Reducing water use, organic waste generation and energy use in the winery

In a nutshell

Summary

Best practice is to:

- reduce water consumption in the winery by improving cleaning operations (Section 3.5) and installing highly water-efficient equipment,
- implement a strategic resource efficiency approach to organic residues generated in the winery, including actions, tailored to the specific case, such as: turning by-products into products for human consumption (e.g. distillation for alcohol from grape pomace); displacing synthetic fertilisers thanks to composting; recovering energy in combined heat, cooling and power plants (Section 3.8),
- reduce energy use by:

- choosing energy-efficient equipment whenever there is a need for replacement or expansion, ensuring the proper sizing of the equipment selected (according to the process needs),
- increasing the insulation of pipes, cooling lines, etc.,
- regularly inspecting the heating/cooling pipes in the tanks in order to prevent and/or repair leaks or damage to their insulation,
- designing highly energy-efficient cellars (i.e. select suitable orientation and location to reduce sun exposure, select construction materials with high U-values, and use green roofs and reflective paints and materials).

Target activities

All food and beverage manufacturing	Processing of coffee	Manufacturing of olive oil	Manufacture of soft drinks	Manufacture of beer
Production of meat products	Manufacture of fruit juice	Cheese making	Manufacture of bread, biscuits and cakes	Manufacture of wine

Applicability

This best practice is applicable to all manufacturers of wine. However, there are some limitations to a number of the measures described above for existing wineries, where the applicability depends on the specific production processes already in place.

Environmental performance indicators

- Total water used in the winery (l) per litre of wine produced. Water used can also be measured at the process level.
- Organic waste generation in the winery (kg) per litre of wine produced per month/year
- Thermal energy use (kWh/l of wine produced): can be calculated annually or during the harvesting season
- Electricity use (kWh/l of wine produced): can be calculated annually or during the harvesting season

Benchmarks of excellence
N/A

Description

The overall environmental concerns that wine producers face are rather complex and likely to vary in scope and scale according to their specific activities and geographic location (Christ and Burritt, 2013). This best practice outlines, for a number of relevant environmental pressures or aspects, the most common actions that can help wine producers minimise their environmental impact.

Water use

Water use is a key input for wineries, which use water not only for cleaning and sanitation (to keep clean and to avoid contamination and spoilage) but also for other purposes (e.g. cooling the fermentation cellars and tanks). It is estimated that wineries use around 2,000-3,000 litres of water to process one tonne of grapes, however, data regarding the quantity of water used are scarce and heavily dependent on the size of the winery (Gabzdylova et al., 2009; Kumar et al., 2009).

The most important water consumption in wineries is due to cleaning operations and maintenance of the facility and machinery[1]. The wastewater produced during these processes is characterised by a high content of wine, lees, tartrates and fining agents, as well as remaining cleaning and disinfectant products.

In order to reduce the water use in wineries, cleaning operations can be improved[2]. Moreover, wine producers can install equipment with high water efficiency (low flow, water recirculation, water reuse) for all processes with substantial water use (e.g. cooling, temperature control). In addition, water use reduction in wineries can be achieved by (WINEC, 2012; Conradie et al., 2013):

- Installation and monitoring of water meters at various sections of the winery.
- Use of brushes and squeegees (dry sweeping of floors before washing).
- Stopping water flow during breaks, e.g. installing nozzles on water pipes.
- Use of low-volume/high-pressure washers or use of equipment for mixing a water jet and a compressed air stream, which reduces water consumption by 50-75% compared to a low-pressure system. The use of low-volume/high-pressure washers may have several disadvantages regarding the maintenance of the tanks and of the equipment used (FAO, 1985; WINEC, 2012).
- Ozone tank cleaning of barrels (see Section 3.5).
- Organising water awareness training for the staff working in the winery.

Organic waste

It is important that wineries implement a strategic resource efficiency approach to organic residues generated in the winery. They can firstly apply measures to minimise the generation of organic waste and secondly, for the waste still generated, treat it appropriately. Initially, winery managers should understand where organic residues are generated (in which processes) and encourage the related data collection.

In general, the main organic residue fractions generated in the wineries are:

- grape pomace, which is the grape material (mainly skin, pulp and seeds) that is left over from crushing and pressing;
- grape stalk, which is the skeleton of the grape bunch and consists of lignified tissues;
- lees, which is the material that accumulates in the bottom of grape juice or wine fermentation tanks;
- filtered solids, which are caught by filter pads, especially from vacuum filters which are used for filtering the must;
- waste water sludge, consisting mainly of microbial cells and grade residues.

One of the main environmental concerns related to the management of residues from wineries is the generation of large amounts during a short period of time (normally three months). For instance, 281 000 tonnes of grape stalks; 787 000 tonnes of grape pomace; 337 000 tonnes of wine lees and 24 million m^3 of waste water were generated in Spain from August to October in 2005 according to Bustamante et al., (2008). These residues have a low pH and electrical conductivity, whilst their net wet calorific value is approximately 16.4 MJ/kg (van Eyk and Ashman, 2010).

The best management options for organic residues produced in the wineries are:

- distillation for alcohol production (e.g. Italian grappa), for the grape pomace,
- as fuel in CHCP plants[3] (especially ligno-cellulosic biomass),
- as substrate for composting (displacing synthetic fertilisers or as soil mulch under the vines).

Energy use

Wine production uses large amounts of energy. For instance, Christ and Burritt (2013) report a consumption of 2,618 GJ of energy for the processing of one tonne of grapes into the finished product while Smyth and Russell (2009) report 1,555 GJ/tonne (excluding bottle making and final product transport).

The energy used in wineries is mainly electricity. The stages where most electricity is consumed are those that include temperature control and/or refrigeration (e.g. stabilisation, fermentation). The rest of the electricity is mainly used for the production of compressed air, for pumping and bottling line motors and for other miscellaneous uses (e.g. lighting, office equipment, space heating) (Galitsky et al., 2005).

A detailed share of the electricity use of a winery is presented in Table 1.

Table 1: Typical proportion of electricity use in a winery (SAWI, 2013)

Technology	**Related processes/activities**	**Energy use**

Refrigeration and tank storage	Must chilling Cold stabilisation Refrigeration Wine storage	50-70% electricity
Pumping	Wine transfer Cleaning Waste water treatment	10-20% electricity
Compressed air	Tank presses Cleaning	5-10% electricity
Hot water and steam	Cleaning and sterilisation	5-10% electricity
Heating, ventilation and air conditioning	Barrel stores Warehouses offices	5-15% electricity
Lighting	Warehouses Barrel stores Processing shed and plant room Offices Security and floodlights	5-10% electricity

As for thermal energy, mainly in the form of hot water or steam, its main uses are for cleaning and heating purposes (e.g. heating of tanks for malolactic fermentation, and preheating wine before bottling or after cold stabilisation, or thermovinification - a method used for dealing with botrytis infection problems on grapes) (Galitsky et al., 2005).

Since wineries use large amounts of energy, improving energy efficiency is very important to improve their environmental performance[4]. The processes offering the most potential for energy efficiency improvements are temperature control, refrigeration, cold stabilisation and lighting. This potential can be realised not only by choosing energy-efficient equipment whenever there is a need for replacement or expansion, but also by ensuring the proper sizing of the equipment used, according to the process needs (e.g. valves, pumps). Moreover, other measures which do not involve the purchase of new equipment can be implemented to optimise the energy efficiency of the existing production processes, such as increasing the insulation of pipes, cooling lines etc. or regularly inspecting the heating/cooling pipes in the tanks in order to prevent and/or repair leaks or damage to their insulation.

Regarding cooling operations in the winery, the whole system should be well maintained and, in particular, suitable cooling temperatures should be selected. In addition, it must be ensured that the cooling supply piping duct and the tanks are sufficiently insulated in order to eliminate potential energy losses. In parallel, variable speed refrigerant compressors can be installed in order to reduce energy consumption. The diameter of the pipe duct is calculated according to several parameters e.g. economy of the whole installation, required velocity of the flow. In particular, the oversized diameter of the pipes may lead to energy savings but must be balanced with other costs for pump systems components.

As for lighting, energy consumption can be reduced by maximising the use of daylight and choosing the most energy-efficient lighting technologies. The installation of skylights in the manufacturing sites and the use of high-efficiency light bulbs (e.g. LED) in the cellar (including proper and suitable motion detectors) result in significant energy savings. The installation of motion detectors can result in energy savings of between 10 and 20% depending on the winery (Galitsky et al., 2005).

Energy savings can also arise from reducing the need for pumping. This can be achieved by designing the building to exploit gravity systems. The reception of the grapes can be at the highest point of the building whereas the bottling phase together with the (temporary) storage room can be at the lowest level. In this case the use of pumps is minimised.

Energy efficiency in the winery can also be improved by optimising the drying stage. The main aim of the drying stage is to achieve a significant reduction in the water content of the grapes and a modification of their physicochemical and aromatic characteristics.

The Unione Italiana Vini has recently created a self-evaluation matrix (scoring from 1 to 4) for wineries to assess their sustainability in a number of different areas (e.g. cleaning of grapes, fermentation stage) (TERGEO, 2015). According to this matrix (Table 2), in the case of grape drying, the frontrunner organisations use non-conditioned stores, a drying process based on the utilisation of suitable exchanges between the outside and inside environment, and the drying process is carried-out outside or directly on the grapevine (Unione Italiana Vini, 2014).

Table 2: Best practice for grape drying where sustainability increases from 1 to 4 (Unione Italiana Vini, 2014)

	4th level	**3rd level**	**2nd level**	**1st level**
Grape drying system	Use of non-conditioned stores; drying process based on utilisation of suitable exchanges between outside and inside environment; drying process carried out outside or directly on grapevine	Use of conditioned and insulated stores (thermo-conditioned and humidity-controlled stores)	Use of conditioned stores but not insulated; drying process based on utilisation of suitable exchanges between outside and inside environment	Use of conditioned stores but not insulated

Finally, an important aspect for reducing the energy use in wineries is the appropriate design of the cellar (rooms where the bottled wine or barrels with wine are placed for wine aging) in order to minimise its cooling needs. The following measures can maximise the energy savings:

1. Selection of a suitable orientation to avoid high sun exposure (avoid SE orientation).
2. locate the aging room, the cellar and the bottling room in the basement of the winery in order to reduce sun exposure.
3. Selection and use of proper construction materials like cement blocks or other suitable materials with low U-value (thermal transmittance).
4. Use of green roofs or reflective paint/materials on the roof of the winery.

When implementing the measures above adequately, only fans or other appliances/systems for ventilation are needed in the aging/storage room. The selection of energy-efficient equipment, the precise definition of its capacity and the use of reflective paint/materials on the roof of the winery contribute to the reduction of approximately 15-20% (depending on the local climate characteristics and the building envelope) of the cooling requirements of aging and storing as well as office buildings (Galitsky et al., 2005).

[1] In the case of cooling plants using water or mixed water/air, there is also significant consumption due to evaporation in cooling towers.

[2] More information about environmentally friendly cleaning operations is provided in the corresponding best practice.

[3] More details on the use of pruning residues for energy generation are provided in the best practice on integrating renewables in the manufacturing operations.

[4] General aspects of energy efficient production processes are presented in the corresponding best practice.

Environmental benefits

The measures described in this best practice allow the use of energy and water in the winery to be reduced (consequently saving natural resources and reducing GHG emissions). The sustainable management of organic waste leads to a reduction of GHG emissions, thanks to the production of renewable energy or to the displacement of the production of fertilisers (and the related use of natural resources and GHG emissions).

Side effects

There are no reported cross media effects for the implementation of the aforementioned measures to save water and energy and reduce organic waste generation. However, there is a negative impact due to the disposal of existing systems when upgrading to new and more efficient ones. This impact may outweigh any increased efficiency offered by new equipment if premature disposal occurs or if the end-of-life treatment of the equipment is not managed properly. Determining the point at which it offers a net environmental benefit to switch to new equipment is not straightforward although, in general, the older the equipment being replaced the more likely it is that the replacement makes good environmental sense. It is always advisable to choose the most environmentally friendly and efficient equipment when a replacement is needed (e.g. due to broken equipment or new technology requirements).

Applicability

This best practice is applicable to all manufacturers of wine. However, there are some limitations to a number of the measures described above for existing wineries, where the applicability depends on the specific production processes already in place.

Economics

The direct economic benefits from savings on the energy and water bills and from the waste management costs differ significantly from case to case. There are also a number of indirect benefits. An example is that improving the environmental reputation of a company can benefit sales thanks to an increased number of customers.

Driving forces for implementation

The main driving forces for the implementation of measures to reduce energy and water use as well as waste generation are their contribution to a reduction in production costs and the improvement of the quality of the final product (bottled wine). This is particularly the case for the proper selection of the materials used for the construction of the winery and the appropriate location of the aging room, which lead to an improved final product.

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