Title

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ABSTRACT

Not all industrial facilities have the staff or the opportunity to perform a detailed audit of their operations. The lack of knowledge of energy efficiency opportunities provides an important barrier to improving efficiency. Benchmarking programs in the U.S. and abroad have shown to improve knowledge of the energy performance of industrial facilities and buildings and to fuel energy management practices. Benchmarking provides a fair way to compare the energy intensity of plants, while accounting for structural differences (e.g. the mix of products produced, climate conditions) between different facilities.

In California, the winemaking industry is not only one of the economic pillars of the economy; it is also a large energy consumer, with a considerable potential for energy-efficiency improvement. Lawrence Berkeley National Laboratory and Fetzer Vineyards developed the first benchmarking tool for the California wine industry called "BEST (Benchmarking and Energy and water Savings Tool) Winery [1]. BEST Winery enables a winery to compare its energy efficiency to a best practice reference winery. Besides overall performance, the tool enables the user to evaluate the impact of implementing efficiency measures. The tool facilitates strategic planning of efficiency measures, based on the estimated impact of the measures, their costs and savings. The tool will raise awareness of current energy intensities and offer an efficient way to evaluate the impact of future efficiency measures.

Introduction

The wine industry is important to California both from an economical and an energy perspective. California has 1100 wineries that produce over 500 million gallons per year, contributing about $33 Billion to the Californian economy (directly and indirectly). California makes most of the total wine in the U.S.; in 2000, California generated 565 million gallons of wine, representing almost 92% of all U.S. production. To make this much wine, the industry consumes over 400 GWh of electricity, the second largest electricity-consuming food industry in California after fruit and vegetable processing. In addition, much of the energy wineries use is during peak hours and season, where increased energy efficiency will not only save energy and money for wineries, but also it will reduce peak demand and increase needed capacity for power generators in California.

[1] While for this paper only the energy efficiency aspects of BEST will be considered, it is important to note that BEST does address water efficiency and recognizes the strong link between water and energy use.

Why Benchmarking?

It is often the perception of companies that they are highly energy efficient, or even the most energy efficient in their industry. However, not all industrial facilities have the staff or the opportunity to perform a detailed audit of their operations and test this perception. Benchmarking, done properly, provides a tool to test this perception using accepted benchmark values for technologies. By accounting for structural differences (e.g. the mix of products produced, climate conditions) between different facilities, benchmarking can provide a fair way to compare the energy intensity of plants.

Benchmarking can be a useful tool for understanding energy consumption patterns in an industrial facility and for designing policy to improve energy efficiency. Benchmarking programs in the U.S. and abroad have shown to improve knowledge of the energy performance of industrial facilities and buildings and to fuel energy management practices (Birchfield, 2000; Phylipsen, et al., 2002; Worrell and Price, 2005). They can stimulate innovative approaches to improve energy management in industrial facilities and organizations.

Energy benchmarking for industry is a process in which the energy performance of an individual plant or an entire sector of similar plants is compared against a common metric that represents “standard” or “optimal” performance. It may also entail comparing the energy performance of a number of plants to each other. Because benchmark evaluation tools are used for comparison across a number of plants, there are two important characteristics they should have. First, because they are applied to plants or sectors of different sizes and outputs, the metric used should be irrespective of plant size. This is accomplished using intensity, which measures energy use per unit of output. Second, the tool should be applicable to a wide range of facilities in order to increase the robustness of the analysis and, therefore, should be able to compensate for differences in production (e.g., product mix and climate) at similar facilities.

In designing an evaluation tool that compensates for production differences, it is necessary to examine the production processes and account for the various steps used. BEST Winery is based on this type of a process-step benchmarking approach. In this approach, the key process stages are identified and a benchmark performance is assigned to each step. The performance of a winery is then compared to a reference or model winery, incorporating information about how each step is performed. The performance of the winery is calculated and expressed as an Energy Intensity Indicator (EII). The EII is expressed relative to the benchmark.

BEST Winery also allows the user to preliminarily evaluate opportunities for energy efficiency improvement, to assess the impact on the performance of the facility, and to evaluate operation costs. The BEST Winery tool, in addition to benchmarking the energy efficiency at a winery, also provides an interactive menu of opportunities for improvement, with energy savings, costs, and payback periods given for each measure, as well as for the entire set of user-selected measures. This will allow lower cost and easier evaluation of energy efficiency improvement potential, reducing transaction costs formerly associated with information collection, evaluation, and energy management at a winery. This can help the user in developing a preliminary implementation plan for energy and water efficiency improvement.

The Wine Industry

California wine production is concentrated in a few areas, most notably in Northern California. Table 1 provides a distribution of the number of wineries within 10 regions in California. Although, the largest number of wineries are located in the Napa and Sonoma regions, the concentration of production also includes the Central Valley, where very large wineries produce low-cost wines. Most notable are the large wineries operated by Michael Hat and E. and J. Gallo. In California, there are a very large number of small wineries that produce less than 20,000 cases per year, while there are few wineries that produce over 1 Million cases per year. The difference in distribution of wineries and capacity is illustrated by the differences in the distribution of share of grapes crushed and that of wineries, as shown in Table 1. While almost 32% of all wineries are located in Napa, they crush only about 4% of all grapes. In the Central Valley 76% of all grapes are crushed, but only 5% of the wineries are located in the region.

Table 1: Distribution of Wineries in California and of Share of Grapes Crushed

Region	Share of grapes processed	Number of Wineries	Share of wineries	Main locations	Number of Wineries
Central Coast	5.2%	32	2.9%	Carmel Valley	8
Central Valley	76.1%	58	5.3%	Lodi	12
Foothills (Sierra Nevada)	0.5%	68	6.2%	Plymouth	15
				Placerville	8
Mendocino/Lake District	2.7%	55	5.0%	Hopland	9
				Philo	15
				Ukiah	11
Napa	4.2%	350	31.8%	Calistoga	45
				Napa	116
				St. Helena	108
Sonoma	5.9%	237	21.5%	Healdsburg	85
				Santa Rosa	26
				Sonoma	30
San Francisco Bay	0.7%	116	10.5%	Livermore	20
South Coast	4.5%	149	13.5%	Paso Robles	48
South California	0.1%	37	3.4%	Temecula	16
Total	**100%**	**1102**	**100%**		**572**

Table 2: Largest varietals in California wine production

Varietal	2002 Production (tons crushed)	Share of total (% by red or white)
Red	1,816,716	
Cabernet Sauvignon	379,183	20.9%
Zinfandel	369,772	20.4%
Merlot	306,992	16.9%
Rubired	183,457	10.1%
Syrah/Shiraz	101,538	5.6%
White	1,287,865	
Chardonnay	594,905	46.2%
French Colombard	312,937	24.3%
Chenin Blanc	117,875	9.2%

Sauvignon Blanc	76,587	6.0%
Burger	50,386	3.9%

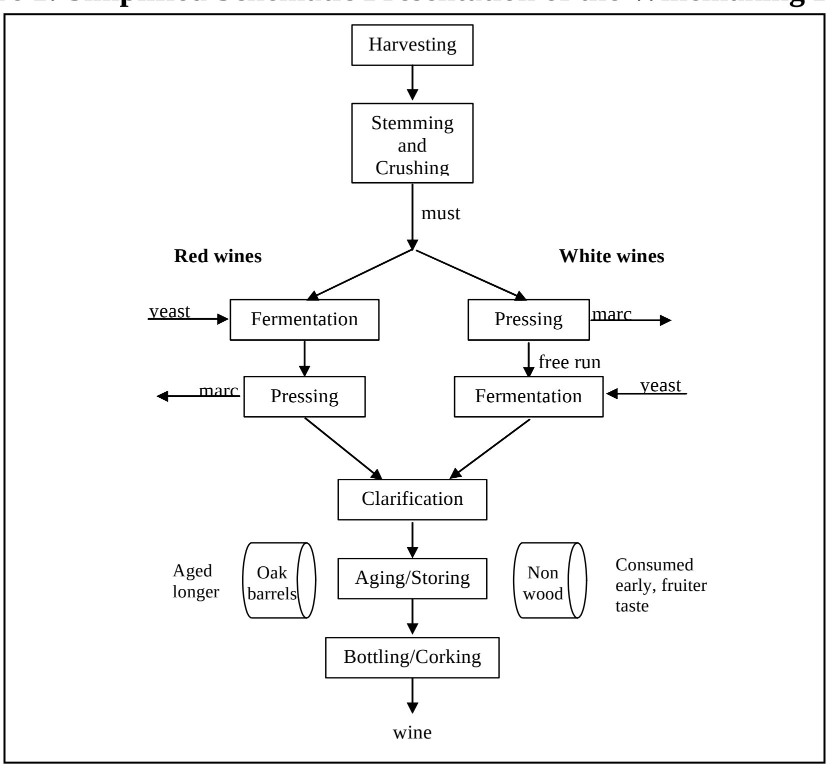
Source: The Wine Institute, 2002

Most wineries produce a number of different wines. In California, wineries produce about 23 varietals of red wines, and 21 varietals of white wine, in addition to desert and sparkling wines. However, a small number of the varietals represent the majority of wines produced in California. The most produced red wines are Cabernet Sauvignon, Merlot, Zinfandel, and Syrah, while the most produced white wines are Chardonnay, Colombard, and Sauvignon Blanc. Table 2 provides a breakdown of the varietals processed, by tons of grapes crushed in the 2002 harvest. In BEST Winery, we used four categories of wine to capture the majority produced in California. These are described below in the section on modeling.

Wine Production

There are numerous variations in the way the grapes are processed. The variations are driven by the type of grapes processed and wine produced, the sugar content of the grapes, product characteristics as specified by the winemaker, the lay-out of the winery, as well as conditions during the harvesting period. In the process description below, we briefly describe the process used for most wineries, focusing on energy use and the implications of process variables on energy use. For a more detailed description of the process and the impact on wine quality we refer to Boulton et al. (1996) or our original report (Galitsky et al., 2005). Figure 1 shows a simple schematic of the process of making wine.

Figure 1: Simplified Schematic Presentation of the Winemaking Process



Harvesting, De-stemming and Crushing

Grapes are generally harvested from early August through October. The grapes are transported to the winery by truck. At the winery, the grapes are received at a receiving bin or station. To prevent damaging the grapes, the grapes are moved with different means, most often a combination of screw conveyors or pumps. After reception, the stems are removed from the grape berries. The skins and pulp are then broken to free the juice without squashing the seeds. Some wineries receive all or part of their grapes as juice, in which case, destemming and crushing have been done elsewhere. The mixture of juice, skins, seeds and pulp (the *must*) is pumped to fermenting tanks (reds) or to the pressing stage (whites).

Draining and Pressing

The *must* is pumped into the tank, and the juice drains from the tank. If the juice does not naturally drain, a press is used to extract the juice. In many (larger) wineries a press will be the main means of extraction. Membrane presses are preferred[2]. A motor operates the membrane presses and pumps and compressors are used to pump must and juice.

For red wine, after crushing, the must goes directly to the fermentation stage and pressing is done after fermentation[3]. For white wine, skins, seeds and pulp are separated from the juice (*free run*) after crushing. One ton of grapes will yield 155 to 195 gallons of must, of which 120 to 160 gallons being free-run juice.

Fermentation

Fermentation is an extremely important step in winemaking, determining taste and quality. In fermentation, yeasts convert the sugars to alcohol and carbon dioxide. The alcohol is the wine’s major flavor component, affects the solubility of many wine constituents and enhances the wine’s resistance to spoilage. Fermenting is mostly done in stainless steel tanks, however, certain wines, such as Chardonnay, are fermented in the barrel.

The fermentation process takes place at a controlled temperature for quality purposes, to which the wine needs to be cooled at the beginning of fermentation and throughout the process. The fermentation reaction also generates heat that needs to be removed. Cooling of the fermentation tanks and/or the barrel room is one of the major energy uses in the winery. The length of the fermentation period depends on the sugar content of the grapes and juice, and is controlled by the winemaker to optimize the quality of the wine. Table 3 gives the typical parameters for the main processing routes of wines.

Table 3: Fermentation process characteristics

Wine	Typical Sugar Content (° Brix)	Typical Fermentation Temperature (°F)	Typical Fermentation Period (days)
Red	22-26	75 - 80	7 – 10

[2] Membrane presses provide quality comparable to draining, with juice is lower in tannins and suspended solids

[3] The skins give the wine its color; so leaving the skins, seeds and pulp in until after fermentation gives the wine a red, rather than clear color.

White – tank fermented sweet	21-22	48 - 50	28
White – tank fermented dry	23-24	58 - 60	14
White – Barrel fermented	23-24	60 (or room temperature 55 to 58)	7

Malolactic Fermentation

Malolactic fermentation is the secondary fermentation reaction that converts malic acid in the wine to lactic acid, reducing the acidity of wines. Some wines have an autonomous malolactic fermentation if kept at a temperature that does not inhibit the fermentation. Most of the red wines in California undergo malolactic fermentation; actual share varies with the winery. Malolactic fermentation in red wines is done in the tank while for other wines, e.g. Chardonnay, the fermentation is started by leaving the wine on the yeast lees and heating the barrels or room containing the barrels to a sufficiently high temperature for fermentation.

Clarification and Stabilization

Clarifying wine separates the clear wine from the spent yeasts and other solids after fermentation. In California, the most common techniques to clarify wine are racking, cold stabilization, fining and filtering. Often a combination is used. A new technique developed in Europe, and being demonstrated in California, is electrodialysis.

Racking, the oldest clarification technique, siphons off clear wine after the dirt, dust, cellulose, dead yeast cells, bacteria, tartrates and pectin have settled to the bottom. *Cold Stabilization* is generally used as an enhancement to racking to remove excess tartaric acid that may form potassium bitartrate crystals (that can show up in wine bottles or on corks). In cold stabilization the wine is first warmed to room temperature and then is chilled down to about 25 to 36ºF (-4 to 0ºC) to crystallize the tartaric acid and draw it off via racking. Due to the need to chill and keep the wine at such low temperatures, cold stabilization is a large energy user in winemaking. *Electrodialysis* is a membrane process that may be able to replace cold stabilization, using an electric current to move the tartrate ions from the wine through a membrane to an aqueous solution.

Storage/Aging

After clarification, the wine is stored and aged at the winery or an offsite warehouse year round, in order to supply wine year round. In most wineries in California, the cellar is a warehouse in which the temperature and humidity is controlled. Temperature control is achieved using cool night air or artificial cooling that supplements the nighttime air at periods of high temperature. In some wineries, the cellar is underground which reduces cooling and humidification needs. In the very large wineries where low-cost wines are produced, storage is kept to a minimum. These wines are often stored in outdoor tanks that are sometimes insulated.

Bottling and Corking

Bottling is the final step in winemaking. Bottling is an important operation to maintain the quality of the wine while aging in the bottle. Wine is pumped to tanks at the bottling facility. The bottling line is contained in a separate room, and is kept dust free and under a slightly positive air pressure to reduce the growth of organisms and reduce contamination of the wine. Bottles are cleaned and dedusted by blowing compressed air into the bottle. Bottling equipment varies from simple siphon hoses, funnels, hand corking and labeling machines to very modern and completely automated bottling lines.

Energy Use in Winemaking

The California winemaking industry consumes over 400 GWh of electricity, the second largest electricity-consuming food industry in California after the canned fruit and vegetables industry. Besides electricity, the industry also consumes considerable amounts of fuel, including natural gas, LPG and propane. Much of the electricity used in winemaking goes to refrigeration for cooling and cold storage. The rest is mainly compressed air, hot water or electricity for pumping and the bottling line motors. Enclosed areas for storage and processes also require lighting and many are cooled. Other power is required for buildings and other miscellaneous administrative or maintenance applications. Compressed air demand in wineries is highly variable. The biggest use of compressed air is in the presses. There the compressor must have sufficient capacity to charge the air receiver so it is ready for each pressing cycle; however, presses are only used about 1200 hours or less per year. Hot water is needed for cleaning barrels and equipment and for heating red wine ferments and yeast generator tanks.

BEST Winery Tool

In BEST Winery, the reference winery is a hypothetical winery composed of all commercially available best practice energy efficiency technologies used anywhere in the world. No real-life winery with every single efficiency measure included in the benchmark will likely exist; however, the benchmark sets a reasonable standard by which to compare. The energy consumption of the benchmark facility will differ due to process variables different at each winery. BEST Winery tries to account for each of these variables and allow the user to adapt the model to operational variables specific for his/her winery.

Benchmark Modeling – How we created the reference winery

In order to model the benchmark or most energy efficient winery so that it represents a facility similar to the user's winery, we first require the user to input production variables in the input sheet in BEST Winery. These variables allow BEST Winery to estimate a reference winery that is similar the user's winery, giving a better picture of the potential for that particular facility, rather than a generic best winery. The production variables required in BEST Winery include the amount of grapes and juice received annually, the amount that is fermented annually, the amount of wine that undergoes malolactic fermentation and cold stabilization, the amount of wine that is stored per year (or, in a twelve month period), the wine produced by the plant annually and the wine that is bottled annually. Each of these must be entered for each of the four categories of wine in the model: red wines, sweet white wines, dry wines that are tank fermented and dry wines that are barrel fermented. These variables will affect the energy used at a reference winery similar in characteristics to the user's winery, but are easily obtained and readily available to wineries. The user must also enter location of the winery and if it pumps and/or treats its own wastewater.

We have modeled the energy use at a winery as seven main process steps: receiving, pressing, fermentation, malolactic fermentation, clarification & stabilization, aging & storing, and bottling. In addition, we have separately calculated energy requirements for pumping and for additional miscellaneous uses, such as lighting, office equipment, water heating, space heating, and forklift operation.

For the receiving and pressing stages, energy use is based on an estimated average crush season length and the amount of time that the equipment runs per day. These variables were determined through discussions with personnel in the wine industry (e.g., Fetzer, 2004; Galitsky, 2005). Though we used these default values for the reference winery, the user can also change these values to model more closely their specific conditions, if different.

For fermentation, the main variables affecting energy use are ambient temperature and the temperature of the incoming juice. Table 4 shows the average temperatures for California's main winery regions during fermentation, as well as malolactic fermentation and cold stabilization. On the input sheet in BEST Winery, we ask the user to choose the region where their winery is located, as well as the main region from which their grapes come. We link these locations to the database below (included in BEST Winery) for temperature data that is used to calculate energy requirements during fermentation. Other variables that affect fermentation energy use are fermentation temperature, fermentation time, sugar content of the incoming grapes, building size, and vessel size. Based partly on the production variables input by the user, BEST Winery estimates the building and vessel size. These, along with fermentation temperature, fermentation time and sugar content of the incoming grapes, are estimated as *default* values in BEST Winery. As with all default values in BEST Winery, the user has the option to change these default values on the optional input sheet for maximum flexibility; however, if the default values are not changed, BEST Winery models them based on data we received from wineries and vendors to the wine industry (see Galitsky, et al., 2005 for references).

Table 4: Average temperatures in California's main winery regions during fermentation, malolactic fermentation and cold stabilization

Area	Fermentation Ambient	Malolactic Ambient	Stabilization Ambient
Calistoga	65.3	54.5	54.5
Central Coast	66.2	53.8	53.8
Foothills	65.3	54.5	54.5
Healdsburg	64.0	53.4	53.4
Hopland	64.0	51.4	51.4
Lodi	68.7	55.2	55.2
Livermore	66.7	53.8	53.8
Napa	61.9	50.0	50.0
Paso Robles	66.6	54.1	54.1
Santa Rosa	64.0	53.4	53.4
Sonoma	64.0	53.4	53.4
St. Helena	61.9	50.0	50.0
Ukiah	66.2	50.4	50.4

Similar calculations are performed to determine energy use in the next two stages of winemaking, malolactic fermentation heating requirements and cold stabilization cooling requirements for the benchmark. For more details, we refer the reader to the original report (Galitsky et al., 2005).

The energy required for aging and storage is based on production inputs described above, particularly how much wine is stored in a twelve month period. The reference winery assumes that using underground caves is the most energy and water efficient means of storage. Hence, BEST Winery estimates the energy required per gallon stored for operating fans only.

Bottling energy requirements are based on the estimated time that the bottling equipment runs annually, estimated at 52 weeks per year, at 40 hours per week for seven weeks and 48 hours per week for five weeks. These variables were determined through discussions with personnel in the wine industry (e.g., Fetzer, 2004; Galitsky, 2005); however, bottling time is another changeable default value used in the BEST Winery which may be changed by the user for best results.

Pumping energy is made of several parts: the energy required for pumping wine, water, cooling water, hot water, and wastewater, if water is treated onsite. Pumping energy for wine for the reference winery is based on the production variables entered by the user. Cooling and hot water pumping for the reference winery are calculated based on assumptions about equipment running time but linked back to production input variables. For example, we estimated for the reference winery, hot water systems for malolactic fermentation will run for 4 months per year at 16 hours per day. Hot water for barrel cleaning, on the other hand, is estimated to require eight hours of pumping per day year round for the reference winery, while pumping for bottling lines cleaning was estimated to run three hours per day. We modeled the reference winery wastewater treatment system to be an aeration pond system, where only water pumping was required, at a rate of 0.034 kWh/case of wine produced. All of these variables were also determined through discussions with personnel in the wine industry (e.g., Fetzer, 2004; Galitsky, 2005).

Heating requirements for hot water production was based on the amount of hot water required by the winery (see Galitsky et al., 2005 for more details), and a 90% efficient boiler.

Based on information from several audits, as well as our literature search, we estimated that the reference winery would require about 12% electricity for lighting requirements, about 5% for office equipment and workshops, and about 1% for other miscellaneous uses not included elsewhere in the model, while space heating would require and addition 1.5% of fuel. Propane used for forklifts was linked directly to production input.

Benchmarking Score

Once the user inputs all required input variables into the model along with any optional input values they choose to input, BEST Winery calculates the score of the winery relative to the reference winery that has the same characteristics of the user's winery. This score, the energy intensity index (EII), gives the user a sense of how efficient their winery is. Figure 2 shows an example of the results page in BEST Winery for a small hypothetical winery. As shown in Figure 2, the EII for this winery is 179. This winery has the potential to save 44% of their total primary energy through energy efficiency management and technologies. If implemented, savings for this small winery could total over $28,000 per year for energy savings alone. Given the relatively large potential for improvement (which would be even greater for larger or less efficient wineries), this winery should next consult the energy efficiency measures sheets in BEST Winery for information on what energy efficiency opportunities are available to their winery, and calculate savings, costs and payback periods for measures that are attractive to them.

Energy Efficiency Opportunities

In addition to evaluating overall performance and providing a benchmarking score, the EII that compares energy use to a reference winery, BEST Winery provides a menu of opportunities for energy efficiency. This menu can be used to examine specific energy efficiency opportunities and to identify a set of possible measures that can help wineries achieve maximum benefit.

The following Energy Efficiency Opportunities included in BEST Winery are common to wineries and many industrial facilities: refrigeration, pumping, compressed air, motors, lighting, hot water supply, cogeneration (combined heat and power), and miscellaneous electric and fuels). For each opportunity, BEST Winery provides typical energy savings, capital costs and payback period. The measures span a wide range of applicability, both in system type and in design and operation, i.e. for new construction to maintenance. The estimates for energy savings and costs are necessarily based on past experiences in the wine and other industries. These are used in BEST Winery; however, actual performance and very specific characteristics for the user's winery may go beyond the model capabilities and change the results. Hence, BEST Winery gives an estimate of actual results for a preliminary evaluation of cost effective projects for the user's winery; for a more detailed and exact assessment, a specialized engineer or contractor should be consulted.

In some sheets, e.g., pumping, compressed air, motors, lighting, the user has the option to prepare an inventory of all pumps, compressors, motors or lights to calculate a more exact share of energy use for that specific end use. If the inventory tables are not used, BEST Winery determines a typical percent energy use for that end-use, based on past experiences in the wine industry as well as the characteristics input by the user.

Individual measures are selected by the user as a percentage to which the measure can still be applied under the column "potential application". Using a pumping as an example, entering 100% for a measure, e.g., controls would mean controls would be placed on all pumps, representing 100% of pumping energy (not 100% of the total energy).

Figure 2: Benchmarking Results in BEST Winery for a Hypothetical Winery

Energy Intensity Index (EII)	179
Water Intensity Index (WII)	154

Detailed Results			
Technical Potential for Efficiency Improvement:			
Electricity (kWh saved/year)		170,365	49%
Fuel (MBtu saved/year)		171	26%
Primary Energy (MBtu saved/yea		1,434	44%
Water (Gallons saved/year)		347,563	35%
Net Operation Cost Reduction:			
Electricity ($/year)	$	25,555	/year
Fuel ($/year)	$	2,351	/year
Energy - Total ($/year)	$	27,906	/year
Water ($/year)	$	586	/year
Total Cost Reduction ($/year)	$	28,492	/year
CO_2 Emission Reduction Potential:			
Total (metric ton CO_2/year)	49.3		
Total (metric ton C/year)	13.4		

Summary Data	
Your Facility:	
Electricity Consumption (kWh/year)	350,568
Fuel Consumption (MBtu/year)	650
Primary Energy Consumption (MBtu/year)	3,250
Energy Intensity (kBtu/case produced)	44.5
Water Consumption (Gallons/year)	989,000
Water Intensity (Gallon/case bottled)	12.1
Reference Facility:	
Electricity Consumption (kWh/year)	180,203
Fuel Consumption (MBtu/year)	479
Primary Energy Consumption (MBtu/year)	1,815
Energy Intensity (kBtu/case produced)	24.9
Water Consumption (Gallons/year)	641,437
Water Intensity (Gallon/case bottled)	7.8

Each measure contains brief description of the specific measure, read by right-clicking on the cell containing the measure name. The information is also contained in the companion report. Each measure sheet adds all individual measures selected by the user to provide a total savings estimate, a cost estimate and an average payback period for those measures. This information is automatically amalgamated into the "Assessment Results" sheet that provides the final results of the self-assessment for energy efficiency improvement. This sheet summarizes the cumulative potential annual energy and water savings, annual cost savings, capital costs, average payback period and reductions in CO_2 emissions for the group of selected measures. This sheet reports the actual EII, as well as the potential EII upon implementation of all the selected energy efficiency measures. In this way, BEST Winery can be used as a tool to aid energy management.

Summary and Conclusions

The wine industry in California is not only important economically, it is also a large energy user – the second largest electricity consumer in the food industry. Because of its significance to California, it is important that the industry stay competitive. Increasing attention for energy intensity and eventually increasing efficiency will help make California wineries more competitive on the world markets.

Lawrence Berkeley National Laboratory and Fetzer Vineyards developed the first benchmarking tool for the California wine industry. By accounting for production and the most important distinguishing characteristics for the user's winery including weather and location, wineries can easily and reliably benchmark water and energy use compared to a trusted best practice winery. Users can then consult the interactive menu of energy efficiency opportunities available to them which shows costs, energy savings and dollar savings. This enables a user easily to assess the current energy use as well as the potential impact of implementing efficiency measures at his/her winery. In this way, BEST Winery will help wineries in California easily and strategically plan efficiency management at their winery.

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References

G. Birchfield. 2000. "Issues and Challenges in Energy Benchmarking". In: *Proceedings of the 22nd National Industrial Energy Technology Conference.* Houston, TX.

Boulton, R.B., V.L. Singleton, L.F. Bisson and R.E. Kunkee. 1996. *Principles and Practices of Winemaking*. New York, NY: Chapman & Hall.

California Wine Mall. 2004. Website: http://www.cawinemall.com/local.html

Fetzer Vineyards (various winemakers). 2004. Personal communication throughout 2004.

Galitsky, C., E. Worrell and A. Radspieler of Lawrence Berkeley National Laboratory and P. Healy and S. Zechiel of Fetzer Vineyards. 2005. *BEST Winery Guidebook: Benchmarking and Energy and Water Savings Tool for the Wine Industry*. LBNL-3184. Berkeley, CA: Lawrence Berkeley National Laboratory.

Phylipsen, D., K. Blok, E. Worrell, and J. de Beer. 2002 "Benchmarking the Energy Efficiency of Dutch Industry: An Assessment of the Expected Effect on Energy Consumption and CO2 Emissions". *Energy Policy* 8 (30) pp 663-679.

Wine Institute. 2002. *Sustainable Winegrowing Practices.* August.

Worrell, E. and L. Price. 2005. "An Integrated Benchmarking and Energy Savings Tool for the Iron and Steel Industry". *International Journal of Green Energy.* (in press).