh/year | % | Associated cost savings (€/year) [4] |
|---|---|---|---|---|
| Small wineries | 20,468 | 4,732 | 23% | 473 |
| Medium-size wineries | 122,878 | 61,316 | 50% | 6,132 |
| Total | 143,346 | 66,048 | 46% | 6,605 |

## 4.2. Baseline environmental impacts calculation

A life cycle assessment methodology has been used as the environmental impact can be quantified using the software Simapro and the Ecoinvent database.

The following environmental impacts have been calculated using the Environmental Footprint (EF) methodology from the EU, thus these environmental impact results are relative to the production of one bottle of 0.75 liters of wine.

- Global Warming Potential (GWP), in kg $CO_2$ eq: The global warming potential is referred to the potential contribution of the studied system in the average temperature growth in the planet.
- Acidification (AP), in mol H+ eq: Acidification potential quantifies the potential contribution of the system in the pH decrease in the environment (soil or water), because of acid substances emission.
- Water Scarcity (WS), in $m^3$: This indicator expresses the consumption of direct water on the analyzed system.
- Abiotic Depletion of elements (AD-E), in kg Sb eq: The depletion of abiotic resources refers to the consumption of non-renewable resources from the planet, in comparison to the known reserves at a global scale from each of them.

Environmental impact results (years 2014-2016 and 2018-2019) are presented below in absolute values and with a comparison between both periods.

*Table 9 Environmental impact results as average values for assessed Priorat Wineries*

| Environmental impact category | Unit per bottle of 0.75 liters produced | Total for 2014-2016 period | Total for 2018-2019 period | Comparison 2018-2019 vs 2014-2016 |
|---|---|---|---|---|
| **GWP** | kg CO2 eq | 9.10E-02 | 9.39E-02 | +3% |
| **AP** | mol H+ eq | 8.51E-04 | 8.79E-04 | +3% |
| **WS** | liters | 3.71E+00 | 2.73E+00 | -27% |
| **AD-E** | Kg Sb eq | 3.89E-09 | 3.42E-09 | -12% |

*Table 10 Environmental impact results as average values for assessed Monsant Wineries*

| Environmental impact category | Unit per bottle of 0.75 liters produced | Total for 2014-2016 period | Total for 2018-2019 period | Comparison 2018-2019 vs 2014-2016 |
|---|---|---|---|---|
| **GWP** | kg CO2 eq | 6.95E-02 | 1.92E-02 | -72% |
| **AP** | mol H+ eq | 6.50E-04 | 1.79E-04 | -72% |
| **WS** | liters | 2.66E+00 | 1.01E+00 | -62% |
| **AD-E** | Kg Sb eq | 2.88E-09 | 9.44E-10 | -67% |

For 2014-2016 period, data from all wineries (10 wineries of DO Priorat and 9 wineries of DO Montsant) has been assessed. For the 2018-2019 period, data from 7 wineries of DO Priorat and 3 wineries of DO Montsant has been reported and assessed.

From Table 9 – Priorat wineries- a global decrease in water consumption can be noted (which is -31%), which impacts the categories of Water Scarcity and Abiotic Depletion, whereas an increase of energy consumption (of +3%) is deduced from the Global Warming and Acidification categories rise.

In Montsant wineries, instead, all environmental categories have a very significant reduction, of more than a half, which also implies a notorious decrease of both water (-60%) and energy consumption (-73%) between periods. However, only 3 wineries out of 9 have reported updated values, thus it cannot be concluded that the general behavior of the group should necessarily be the same.

## 4.3. Environmental impacts reduction with measures application

By applying the set of measures identified, LCA results are presented on the table below as well as the percentage of reduction for each of the environmental impacts. Reference values have been taken from 2014-2016 data since not all the wineries reported values for 2018-2019.

In both tables, it has been presented the impact results of the baseline data (2014-16), and separately, the impact results with the application of water efficiency measures and energy measures. Similarly, the reduction in terms of relative values both for water and energy reduction of impacts has been reported, and a final column with the overall reduction potential, if we sum up the impact reduction potential from water and energy measures that could be implemented.

For Priorat wineries, energy measures that could be applied could reduce by 46% the consumption of energy; and water measures could save 39% of water consumption (in average). This is translated into environmental impacts as the following: the reduction of impacts with energy measures could potentially save about 35% of the GWP and AP impact categories; whereas 31% and 16% of WS and AD-E, respectively, with the application of water measures. Globally, the maximum potential of savings when considering all measures applicable is around 35-36% of reduction in all categories.

*Table 11 Environmental impact reduction with efficiency measures in Priorat Wineries*

| Environmental impact category | Unit | Impact results for 2014-16 baseline data | Impact results for 2014-16 with energy efficiency measures | Impact results for 2014-16 with water efficiency measures | Reduction of impacts with energy measures (%) | Reduction of impacts with water measures (%) | Overall reduction potential (%) |
|---|---|---|---|---|---|---|---|
| **GWP** | kg CO2 eq | 9.10E-02 | 6.00E-02 | 9.07E-02 | -35% | -0.35% | -35% |
| **AP** | mol H+ eq | 8.51E-04 | 5.60E-04 | 8.49E-04 | -35% | -0.25% | -35% |
| **WS** | liters | 3.71E+00 | 3.54E+00 | 2.54E+00 | -5% | -31% | -36% |
| **AD-E** | Kg Sb eq | 3.89E-09 | 3.16E-09 | 3.26E-09 | -19% | -16% | -35% |

*Table 12 Environmental impact reduction with efficiency measures in Montsant Wineries*

| Environmental impact category | Unit | Impact results for 2014-16 baseline data | Impact results for 2014-16 with energy efficiency measures | Impact results for 2014-16 with water efficiency measures | Reduction of impacts with energy measures (%) | Reduction of impacts with water measures (%) | Overall reduction potential (%) |
|---|---|---|---|---|---|---|---|
| **GWP** | kg CO2 eq | 6.95E-02 | 3.92E-02 | 6.93E-02 | -44% | -0,32% | -44% |
| **AP** | mol H+ eq | 6.50E-04 | 3.66E-04 | 6.49E-04 | -44% | -0,23% | -44% |
| **WS** | liters | 2.66E+00 | 2.50E+00 | 1.84E+00 | -6% | -31% | -37% |
| **AD-E** | Kg Sb eq | 2.88E-09 | 2.16E-09 | 2.43E-09 | -25% | -16% | -41% |

In Montsant wineries, energy measures that could be implemented could reach a 70% of energy savings on average, whereas water measures could reduce water consumption by 45%. This is reflected on the environmental savings on Table 12, with an overall reduction potential of between 37% and 44% among all impact categories.

# 5. Conclusions

A robust characterization of the environmental performance of wineries of Priorat and Montsant has been performed in this report. 19 wineries, 10 for Priorat and 9 for Montsant, have reported environmental data for the years 2014-2016, regarding water and energy consumption. Average values and standard deviations have been shown for each region: regarding energy consumption, **0.21 kWh/bottle** of wine for Montsant, and **0.31 kWh/bottle** for Priorat. However, for both groups, the water consumption is the same average: **2 liters of water per bottle of wine** (0.75 liters).

Best practices in optimization of water and energy resources have been investigated in the wine sector, and a selection of **24 energy saving measures and 18 water measures** have been proposed for the wineries, specifying which ones of them apply for each winery, depending on the size of it. The application of such measures, should them be applied in all wineries, when comparing with 2014-2016 values, could have an estimated savings of **30,000 €/year** in Montsant wineries and **7,000 €/year** in Priorat wineries. Results give the indication that the efforts of efficiency must be put in the biggest wineries, which cumulate more consumption of resources, so that the reduction measures have significant impact.

**Environmental results** with a life-cycle perspective from the best practices application also show that if the measures should be applied, an improvement of environmental impacts is expected, with a **reduction of impacts** between **35-36% in Priorat** wineries, and **37-44% for Montsant** wineries; for all categories studied: Global Warming Potential, Acidification Potential, Water Scarcity, and Abiotic Depletion of resources.

A total of 3 wineries in Montsant and 7 in Priorat have reported updated values from 2018-2019 period. In Montsant, a **reduction of 73% in energy consumption and 60% in water consumption** has been registered, while in Priorat region, there is a **decrease of 31% in water consumption and a rise of 3% in energy** consumption. It can be concluded, for one side, that the **minimum 8% of reduction** in costs on average proposed in this project **has been reached successfully**, but that there is **still room for improvement**, if we look at the potential savings from the measures application. The list of measures suggested in this report and to each winery, in the individual reports, can be a support to complement the monitoring of consumption values, as a tool for wineries to use yearly.

# References

[1] S. W. B. C. SWBC, «Winery Process Wastewater Management Handbook: Best Practices and Technologies,» 2018.

[2] W. f. C. Protection, «Catálogo de buenas prácticas,» 2019.

[3] J. Nagle, «Winery Water Conservation,» de *Gallo Winery*, 2014.

[4] ESIOS, «Red Eléctrica de España,» [En línea]. Available: https://www.esios.ree.es/es/pvpc. [Último acceso: 15 June 2020].