

REDUCING ENERGY CONSUMPTION AT NORTH CAROLINA WINERIES:  
A CASE STUDY OF SHADOW SPRINGS VINEYARDS  
AND WINDSOR RUN CELLARS

by

Kayla DeCarr

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Dr. Timothy L. Johnson, Adviser

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## Executive Summary

Wine making is an energy intensive process. Even small operations use large amounts of energy. Because of this, some states have begun to implement formal sustainability programs to reduce energy use at wineries. These programs have demonstrated that energy efficiency improvements and on-site renewable energy generation can significantly reduce a winery's energy demand.

North Carolina hosts a rapidly growing wine industry and is home to the nation's most visited winery, the Biltmore Estate Winery. With continuing growth trends, the wine industry will place increasing demand on the state's energy resources. This growth, in combination with a slow adoption of sustainability measures, presents an opportunity for significant energy savings in the North Carolina wine industry.

This project provides a case study of energy reduction efforts at two small-scale wineries: Shadow Springs Vineyard and Winders Run Cellars, located in Hamptonville, North Carolina. The analysis utilized a three phase approach:

- 1) an examination of historical electricity use,
- 2) an energy assessment equivalent to ASHRAE Level 2 audit specifications; and
- 3) an evaluation of on-site solar photovoltaic generation potential.

This report summarizes current energy use, provides recommendations for reducing energy consumption, and discusses how the lessons learned from this case study might scale across the rapidly growing North Carolina wine industry.

Examining historical electricity use revealed four key drivers of energy consumption: weather, building size, primary function of the facility, and energy efficiency. The tasting rooms at Shadow Springs Vineyard and Windsor Run Cellars are highly influenced by weather conditions. The former uses more total energy due to its larger size; however, energy consumption per square foot is very similar between the two sites. The winery consumes significantly more energy in total and per square foot of building space. The building's function drives its high space conditioning and winery equipment energy needs.

The energy assessment determined current efficiencies and inefficiencies, focusing on lighting, building envelope, HVAC systems, and plug loads. Several potential energy efficiency upgrade opportunities, ranging from no-cost to capital-intensive projects, are described in detail within this report. Final recommendations are based on savings, investment analysis, and non-energy benefits.

Sites were assessed for the potential installation of a solar photovoltaic electricity generation system. Four scenarios were evaluated: a PV system that could supply 100%, 50%, and 25% of the site's electricity needs, and covering the winery roof in solar panels. Scenarios 1, 2, and 3 considered both fixed and sun-tracking PV system types. A financial analysis revealed that access to an U.S. Department of Agriculture grants makes any project economical with a simple payback period ranging from 2.5 to 3.5 years.

Two products were derived from this energy analysis: 1) a site-specific energy analysis and recommendations for Shadow Springs Vineyard and Windsor Run Cellars; and 2) findings that can be used to scale up energy reduction across the state's wine industry.

Shadow Springs Vineyard and Windsor Run Cellars should begin by pursuing energy efficiency projects with payback period of less than 2 years. These include programming existing programmable thermostats, replacing all light bulbs in each tasting room with LED alternatives, conducting maintenance system checks, and properly air sealing all buildings. Next, capital intensive projects with significant energy savings should be pursued in the winery. Lighting should be replaced with LEDs and ceiling fans should be installed. Pursuing these projects simultaneously can reduce capital costs. After reducing energy consumption through these energy efficiency projects, Windsor Run Cellars should investigate opportunities to install a solar photovoltaic system on the winery's roof, by obtaining estimates from solar PV contractors and engaging with the USDA's rural energy grant program.

Four key lessons, ascertained from this energy analysis, can be used to inform energy reduction at other wineries across North Carolina and to inform the development of a formal sustainability or energy program for the state's wine industry. These are:

- Tasting rooms are similar to residential construction.
- Lighting projects are highly economical.
- Space conditioning and winery equipment are the primary drivers of energy use in a winery.
- Several financial incentives exist for energy efficiency and renewable energy projects.

## Introduction

### Background on Energy and the Wine Industry

Energy plays an integral role in the production of wine. In the wine industry, the process of growing grapes is referred to as viticulture. Vineyards may be tended by hand or through fossil fuel-powered machinery for irrigation, pesticide or fertilizer application, harvesting, and sorting. Viniculture, the process of making wine, is more likely to be dependent on fossil fuel energy inputs. Typically, a machine is used after grapes are harvested to remove grape stems and crush the fruit. Another machine is used to press and remove grape skins (Good, 2014). During the fermentation process, yeast is added to the grapes in stainless steel or oak barrels. Depending on the type of grape used and wine being produced, barrels may be refrigerated at different temperatures and durations (Wilson Creek Winery, 2014). Wine will age in these barrels, which may require months or years of refrigeration (Good, 2014).

Thus, even small operations that conduct most of their viticulture activities by hand are likely to use significant amounts of energy during the viniculture process. Energy is also used in the electrification and space conditioning of production and customer-facing facilities. Because most wineries rely on the use of conventional electricity sources, which is largely generated from fossil fuels, most wineries produce ozone depleting and smog-forming emissions during the wine-making and selling process (Benedetto, 2013).

Because of these and additional environmental and human health impacts, wine industry associations have begun to take action to reduce the negative impacts associated with wine production. Formal sustainability programs are being implemented in California, New York, Oregon, and Washington state (WineAmerica & Winegrape Growers of America, 2008). California represents not only the greatest domestic market share, producing approximately a third of the country's wine (Held, 2008), but also the state with the most widely adopted sustainability program in the United States (WineAmerica & Winegrape Growers of America, 2008).

In 2001, the California wine industry launched an initiative to engage 100% of its growers and winemakers in sustainability practices through the California Sustainable Winegrowing Alliance (California Sustainable Winegrowing Alliance, 2014; Desta, 2008). Through this organization vineyards and wineries can become "Certified California Sustainable Wine Growing." Since its launch, the program has enrolled over 1,000 participants (WineAmerica & Winegrape Growers of America, 2008), and more than 52 organizations have achieved the sustainability certification (California Sustainable Winegrowing Alliance, 2014).

While California’s sustainability initiatives encompass many different ways for growers and winemakers to reduce their environmental impact, many participants have pursued energy efficiency and on-site clean energy. From 2008 to 2012, the adoption of energy efficiency projects at wineries increased from 76 to 520 (California Sustainable Winegrowing Program, 2013). As a result, annual electricity savings escalated from 1,000 MWh in 2008 to 200,000 MWh in 2012. The installation of solar photovoltaic systems has been a rising trend in California, as these systems provide energy savings and serve as a marketing tool to attract tourists (California Sustainable Winegrowing Alliance, 2014).

North Carolina ranks ninth in the United States for both grape and wine production. Home to more than 400 vineyards and 140 wineries, the wine industry is rapidly growing. The number of wineries in North Carolina has increased five-fold since 2001. The most visited winery in the country, seeing over one million visitors annually, Biltmore Estate Winery is located in Asheville (North Carolina Department of Commerce, 2013).

Continued growth will place increasing demand on state resources, including energy. While the California wine industry received recognition for adopting solar panels 42 times faster than the rest of California’s commercial sector in 2007, the first solar installation at a North Carolina winery did not take place until 2009 (McKee, 2009). This slower trend of adoption of sustainability measures may be the result of a number of different factors, such as less awareness and education of the topic and/or fewer financial incentives. This gradual adoption, in combination with a rapidly growing industry, presents a significant opportunity for potential energy savings in the North Carolina wine industry.

## **Project Overview**

This project will serve as a pilot study of the potential energy saving opportunities available to North Carolina vineyards and wineries. It evaluates two entities: Shadow Springs Vineyard and Winders Run Cellars. These two entities differ in facility type and use, and property size and layout; therefore, they represent some of the dissimilarities among North Carolina winemakers. This study evaluates energy efficiency and on-site renewable energy projects in terms of viability and scalability across the North Carolina wine industry.

This study focuses on improving energy efficiency and reducing overall energy demand at winery facilities. Investigating potential alterations to the winemaking process itself is beyond the scope of this analysis and represents measures that are less likely to be adopted by local wineries.

The energy evaluation and recommendations for Shadow Springs Vineyard and Windsor Run Cellars was conducted in three phases:

1. Electricity utility bills were analyzed to develop a baseline of current energy use.
2. An energy assessment was performed at both client locations, Shadow Springs Vineyard and Windsor Run Cellars, in pursuit of potential energy efficiency measures for facilities.
3. The two sites were assessed for the potential implementation of an on-site solar photovoltaic system.

This report represents a summary assessment of the sites' current energy use, recommendations for reduced energy consumption, and recommendations for continued program scaling across the North Carolina wine industry.

## Site Description

Both sites are currently owned and operated by Chuck Johnson and are located in Hamptonville, North Carolina. The region within which it resides is considered the Yadkin River Valley, or more largely the Piedmont region. Historical climate data for the area can be found in Table 1. Below, Table 2 outlines basic site characteristics for the facilities of interest for this analysis.

**Shadow Springs Vineyard** is a vineyard and a winery. Its grounds consist of 10.5 acres of grapevines, an unoccupied house with garage, a tasting room, and a storage building (referred to as “wine warehouse”). The tasting room and wine warehouse are the two facilities of interest in this analysis. Constructed in 2008, they are serviced by a shared electric meter. The house formerly acted as a rental property, but will remain unoccupied storage site for the indefinite future. The viticulture for Shadow Springs Vineyard takes place at the winery at Windsor Run Cellars.

**Windsor Run Cellars** is a vineyard, winery, and distillery. The site hosts a water pump, tasting room, and a building containing the winery and distillery (referred to as “winery”). The tasting room was originally built in 2005 with a major renovation in 2011. Constructed in 2006, the winery houses over 34,000 gallons of tank capacity, 700 barrels, and 2 stills.

**Table 1.** Hamptonville, North Carolina Climate Data.



Source: Alexrk2, 2009

Climate zone	4
Average high temp	68.2°F
Average low temp	44.6°F
Average precipitation	44.75"

Source: International Code Council, 2009; Your Weather Service, 2015

Table 2. Site characteristics for the facilities of interest in this energy analysis.

	Year Built	BUILDING		Average Occupied Use (hours/week)	Volume (ft <sup>3</sup> )	Energy Intensity (kWh/sq. ft.)	number of Lightbulbs (#)	Lighting Energy Intensity (W/sq. ft.)	HVAC System	Domestic Hot Water	Types of Appliances Present
		Area (sq. ft.)	Area (sq. ft.)								
<b>Shadow Springs Vineyard Tasting Room</b>	2008	5,752	119,424	8.95	231	0.92	Ductless minisplit heatpump (electric)	Tankless (electric)	Kitchen/tasting room appliances, projector		
<b>Wine Warehouse</b>	2008	4,800	108,000	2	211	0.87	Ductless minisplit heatpump (electric)	n/a	n/a		
<b>Windsor Run Cellars Tasting Room</b>	2005, 2011	16,591	456,120	8.53	109	1.04	Ductless minisplit heatpump (electric)	Free-standing tank (electric)	Kitchen/tasting room appliances, office appliances, filtration system, security system		
<b>Winery</b>	2006	14,700	441,000	12.97	43	1.38	Forced hot air, chiller, & air handlers (electric)	Free-standing tank (electric)	Wine-making equipment, storage tanks, kitchen appliances, laboratory equipment		

## Baseline Energy Use

This preliminary analysis of historical energy use establishes a baseline against which recommendations can be compared and progress measured (ENERGY STAR, 2008). Electricity serves as the primary energy form for both clients. Windsor Run Cellars also uses propane for its distillery process; however, this study focuses on electricity consumption. 18 months of electric data, obtained from utility bills, were analyzed for Shadow Springs Vineyard and Windsor Run Cellars. This evaluation considers both energy consumption and costs.

In 2013, Shadow Springs Vineyard used over 57,000 kilowatt hours of electricity. Approximately, 80% of this consumption is attributed to the tasting room and wine warehouse; the remainder is used in a garage/apartment on the premise.

Windsor Run Cellars consumed nearly 210,000 kWh of electricity in 2013. The predominant driver of this energy demand, the winery used 91% of this electricity. The tasting room comprised an additional 8%. The facility used 3,000 kWh to pump water.

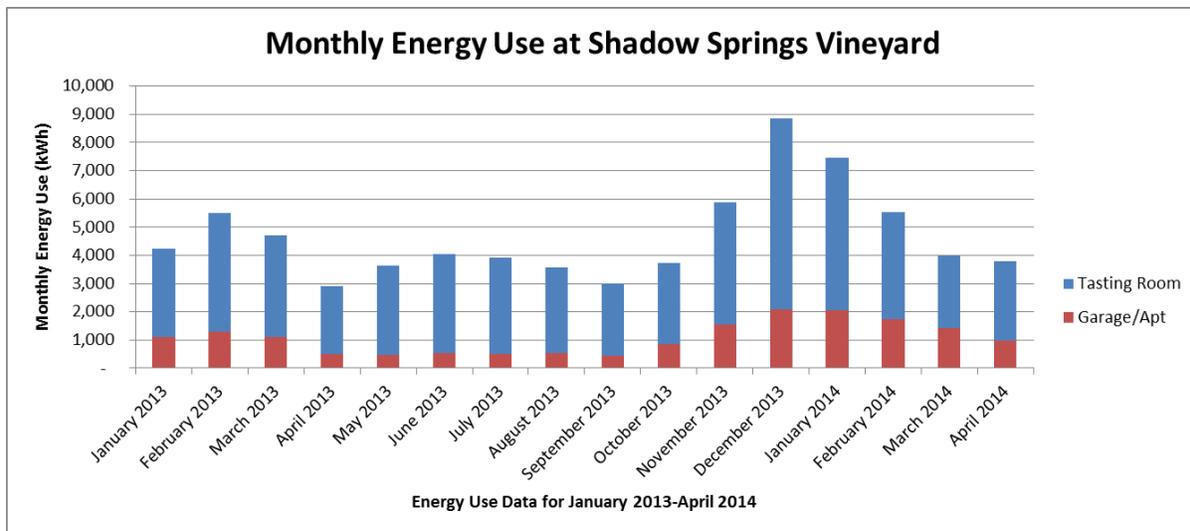


Figure 1. Total monthly energy use at Shadow Springs Vineyard (in kilowatt hours) for January 2013 - April 2014

Electricity use for water pumping demonstrates a seasonal trend in demand. Electricity use increased approximately five-fold during the winter months, with consistently lesser use from May to October. These latter months represent both the vineyard's growing season and winery's peak visitation to tasting rooms, while the former reflects periods of wine-making. This suggests that the viticulture process demands large quantities of water and, thereby, electricity. If water conservation measures can be implemented during the wine-making process, it can reduce both water and electricity use.

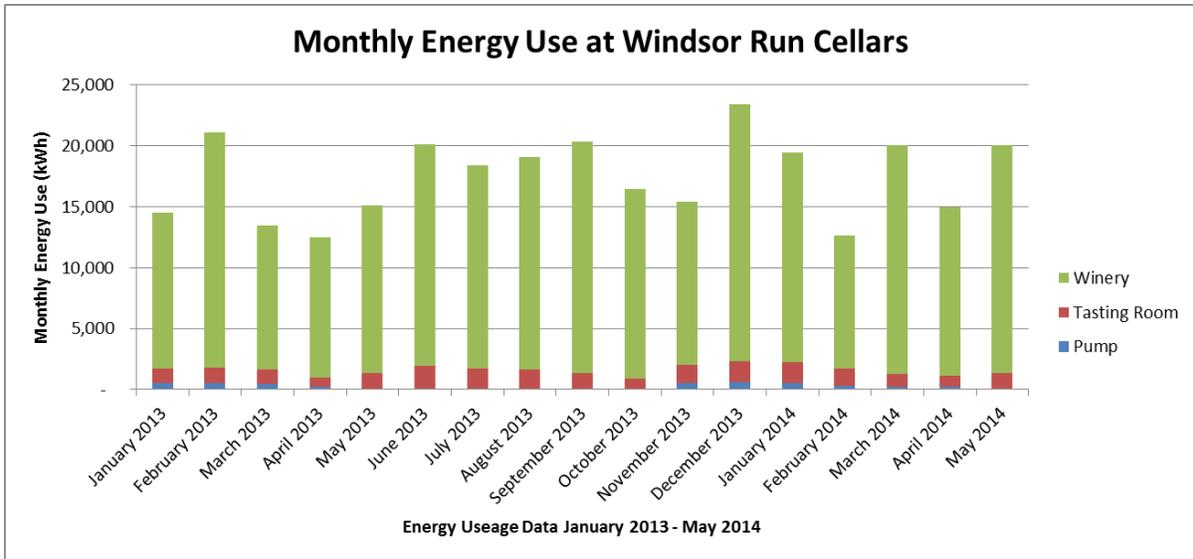


Figure 2. Total monthly energy use at Windsor Run Cellars (in kilowatt hours) for January 2013 - May 2014

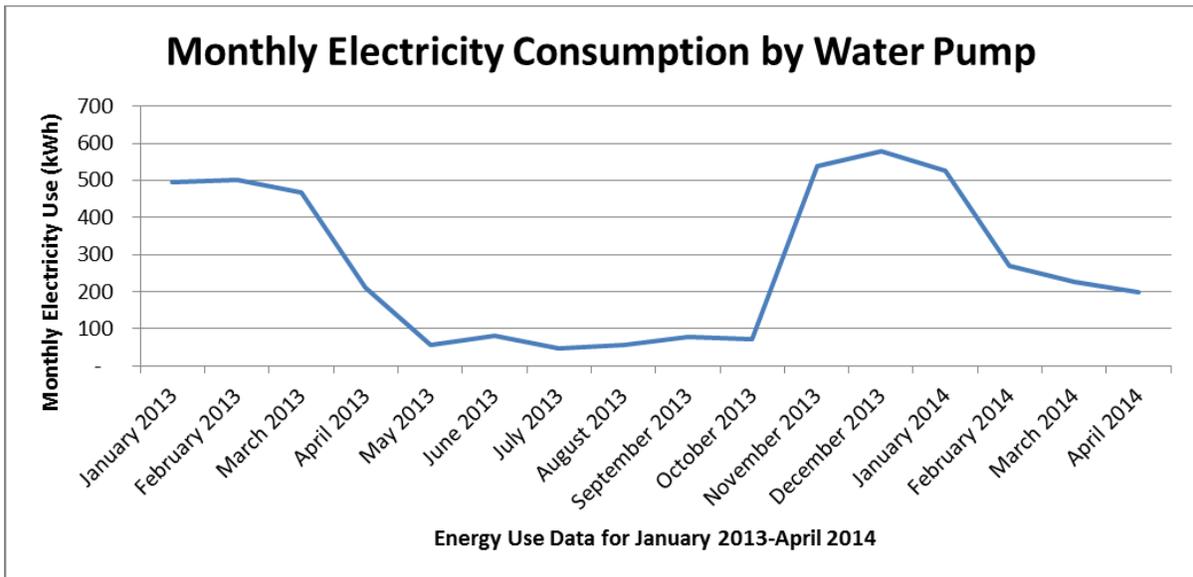


Figure 3. Monthly electricity use in kilowatt hours by the water pump at Windsor Run Cellars

Space conditioning often comprises the majority of a building’s energy use. The tasting rooms at both Shadow Springs Vineyard and Windsor Run Cellars somewhat reflect trends in space conditioning as a result of weather. This can be seen through the graph comparing energy use to Heating Degree Days and Cooling Degree Days. It is important to note that these facilities use electricity for both heating and air conditioning.

This trend is not consistent for the winery located at Windsor Run Cellars; thereby suggesting that the instruments and viticulture process is a greater driver of electricity use than weather. A clear temporal trend cannot be distinguished for the January 2013 to May 2014 time period. Electricity use in the winery steadily increases until September 2013, when it experiences a temporary

decline, followed by monthly fluctuations. The winery's energy use likely reflects the different wine-making processes occurring at the various times of the year. Further investigation into the particular activities and viticulture processes is needed to understand the key drivers of electricity demand at the winery.

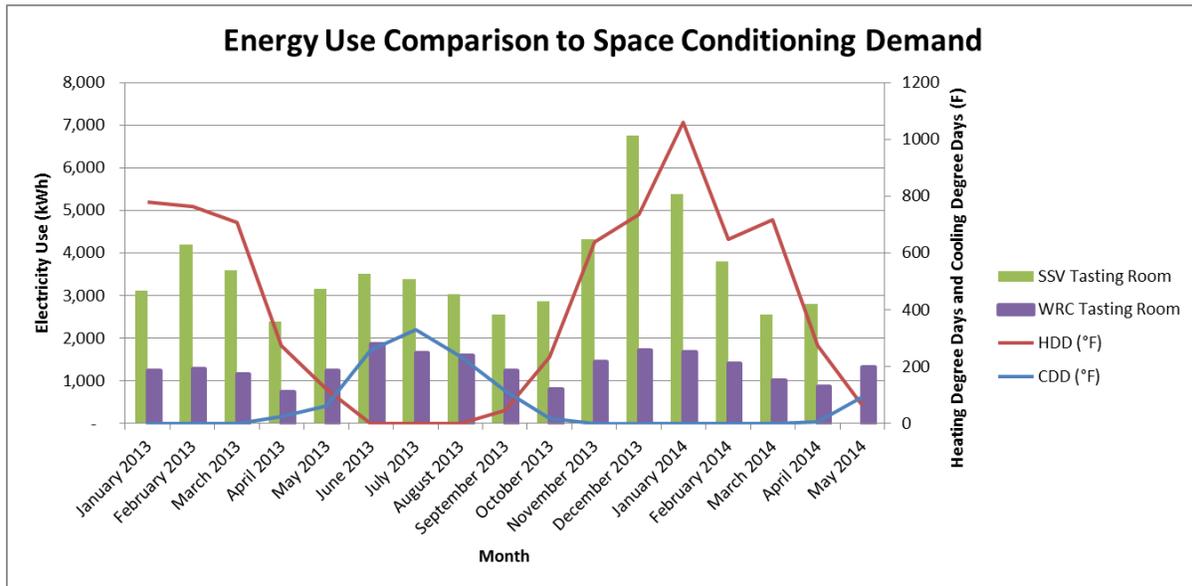


Figure 4. Energy Use Comparison of tasting rooms to Space Conditioning Demand

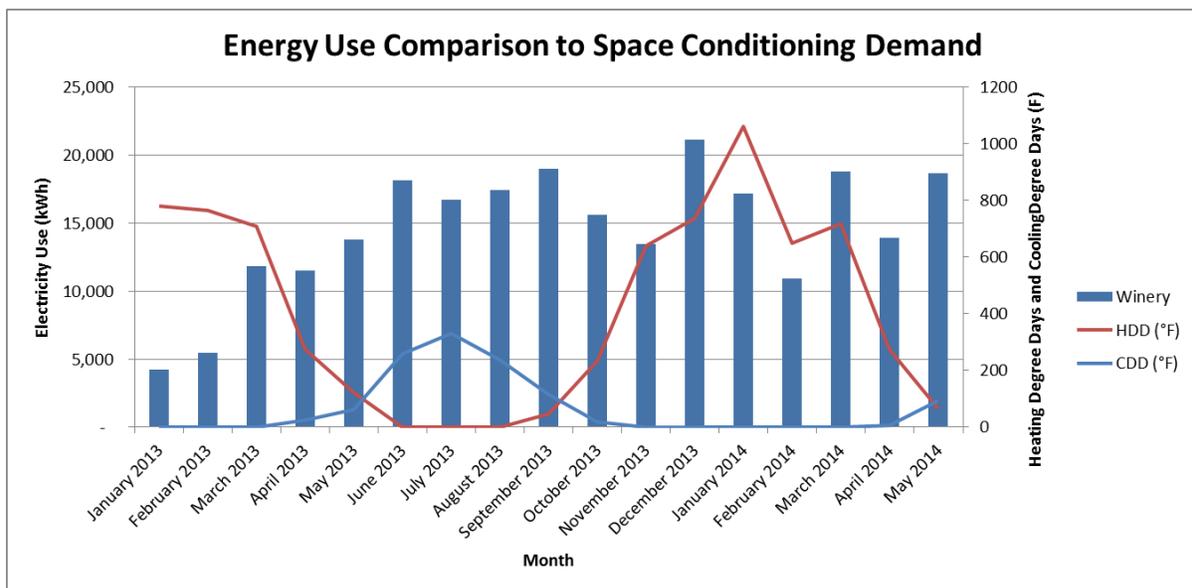


Figure 5. Energy use comparison of winery to space conditioning demand

## Summary Baseline Energy Analysis

**Weather influences** – The tasting rooms at Shadow Springs Vineyard and Windsor Run Cellars are highly influenced by local climate. The greatest monthly energy use corresponds to the times of year with the greatest heating and air conditioning demands, as can be seen in Figure 4 above. While total consumption is different across years, the general trend for months and seasons is consistent between 2013 and 2014 data. Both graphs have very similar shapes; however, Shadow Springs Vineyard experiences peak energy during the winter months and Windsor Run Cellars experiences peak energy during the summer months.

The winery does not follow similar seasonal trends in its energy consumption. This suggests that the wine-making process drives the majority of the site's energy consumption. Reducing the energy use for heating, air conditioning, and lighting will likely reveal the energy demand for wine production throughout the year. Assuming that the wine production process cannot be changed, this would represent the base load energy demand for the winery at its current scale.

Additional data would be helpful in identifying monthly or seasonal peak times of energy consumption. The process of making wine consists of many different stages, as described above. Comparing when these activities occur to energy during the year will likely indicate the most energy-intensive viticulture processes.

**Size influences** – The tasting room at Shadow Springs Vineyard uses more than twice the amount of electricity than the tasting room at Windsor Run Cellars each month. This is unsurprising, as one facility is more than double the size of the other. Using a standardized metric can more accurately compare the two facilities. Figure 6, below, shows a comparison of the Energy Use Intensity (EUI) (the monthly electricity consumption in kilowatt hours per square foot of building space) for the two tasting rooms. This graph illustrates that the two facilities are very similar in their energy consumption. These similarities deviate in the winter and summer months. The SSV tasting room uses comparably more electricity during the winter months, while the WRC tasting room uses more during the summer.

The winery uses significantly more energy than all of the other facilities located at Shadow Springs Vineyard and Windsor Run Cellars. The magnitude of this difference can be seen in Figure 2 (above). Therefore, the winery presents the opportunity for the most significant energy reductions; however, this will be impeded by the base load energy required for wine production. Targeting energy inefficiencies in areas such as lighting and space conditioning has the opportunity for substantial energy reduction, and may yield a greater change in energy costs.

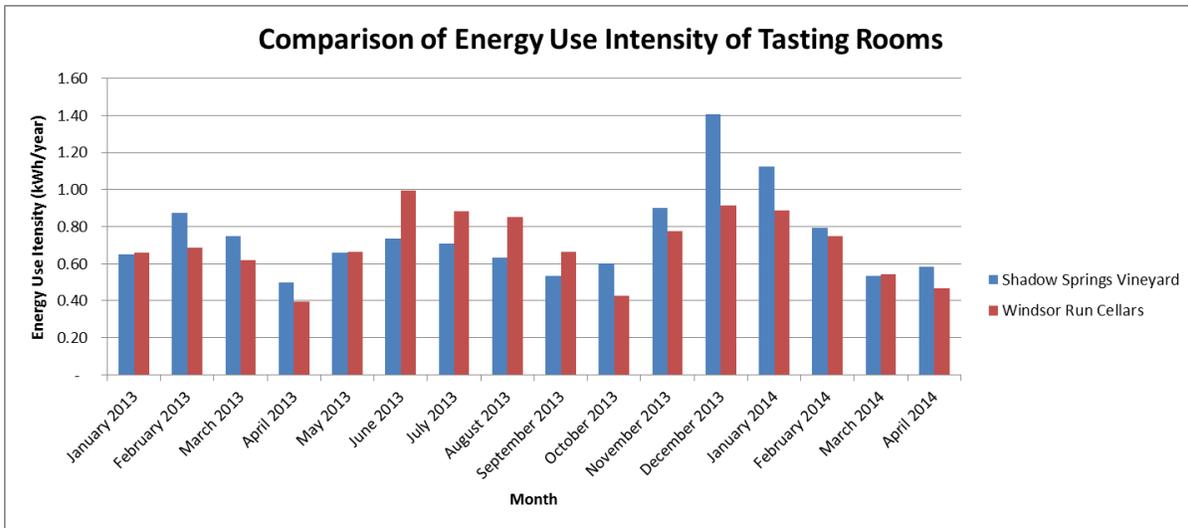


Figure 6. Comparison of monthly electricity use per square foot for the tasting rooms.

Due to the scale of electricity consumption at the winery, it experiences a monthly “demand charge”. This charge is additional to the typical per kilowatt hour energy rate cost. For Energy United, the demand charge is determined by the peak sustained power demand (in kilowatts) for a fifteen minute interval during the billing month. Figure 7 shows that while the demand charges will often correlate with total monthly energy use, there are a number of times when this is not the case. For example, March and April 2013 represent the months with the lowest total monthly electricity use, but have large demand charge costs. Reducing electricity consumption in the winery will lower both electricity rate costs (per kilowatt hour) and demand charges, due to lower peak energy demand.

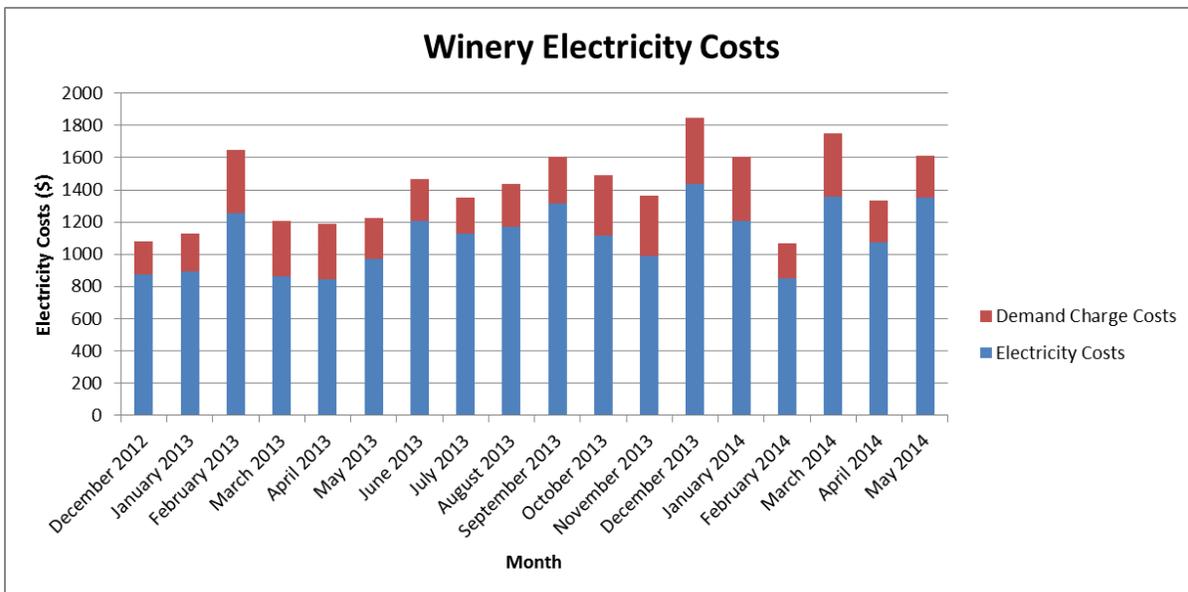


Figure 7. Comparison of unit and demand charge costs for monthly electricity consumption.

**Additional influences** – Beyond climate conditions and size, energy consumption at Shadow Springs Vineyard and Windsor Run Cellars are likely influenced by facility function, use, and energy efficiency. Figure 6 demonstrated that the two tasting rooms differed in peak energy use by season. This could be attributed to any of these three factors. For example, Shadow Springs Vineyard may experience higher visitation rates than Windsor Run Cellars during the winter months, which would result in its comparably higher electricity consumption. Shadow Springs Vineyard hosts weddings during the summer months. During such events, guests are likely to stay in the banquet room for extended periods of time or may take place entirely outside, thereby reducing the air conditioning needs for the entire facility. It is also possible that more guests visit the nearby Windsor Run Cellars tasting room, where an increase number of visitors could increase air condition demand through increase body heat generation or cooled air escaping through the opening of doors. The heating, ventilation, and air conditioning (HVAC) equipment could be different at these two sites, which experience different efficiencies in different outside temperatures.

## Benchmarking Energy Use

Benchmarking is a common and useful tool for estimating the energy efficiency of a facility. It compares the energy use data for similar facilities, typically using Energy Use Intensity. An attempt was made to benchmark the buildings at Shadow Springs Vineyard and Windsor Run Cellars against similar facilities, as defined by ASHRAE’s Preliminary Energy Use Analysis guidelines (Kelsey & Pearson, 2011). Sufficient data was not publicly available to achieve this objective.

The Energy IQ tool, developed by the Lawrence Berkeley National Laboratory (2015), was used to explore benchmarking these facilities. The two tasting rooms were compared to similar retail facilities of less than 10,000 square feet. This yielded only three peer buildings, as can be seen in Figure 8. It is unlikely that these reflect a true comparison of similar building types, particularly as both tasting rooms had annual Energy Use Intensities less than those included: 9.0 kWh per square foot at SSV and 8.5 kWh per square foot at WRC.

Because the tasting rooms share many similarities with residential construction, Figure 9 compares these EUI values to regional and national averages for detached single family homes. EUI values are more similar in this graph, though the tasting rooms are about 3.5-4.0 kWh per square foot less than the EUI for homes located in the South. Though a seemingly closer comparison, this may not be an adequate representation of building efficiency due to the differences in building use between the tasting rooms and homes.

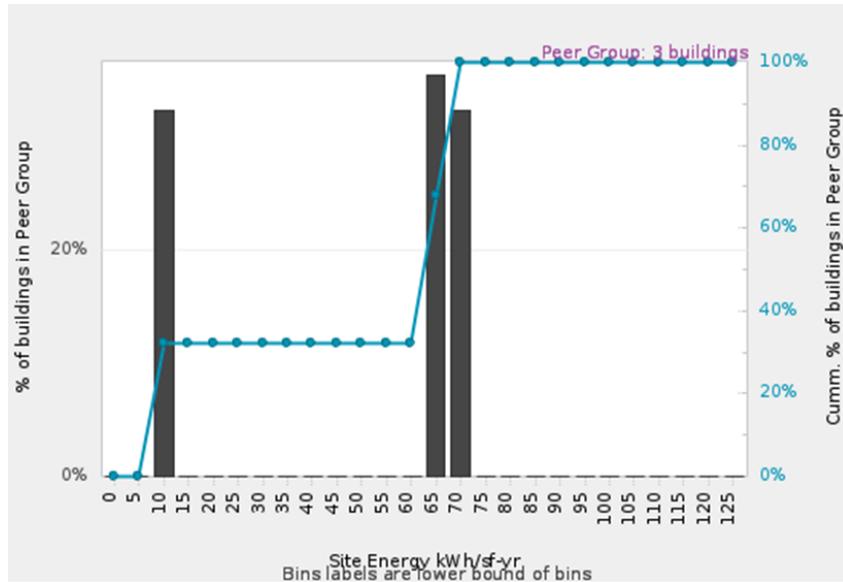


Figure 8. Benchmarking SSV and WRC tasting rooms to peer buildings in the Energy IQ Database. Source: Lawrence Berkeley National Laboratory, 2015

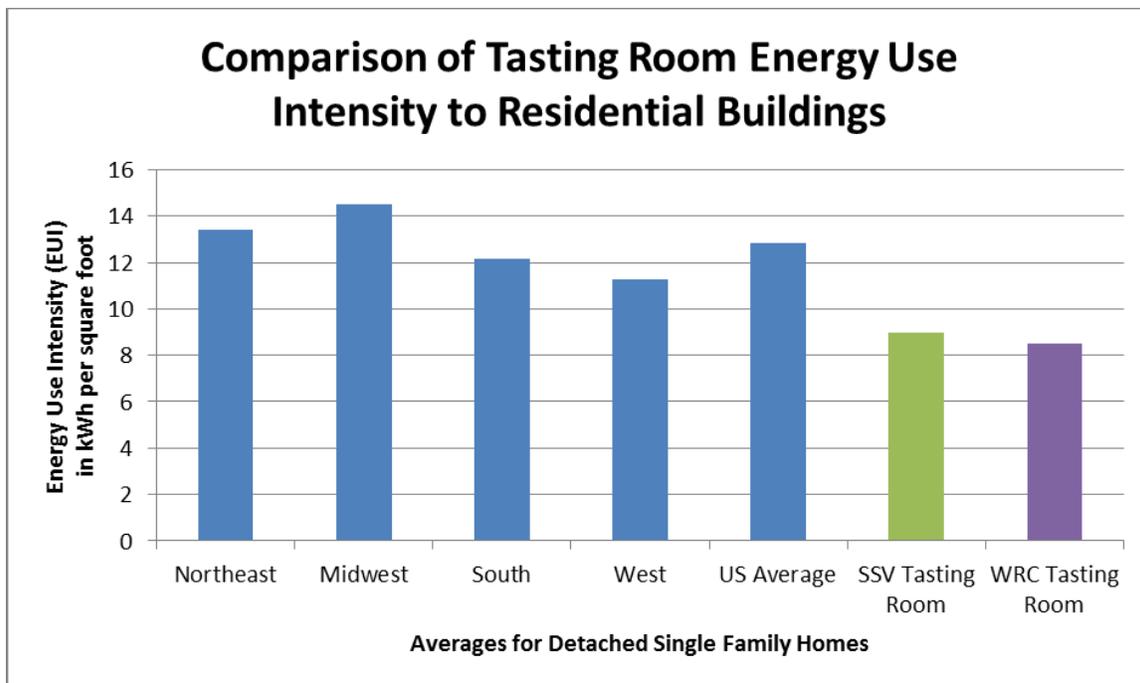


Figure 9. Comparison of the Energy Use Intensity (EUI) of the tasting rooms to regional and national averages for detached single family homes. Source: Ueno, 2010

The Energy IQ tool could not be used to benchmark the winery’s energy consumption, because building characteristics did not include electricity-intensive processes such as that experienced in the wine industry.

The Lawrence Berkeley National Laboratory has developed a “Benchmarking and Energy and Water Savings Tool for the Wine Industry” for the California Energy Commission in an effort to assess and compare energy use at California’s over 1,000 wineries (2005). This publicly available tool requests energy, input, and production data, and uses California-specific climate and typical viticulture systems data to benchmark wineries. Because this tool was developed specifically for California’s wine industry, its use will produce inaccurate results for wineries that are located outside the state and operate at a smaller scale; however, it can be used to provide an introductory energy analysis for wineries.

Shadow Springs Vineyard and Windsor Run Cellars could utilize this tool for preliminary benchmarking. A more accurate benchmarking assessment could be derived from launching a tool for North Carolina’s wineries. This would more accurately account for climate and operating scale. An effective tool would differentiate between tasting room and winery production facilities. As exemplified by SSV and WRC, this can likely be accomplished due to the use of separate utility meters.

## Energy Assessment

An energy assessment was performed on the tasting room and wine warehouse at Shadow Springs Vineyard and tasting room and winery at Windsor Run Cellars to determine potential energy efficiency upgrade opportunities. This was performed at ASHRAE Level 2 audit specifications; thereby, incorporating an analysis of costs and savings for proposed recommendations (Kelsey & Pearson, 2011). Final recommendations are based on savings, investment analysis, and non-energy benefits.

The following section includes key findings from each of the assessed buildings. They are categorized under four subheadings.

**Lighting** was assessed for type of technology used, current lighting use behaviors, and lighting quality. This assessment enables a disaggregation of electricity used for lighting. Typically, 8% to 20% of a winery's electricity use will power lighting (Snell, 2010). Table 3 shows that the buildings at Shadow Springs Vineyard and Windsor Run Cellars lie within this expected range, at 12%, 16%, and 24%. This table also highlights the differences in lighting energy demand across sites. A comprehensive inventory of the lighting can be viewed in Figures 4 and 5.

**Building Envelope** refers to the outer bounds of the building separating its interior from the outside world. Key considerations for this category include insulation, fenestration (door and windows), and the presence of any holes or gaps that allow the exchange of conditioned indoor air and outside air.

**HVAC** includes an assessment of current Heating, Ventilation, and Air Conditioning equipment, as well as the identification of opportunities to reduce space conditioning demand. An inventory of these systems can be found in Table 6.

**Plug Loads** refers to any electric appliance that is plugged into an outlet. Table 7 details a list of appliances found at the Shadow Springs Vineyard and Windsor Run Cellars. This inventory does not include the electric equipment required throughout the winery production process.

This analysis did not target potential energy efficiency improvements to the winery production process. This reasoning was two-fold: firstly, it requires an expertise in wine chemistry, so as to avoid any energy efficiency or technology changes that would result in changes to the quality and taste of the wine; and secondly, many efforts have already been conducted in this area by the facility owner. For example, tank insulation is a widely advocated energy efficiency improvement for wineries; it can reduce energy use associated with refrigeration by about 25% (Snell, 2010). Windsor Run Cellars has already completed this project.

**Table 3.** Lighting analysis at Shadow Springs Vineyard and Windsor Run Cellars

	Energy Intensity (Watts/square foot)	Annual Energy Use (kWh)	Percent of Total Electricity Load (%)
<b>Shadow Springs Vineyard</b>	0.96	6,093	12%
<b>Tasting Room</b>	0.87	6,044	
<b>Wine Warehouse</b>	0.53	48	
<b>Windsor Run Cellars</b>			
<b>Tasting Room</b>	3.83	3,964	16%
<b>Winery</b>	0.68	29,400	25%

**Table 4.** Inventory of current lighting at Shadow Springs Vineyard

Room	Lightbulb type	# bulbs	Watts per bulb	Watts (total)	Kilo- watts	Monthly Use (hrs)	Monthly Use (kWh)	Annual Use (hrs)	Annual Use (kWh)
Wine Warehouse	CFL Recessed Light	20	12	240	0.24	8.0	1.9	96.0	23.0
Tasting Room	CFL Recessed Light	42	12	504	0.50	198.9	100.3	2,586.2	1,303.5
Tasting Room	Halogen Pendant Lighting	6	50	300	0.30	198.9	59.7	2,586.2	775.9
Tasting Room	Halogen Track Lighting	12	50	600	0.60	198.9	119.4	2,586.2	1,551.7
Tasting Room	CFL Sconce Lighting	2	13	26	0.03	198.9	5.2	2,586.2	67.2
Tasting Room	Incandescent Ceiling Fan Lights	9	60	540	0.54	198.9	107.4	2,586.2	1,396.6
Bathrooms	CFL Recessed Light	12	12	144	0.14	198.9	28.6	2,586.2	372.4
Bathrooms	CFL Sconce Lighting	4	13	52	0.05	198.9	10.3	2,586.2	134.5
Hallway	CFL Sconce Lighting	2	13	26	0.03	198.9	5.2	2,586.2	67.2
Closet	Fluorescent Tube	2	32	64	0.06	0.2	0.0	2.0	0.1
Kitchen	Fluorescent Tube	5	32	160	0.16	3.5	0.6	42.0	6.7
Office	Fluorescent Tube	2	32	64	0.06	26.8	1.7	321.9	20.6
Office	CFL Recessed Light	2	12	24	0.02	26.8	0.6	321.9	7.7
Office Bathroom	CFL Recessed Light	2	12	24	0.02	7.5	0.2	90.0	2.2
Office Bathroom	CFL Sconce Lighting	2	13	26	0.03	7.5	0.2	90.0	2.3
Exterior Lights	Incandescent Recessed Light	6	65	390	0.39	30.4	11.9	365.0	142.4
Stairway	Incandescent Sconce Lighting	2	60	120	0.12	15.0	1.8	180.0	21.6
Event Room	CFL Recessed Light	44	12	528	0.53	15.0	7.9	180.0	95.0
Event Room	Halogen Pendant Lighting	4	50	200	0.20	15.0	3.0	180.0	36.0
Catering Garage	Fluorescent Tube	8	32	256	0.26	2.0	0.5	24.0	6.1
Caterer Kitchen	Fluorescent Tube	12	32	384	0.38	2.0	0.8	24.0	9.2
Cellar	Fluorescent Tube	10	32	320	0.32	4.0	1.3	48.0	15.3
Closet (downstairs)	Fluorescent Tube	1	32	32	0.03	0.2	0.0	2.0	0.1
Bathrooms (downstairs)	CFL Recessed Light	12	12	144	0.14	3.8	0.5	45.0	6.5
Bathrooms (downstairs)	CFL Sconce Lighting	4	13	52	0.05	3.8	0.2	45.0	2.3
Event Room (behind bar)	CFL Recessed Light	4	12	48	0.05	2.0	0.1	24.0	1.2
<b>Total</b>		<b>231</b>		<b>5,268</b>	<b>5.27</b>		<b>469.3</b>		<b>6,067.5</b>

**Table 5.** Inventory of current lighting at Windsor Run Cellars

Room	Lightbulb type	# bulbs	Watts per bulb	Watts (total)	Kilowatts	Monthly Use (hrs)	Monthly Use (kWh)	Annual Use (hrs)	Annual Use (kWh)
Wine-making	Metal Halide	25	400	1,0000	10.00	222.0	2,220.0	2,664.0	26,640.0
Distillery space	Metal Halide	9	400	3,600	3.60	86.6	311.8	596.8	2,148.6
Office	Fluorescent Tube	32	32	1,024	1.02	222.0	227.3	596.8	611.1
Tasting area	Incandescent Recessed Lights	16	65	1,040	1.04	198.9	206.9	2,387.3	2,482.8
Bathroom	Incandescent A-lamp	1	60	60	0.06	49.7	3.0	596.8	35.8
Bathroom	Incandescent Globe	4	40	160	0.16	49.7	8.0	596.8	95.5
Front Room	Incandescent Recessed Lights	5	65	325	0.33	198.9	64.7	2,387.3	775.9
Front Room	Track Incandescent Recessed Lights	3	65	195	0.20	198.9	38.8	2,387.3	465.5
Kitchen	Incandescent Recessed Lights	1	65	65	0.07	28.0	1.8	335.5	21.8
Kitchen	Incandescent A-lamp	1	60	60	0.06	1.0	0.1	12.0	0.7
Kitchen	Incandescent A-lamp	2	60	120	0.12	28.0	3.4	335.5	40.3
Office closet	Fluorescent Tube	1	32	32	0.03	0.2	0.0	2.0	0.1
Office closet	Incandescent A-lamp	1	60	60	0.06	1.0	0.1	12.0	0.7
Bathroom (upstairs)	Incandescent Globe	4	60	240	0.24	14.0	3.4	167.8	40.3
Hallway (upstairs)	Incandescent A-lamp	2	60	120	0.12	1.0	0.1	12.0	1.4
Tasting area (upstairs)	Incandescent Recessed Lights	2	65	130	0.13	2.0	0.3	24.0	3.1
<b>Total</b>		<b>109</b>		<b>17,231</b>	<b>17.23</b>		<b>3,089.4</b>		<b>33,363.5</b>

**Table 6.** Inventory of Heating, Ventilation, Air Conditioning (HVAC) and Domestic Hot Water (DHW) systems at Shadow Springs Vineyard and Windsor Run Cellars.

	Appliance Type	Make	Model	Year
<b>Shadow Springs Vineyard</b>				
<b>Tasting Room</b>	Tankless domestic water heater (propane)	Rinnai	R75LS	2007
	Ductless minisplit heat pump (electric)	Fujitsu	ASU24GL	2008
<b>Wine Warehouse</b>	Ductless minisplit heat pump (electric)	Crosley	CRTE183ABM	2008
<b>Windsor Run Cellars</b>				
<b>Tasting Room</b>	Ductless minisplit heat pump (electric)	Daiken	FTXS24HVJU	
<b>Winery</b>	40-gallon hot water tank (electric)	American	E61-40R-045DV	1999
	Forced hot air (electric)	Trane	WCH180B300G	-
	Forced hot air (electric)	Trane	WSC120A3R	-
	Forced hot air (electric)	Trane	TWE018C140	-
	Air Handler	Trane	-	-
	Chiller	G&D	CG7VZ	-

**Table 7.** Inventory of appliances at Shadow Springs Vineyard and Windsor Run Cellars

	<b>Appliance Type</b>	<b>Make</b>	<b>Model</b>	<b>Year</b>
<b>Shadow Springs Vineyard</b>				
<b>Tasting Room</b>	Refrigerator	Frigidaire	FCRS201LFB4	2008
	Ice Machine	Scotsman	SCE170A-14	-
	Dishwasher	Hobart	LXIH 130017	-
	Refrigerator	Crosley	CRTE183ABM	2008
	Stove	Crosley	-	-
	Microwave	Frigidaire	FMV157GB	2007
	Projector	Benq	-	-
<b>Wine Warehouse</b>				
	-	-	--	-
<b>Windsor Run Cellars</b>				
<b>Tasting Room</b>	Refrigerator	Whirlpool	ET8CHMXKQ05	2005
	Stove	Kenmore	233.533.455.91	1991
	Dishwasher	Kenmore	587.K1012400	
	Microwave	Whirlpool	MT6901XW-0800w	1991
	Desktop computer (2)	Dell	-	
	Printer	HP	Office Pro 8600	
	Security system	-	-	
	Filtration system	Express LLC	1665	
<b>Winery</b>				
	Desktop computer	Dell	-	-
	Microwave	GE	JES1456BJ01	-
	Refrigerator	Roper (Whirlpool)	RT14BKXKQ04	2004

## Shadow Springs Vineyard - Tasting room

**LIGHTING** – The tasting room contains 211 light bulbs in 118 different lighting fixtures. The majority of these are compact fluorescent lightbulbs (CFL) or fluorescent tubes. Many of the former are set up with two CFLs placed within one ceiling recessed light can. There are also halogen lightbulbs located in pendant lighting over the tasting room bar and in track lighting fixtures in the tasting and event rooms. These types of lightbulbs and fixtures do not have comparable fluorescent alternatives; however, they can be upgraded to light emitting diode (LED) technologies which use significantly less energy to produce the same amount of light. Such technology is also dimmable, making it an energy efficient alternative capable of the same lighting services as the current halogens.

The event room, stairway, and bathrooms are used sporadically and are susceptible to lights being left on when the areas are not in use. These rooms could benefit from the installation of occupancy sensors to reduce energy waste.

**BUILDING ENVELOPE** – The tasting room was built in 2008, which required adherence to the 2006 North Carolina building code standards. External walls contained fiberglass insulation. While the attic was inaccessible, it is assumed to contain the minimum requirement of R-38 fiberglass insulation (International Code Council, 2006). Such insulation levels are adequate for the climate and while increasing attic insulation could result in energy savings, feasibility of such a project is unknown due to attic inaccessibility.

Air leaks were found at three doors in the tasting room building. This energy waste can be avoided by adding a door sweep to the back door of the sunroom and two doors leading to the downstairs wine cellar. The middle door to the wine cellar could also benefit from adding weather stripping. Because the wine cellar requires more air conditioning than the event room, creating air barriers between the two rooms will reduce energy use. The remaining exterior doors were properly sealed.

The tasting room's sunroom has 195 square feet of directly south-facing windows. The windows are double-paned, however, the direct southern exposure results in a hot, uncomfortable environment during warmer months. This necessitates increased air conditioning requirements. Adding blinds, shades, or a tint to the windows can reduce energy requirements for and increase the comfort level of this room.

**HVAC** – The tasting room is both heated and air conditioned by electric ductless mini-split heat pumps. These are an efficient HVAC option and the most affordable fuel option for the facility (compared with propane). Programmable thermostats are installed in the tasting room, though they are not currently programmed. Making use of these thermostats in combination with the efficient HVAC system can reduce space conditioning.

**PLUG LOAD** – The building houses a number of different appliances, including a stove, microwave, commercial refrigerator, commercial dishwasher, ice machine, and projector. All of these appliances are model year 2007 or newer. Some of these appliances could be upgraded to more efficient alternatives, however, energy reductions would likely be minor. Domestic hot water is produced by an efficient tankless water heater with a set-point temperature of 120°F. Hot water pipes are wrapped in the unconditioned service closet in which the water heater is located.

**SUMMARY** – The tasting room uses mostly energy efficient lighting. These can be upgraded to LEDs and current halogens can also be upgraded to more efficient alternatives. Occupancy sensors could be used to reduce energy waste. HVAC and hot water systems are very efficient. Space conditioning needs can be reduced through low-cost projects, including installing some door sweeps, weather-stripping, and window blinds or shades.

### **Shadow Springs Vineyard - Wine warehouse**

**LIGHTING** – The wine warehouse contains 20 CFLs in 10 recessed light fixtures.

**BUILDING ENVELOPE** – The wine warehouse acts as cool storage for bottled wine. It is built into the side of a hill with one foot thick cement walls. The attic space was inaccessible, but likely contains R-38 fiberglass insulation (International Code Council, 2006). It contains one conventional door and one 90 square foot garage door, insulated with rigid foam insulation.

**HVAC** – An electric ductless mini-split heat pump is used to space condition the wine warehouse.

**PLUG LOAD** – Currently, this building does not contain any appliances.

**SUMMARY** – The wine warehouse was well designed for energy efficiency. Lighting can be upgraded to even more efficient LED technology. Doors should be routinely checked to ensure they maintain a proper barrier between interior and exterior space.

## Windsor Run Cellars - Tasting room

**LIGHTING** – The tasting room at Windsor Run Cellars contains 42 incandescent lightbulbs and 1 fluorescent tube. This presents a substantial opportunity for low-cost energy-saving projects. The incandescent light bulbs consist of R-30 recessed reflector, globe, and the typical a-frame bulb shapes, making them easily replaceable with either CFL or LED alternatives. An open floorplan suggests that this tasting room is less susceptible to lights being left on in unoccupied spaces.

**BUILDING ENVELOPE** – This building was originally built in 2005 with a large-scale renovation completed in 2011. It has fiberglass insulation in its walls and sloped ceilings. Doors did not show signs of air leakage and windows are all double-paned.

**HVAC** – An electric ductless mini-split heat pump provides both heat and air conditioning.

**PLUG LOAD** – The tasting room contains a visitor space, office, and kitchen. As such, a variety of appliances are present in this building, including a stove, microwave, refrigerator, dishwasher, miniature refrigerator, security system, printer, and desktop computers. These appliances spanned several model years, ranging from 1991 to 2005. Replacing the older appliances with newer more efficient alternatives would reduce energy use. Of the oldest appliances (i.e. stove, microwave, dishwasher), the dishwasher should be the priority replacement, because it would reduce both electricity and water consumption.

**SUMMARY** – The primary opportunity for reducing energy use at Windsor Run Cellar’s tasting room is replacing the current lighting with more efficient alternatives. Older kitchen appliances can be replaced with newer, more efficient technologies.

## Windsor Run Cellars - Winery

**LIGHTING** – The winery uses 34 metal halide lamps to light the winery and distillery areas, and 32 fluorescent tubes to light the bathroom, office, and laboratory spaces. 3 of the metal halide lamps were burnt out and a number were dirty, reducing their lighting output. The 400-watt metal halide lamps can be replaced with LEDs, for significant energy savings. The fluorescent tubes can also be replaced with LED alternatives for smaller energy reductions.

**BUILDING ENVELOPE** – Built in 2006, the winery has enclosed metal walls and ceilings, containing R-18 fiberglass insulation. This insulation could be markedly improved and could result in substantial energy savings, due to the high space conditioning requirements of the winery; however, such a

project would likely be very capital intensive and could potentially disrupt the wine-making process if performed from the building's interior.

The winery contains several air leaks. A 168 square foot garage door is backed with rigid foam board insulation; however, it has been damaged and displays noticeable gaps where the door meets the building walls. In the distillery area, there is an open pipe leading through a wall and an uncovered exhaust fan. The front door also exhibits gaps. These gaps in the building envelope can be sealed with low-cost spray foam insulation, door sweeps, and weather-stripping. A more capital-intensive project, replacement of the garage door would provide the most effective way to address the air leaks surrounding it, and would allow for use of a new functioning door.

**HVAC** – The winery makes use of an electric forced hot air and air conditioning unit for its space conditioning needs. Air handlers distribute air from the peak of a 30-foot high ceiling. The building experiences significant air stratification. Employees noticed a discernable temperature difference between the ground and the 10-foot high catwalk. When the energy assessment was conducted in July of 2014, temperature differential were detected: 58°F on the floor, 64°F on the wall at a point 16 feet above the floor, and 70°F on the ceiling about 26 feet above the floor. Installing ceiling fans in the winery could reduce the amount of energy required for space conditioning and improve the comfort level of the employees working within the facility.

**PLUG LOAD** – A substantial portion of the winery's energy consumption is derived from its plug loads, attributable to the equipment necessary for wine production. A number of technologies have been employed to reduce energy consumption. For example, jacketed stainless steel tanks with glycol-chilling systems to reduce space conditioning needs and variable-capacity tanks reduce the need for pumping between different sized tanks.

In addition to viticulture equipment, appliances included a desktop computer, microwave, and refrigerator, the oldest of which has a model year of 2004. The winery also contains an electric hot water tank with a 1999 model year. A new hot water tank would be significantly more energy efficient.

**SUMMARY** –Wine-making is an inherently energy-intensive process. Fortunately, the winery already utilizes a number of energy efficient equipment. The greatest opportunities for energy reduction are by retrofitting the metal halide lights with LEDs and installing ceiling fans. The lighting upgrade will reduce lighting electricity demand, improve lighting quality (as the current bulbs are dirty and dim),

and will reduce space condition needs, as they do not generate as much heat as the metal halide lamps. Ceiling fans will reduce space conditioning needs and improve the comfort level for winery employees. The current water heater should be replaced. Because it is more than 15 years old, it is very inefficient compared to modern technologies. Water heaters typically have a life expectancy of 10 years; therefore, it is likely to breakdown in the near future.

## Energy Efficiency Recommendations

### No-cost

PROGRAM THERMOSTATS – Scheduling thermostats to change to a desired temperature when a room is in use and to automatically change when not in use is an easy, no-cost way to reduce the energy required for space conditioning. Temperature settings can fluctuate 10°F between “on” and “off” periods to achieve energy savings. The U.S. Department of Energy estimates that this can reduce space heating and cooling energy needs by about 10% (Matulka, 2014). The tasting room at Shadow Springs Vineyard could benefit from this solution.

CONDUCT ROUTINE MAINTENANCE CHECKS – Checking the condition and cleanliness of appliances, door sweeps, and weather stripping can reduce unnecessary energy waste. See *Appendix C* for an Energy Efficiency Maintenance Checklist of things to pay attention to. This will apply to all facilities at Shadow Springs Vineyard and Windsor Run Cellars.

### Low-cost

REPLACE HALOGEN LIGHTBULBS WITH LEDs – Despite their small size, halogen lightbulbs can consume a deceptively large amount of energy. They will also generate heat, which can reduce air conditioning requirements. The halogen lightbulbs in the Shadow Springs Vineyard tasting room can be replaced with more energy efficient LEDs. This project would cost approximately \$85 (after initial cost and a rebate from Energy United) and save about 2,052 kWh and \$144 per year. This results in a simple payback in about 7 months.

REPLACE ALL LIGHTBULBS WITH LEDs – LEDs use even less energy than CFLs to produce the same amount of light. They also have a longer life expectancy (50,000 hours as compared to 10,000 hours), thus reducing replacement costs and the time needed to install the lighting replacement. Replacing all of the lightbulbs in the Shadow Springs Vineyard tasting room and wine warehouse with LEDs would cost approximately \$843, after a \$2,500 rebate from Energy United. This project would save about 4,735 kWh and \$426 annually, and pay for itself in 2 years.

REPLACE INCANDESCENT LIGHTBULBS – The tasting room at Windsor Run Cellars uses almost exclusively incandescent bulbs for its lighting needs. These could easily be replaced with either CFL or LED alternatives. CFLs would require almost no initial investment after a \$399 rebate from Energy United and save an estimated 3,096 kWh and \$340 per year in electricity costs. LEDs would cost about \$248

after a \$442 rebate, saving an estimated 3,184 kWh and \$350 per year. This project has a payback of less than 9 months.

SEAL AIR LEAKS – Sealing air leaks can reduce energy waste associated with the loss of conditioned air. This can be achieved through the installation of door sweeps and weather stripping, using caulk or spray foam insulation to close holes or larger gaps, or covering exposures, such as exhaust fans. Such measures can save up to 15 percent of the energy required for space conditioning or refrigeration (Snell, 2010). There are opportunities to seal air leaks in the Shadow Springs Vineyard tasting room and winery. Detailed locations for these improvements can be found under the Building Envelope section for each facility.

INSTALL OCCUPANCY SENSORS – Rooms that are used infrequently by different individuals often experience energy waste when lights are left on in unoccupied spaces. The downstairs event room, stairway, and bathrooms in the Shadow Springs Vineyard tasting room, as well as the bathrooms in the Windsor Run Cellars tasting room, are examples of locations that could benefit from occupancy sensors that automatically extinguish lights.

Estimates suggest occupancy sensors can reduce lighting energy use by 30% to 75% (Snell, 2010); however, a conservative analysis for these facilities suggests an annual savings of only 324 kWh and about \$29. This would result in a simple payback period of 34 years. The underlying assumption of this assessment is that occupancy sensors would reduce lighting use by about half in these rooms. If lights are frequently left on when spaces are not in use, actual savings would be greater and payback period shorter. Thus, occupancy sensors should be pursued in specific problem areas, or if upfront cost for the sensors declines or financial incentives increase; otherwise, enhanced monitoring and conservation efforts may be more financially viable.

INSTALL WINDOW SHADES OR BLINDS – The sunroom at SSV tasting room experiences uncomfortable temperatures and an increased air conditioning need due to its large south-facing windows. Installing window shades, blinds, or tint can reduce energy bills and improve comfort. Because they reduce solar heat gain by about 45%, this energy project could save nearly 800 kWh and \$71 in cooling costs between April and September. The payback period for this project is about 20 years for window shades costing around \$1,400. Reduced upfront costs could greatly improve the economics of this investment. This project has the substantial co-benefit of being able to greatly improve the comfort level of patrons using this sunroom during the summer day.

## Medium-cost

REPLACE DISHWASHER – Replacing the dishwasher at the Windsor Run Cellars tasting room can reduce both energy and water use. A new Energy Star-rated dishwasher can save about \$25 per year in electricity costs, and will save additionally in reduced water use, when replacing a model older than 1994 (Natural Resources Defense Council, 2010). Assuming a replacement with a typical residential-grade dishwasher without any financial incentives, this would result in a simple payback period of about 52 years. Thus, this is a lower priority of energy efficiency projects and would best be pursued for improvements in functionality or aesthetics.

REPLACE WATER HEATER – The electric hot water tank in the winery is more than 15 years old and far less energy efficient than modern technologies. Proactive replacement could result in energy savings. Upgrading from a tank to tankless hot water system could save approximately 1,000 kWh or \$75 per year, yielding a payback period of about 29 years. This assumes typical levels of water consumption for heat. The wine-making process uses a significant amount of water; if a large portion of this water is heated by this tank, energy and cost savings will increase substantially. Due to the age of the tank, an energy efficient replacement would be wise to avoid inconvenience or water and property damage due to tank failure.

## Capital Intensive

REPLACE WINERY LIGHTING – LEDs are an excellent replacement for the metal halide lamps currently in use in the winery. They use less than half the energy required to produce the same amount of light. Open fixtures will prevent the dimness resulting from dirty bulbs, and their longer lifespan will reduce the frequency of replacement. After a \$1,600 rebate, the upfront cost for this project would be approximately \$10,000. It would save approximately 17,273 kWh and \$1,209 per year, giving it a simple payback of about 8 years.

INSTALL CEILING FANS – The installation of ceiling fans in the winery would destratify the air, reduce energy requirements for space conditioning, and make the winery a more comfortable working environment. This would save approximately 50,000 kWh and \$3,500 each year, resulting in a payback period of just over 5 years. The winery is eligible for a grant sponsored by the U.S. Department of Agriculture for energy efficiency projects that would drop the simple payback period to just 4 years (U.S. Department of Agriculture, 2015).

IMPROVE INSULATION – Built in 2006, the winery has enclosed metal walls and ceilings, containing R-18 fiberglass insulation. This insulation could be markedly improved and could result in substantial energy savings, due to the high space conditioning requirements of the winery; however, such a project would likely be very capital intensive and could potentially disrupt the wine-making process if performed from the building’s interior. Calculating estimated costs and savings was beyond the scope of this project, and can be revisited after other energy efficiency measures that will reduce energy consumption for space conditioning, such as installing ceiling fans.

REPLACE GARAGE DOOR – A more capital-intensive project, replacement of the garage door would represent the most effective way to address the air leaks surrounding it, and would allow for use of a new functioning door. As mentioned above, sealing up air leaks can reduce the energy use for space conditioning as much as 15% (Snell, 2010).

## Solar Site Assessment

The final stage for the evaluation of energy saving opportunities for Shadow Springs Vineyards and Windsor Run Cellars is a solar photovoltaic (PV) site assessment. Historical utility data was analyzed to determine yearly, monthly, and daily electric demand. This information predicts solar generation needs. Opportunities for both rooftop and ground-mounted solar PV applications were considered in an effort to meet this generation need. Four different scenarios were investigated:

Scenario 1: 100% on-site generation

Scenario 2: 50% on-site generation

Scenario 3: 25% on-site generation

Scenario 4: Entire winery roof covered in solar panels

Initial estimation was performed using PVWatts and System Advisor Model, the National Renewable Energy Laboratory's modeling tools for estimating solar photovoltaic generation and projected finances (2014a, 2014c).

A more elaborate model was then developed in Microsoft Excel. This model establishes a baseline condition for estimated expected system electricity generation and costs. Using PVWatts insolation data, Scenarios 1, 2, and 3 included three separate systems analyses: two for a traditional fixed, stationary PV system that is either east-facing or west-facing, and another for a south-facing ground-mounted tracking PV system that follows the sun's direction, so as to maximize daily power generation. Potential investment strategies to fund proposed recommendations are also analyzed for associated costs and benefits. Recommendations were based on this analysis of potential energy savings and economic viability.

### Scenario 1: 100% on-site generation

Table 8 displays the solar PV system size and electricity generation required to meet 100% of Shadow Springs Vineyard and Windsor Run Cellars' electricity demand. These results show that west-facing panels generate slightly more electricity than east-facing panels at the latitude of Hamptonville, North Carolina. South-facing tracking panels are more efficient, generating more energy each day and require a smaller system size and space requirements. This system would need to be 137 KW system, as compared with a 193 KW (West-facing) or 195 KW (East-facing) system. The reduced size corresponds to a lower investment cost and improved payback period.

## Scenario 2: 50% on-site generation

The size requirements of a solar PV system scale in proportion to the electricity generation demand, as can be seen in Table 9. In this scenario, ground-mounted tracking panels would require a 68 KW system consisting of 340 panels, roughly 70% that of the 97 KW west-facing stationary PV systems that would use 482 panels.

## Scenario 3: 25% on-site generation

Scenario 3 demonstrates that system size requirements continue to scale proportionally with decreased electricity generation needs, as can be seen in Table 10. To achieve 25% on-site generation, stationary east-facing or west-facing systems would require the same system size, 48 KW and 242 panels, unlike Scenarios 1 and 2, which had slightly different requirements for these two systems. South-facing tracking panels continue to be more efficient, and require a system size of 34 KW and 169 panels.

## Scenario 4: Entire winery roof covered in solar panels

The roof of the winery at Windsor Run Cellars is approximately 200 feet long and has a nearly direct east-facing and west-facing roof orientation. Because of these characteristics, the winery roof may be a good option for a roof-mounted solar PV system. The roofs of the tasting rooms at both sites are not conducive to accommodating roof-top solar panels, because of their orientation, small size, and obstructions on the roof. This scenario investigates the maximum system size the winery roof could accommodate.

Table 11 displays how this analysis was addressed by evaluating each roof separately due to the different sun exposure. Solar panels were assumed to be of standard size (3' x 5') and efficiency. The roof was assumed to accommodate 90% of the total surface area of the roof to account for any roof obstructions, lay-out requirements, space between panels, and technical difficulties that would prohibit using the entirety of the roof.

The winery roof could accommodate an 81 KW system on each roof, or 161 KW in total. This sized solar PV system could produce enough energy to entirely meet the energy demand of the winery (115%).

**Table 9. Solar Site Assessment for Scenario 1**

	Annual energy demand (kWh)	East-facing panels			West-facing panels			South-facing panels					
		Area needed (m2)	# panels	Total Watts	System Size (KW)	Area needed (m2)	# panels	Total Watts	System Size (KW)	Area needed (m2)	# panels	Total Watts	System Size (KW)
Shadow Springs Vinyard	53,976	324	199	39,800	40	322	197	39,400	39	227	139	27,800	28
Windsor Run Cellars	209,902	1,261	775	155,000	155	1,251	769	153,800	154	884	543	108,600	109
<b>Total</b>	<b>263,878</b>	<b>1,585</b>	<b>974</b>	<b>194,800</b>	<b>195</b>	<b>1,573</b>	<b>966</b>	<b>193,200</b>	<b>193</b>	<b>1,111</b>	<b>683</b>	<b>136,600</b>	<b>137</b>

**Table 8. Solar Site Assessment for Scenario 2**

	50% energy demand (kWh)	East-facing panels			West-facing panels			South-facing panels					
		Area needed (m2)	# panels	Total Watts	System Size (KW)	Area needed (m2)	# panels	Total Watts	System Size (KW)	Area needed (m2)	# panels	Total Watts	System Size (KW)
Shadow Springs Vinyard	26,988	162	99	19,800	20	161	98	19,600	20	114	69	13,800	14
Windsor Run Cellars	104,951	630	387	77,400	77	625	384	76,800	77	442	271	54,200	54
<b>Total</b>	<b>131,939</b>	<b>793</b>	<b>486</b>	<b>97,200</b>	<b>97</b>	<b>786</b>	<b>482</b>	<b>96,400</b>	<b>96</b>	<b>555</b>	<b>340</b>	<b>68,000</b>	<b>68</b>

**Table 11. Solar Site Assessment for Scenario 3**

	25% energy demand (kW/h)	East-facing panels			West-facing panels			South-facing panels		
		Area needed (m2)	# panels	Total Watts	Area needed (m2)	# panels	Total Watts	Area needed (m2)	# panels	Total Watts
Shadow Springs Vineyard	13,494	81	49	9,800	10	10	10	57	34	6,800
Windsor Run Cellars	52,476	315	193	38,600	39	38	221	135	27,000	27
<b>Total</b>	65,970	396	242	48,400	48	48	278	169	33,800	34

**Table 10. Solar Site Assessment for Scenario 4**

	Area (ft2)	Area (m2)	# panels	# panels - 10%	Energy produced (kWh)	% Energy Demand	Total Watts	System Size (KW)
East-facing roof	7,840	728.6	448	403	109,103.8	57.24%	80,600	81
West-facing roof	7,840	728.6	448	403	109,982.3	57.70%	80,600	81
<b>Total</b>	15,680	1,457.2	1,942	1,747	219,086.1	114.94%	161,200	161

## Financial Analysis

After determining the physical requirements for the solar PV systems, these four scenarios were assessed for their economic viability. The cost for the systems was assumed to be about \$3.30 per watt (Johnson, 2015). They factored in the projected electricity use and cost savings and incorporated the following financial incentives:

**Federal Tax Incentives** – The Federal Government offers a 30% tax credit for businesses that install solar photovoltaic systems under the Business Energy Investment Tax Credit (ITC)(Database of State Incentives for Renewables and Efficiency (DSIRE), 2013a). The client is guaranteed access to this incentive.

**State Tax Incentives** – The State of North Carolina offers a 35% tax credit for businesses that install a solar PV system under the Renewable Energy Tax Credit (Corporate) (Database of State Incentives for Renewables and Efficiency (DSIRE), 2013c). The client is guaranteed access to this incentive.

**Rural Energy Grant** – The United States Department of Agriculture offers a program entitled: Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Loans & Grants (2015). Shadow Springs Vineyard and Windsor Run Cellars satisfy eligibility requirements since: 1) they are small businesses; 2) they operate in a rural area; and 3) they derive at least half of their income from agricultural activities. With an approved application, they would have access to a grant for up to 25% of project costs and \$500,000, and a loan for up to 75% of project costs and \$25 million to support the funding of an onsite solar PV system.

Table 12 below details the investment, energy and monetary savings, and two metrics for financial analysis (i.e. simple payback period and return on investment (ROI)) for each scenario mentioned above. Because the wineries are guaranteed access to the federal and state tax incentives, they were included in each analysis. Because the Rural Energy Grant requires approval before having access to the 25% grant, it was considered in a separate scenario for comparison.

Each scenario has a pretty substantial initial investment cost, ranging from about \$11,000 to \$225,000. These scenarios have similar payback periods and ROIs, due to the increased electricity cost savings resulting from larger system sizes. These potential systems could save approximately 4,600 kWh to 18,500 kWh, which amounts to nearly \$66,000 to \$264,000 in annual electricity cost savings.

Simple payback period (SPP) is a metric that is useful in comparing the economic feasibility of these projects and estimate the value of the investment for each scenario. This metric demonstrates

**Table 12. Financial analysis for solar site assessments at Shadow Springs Vineyard and Windsor Run Cellars**

	Initial Investment	Savings (\$/year)	Savings (kWh/yr)	Simple Payback Period	Return On Investment (ROI)	
Scenario 1: 100% on-site generation	Stationary Panels	\$ 224,994.00	\$ 18,471.46	263,878	12.18	8.2%
	Stationary Panels with Grant	\$ 64,284.00	\$ 18,471.46	263,878	3.48	28.7%
	Tracking Panels	\$ 157,773.00	\$ 18,471.46	263,878	8.54	11.7%
	Tracking Panels with Grant	\$ 45,078.00	\$ 18,471.46	263,878	2.44	41.0%
Scenario 2: 50% on-site generation	Stationary Panels	\$ 112,266.00	\$ 9,235.73	131,939	12.16	8.2%
	Stationary Panels with Grant	\$ 32,076.00	\$ 9,235.73	131,939	3.47	28.8%
	Tracking Panels	\$ 78,540.00	\$ 9,235.73	131,939	8.50	11.8%
	Tracking Panels with Grant	\$ 22,440.00	\$ 9,235.73	131,939	2.43	41.2%
Scenario 3: 25% on-site generation	Stationary Panels	\$ 55,902.00	\$ 4,617.87	65,970	12.11	8.3%
	Stationary Panels with Grant	\$ 15,972.00	\$ 4,617.87	65,970	3.46	28.9%
	Tracking Panels	\$ 39,039.00	\$ 4,617.87	65,970	8.45	11.8%
	Tracking Panels with Grant	\$ 11,154.00	\$ 4,617.87	65,970	2.42	41.4%
Scenario 4: winery roof	East Roof	\$ 93,093.00	\$ 7,637.26	109,103.8	12.19	8.2%
	West Roof	\$ 93,093.00	\$ 7,698.76	109,982.3	12.09	8.3%
	Entire Roof	\$ 186,186.00	\$ 15,336.03	219,086.1	12.14	8.2%
	East Roof with Grant	\$ 26,598.00	\$ 7,637.26	109,103.8	3.48	28.7%
West Roof with Grant	West Roof with Grant	\$ 26,598.00	\$ 7,698.76	109,982.3	3.45	28.9%
	Entire Roof with Grant	\$ 53,196.00	\$ 15,336.03	219,086.1	3.47	28.8%

that the Rural Energy Grant significantly improves the economic attractiveness of installing an onsite solar electricity generation system, as can be seen in Figure 9. Without this incentive, fixed PV systems have a Simple Payback Period of about 12 years without use of this grant, and only 3.5 years with the grant. Similarly, tracking PV systems improved SPP from about 8.5 years without the grant to 2.5 with it.

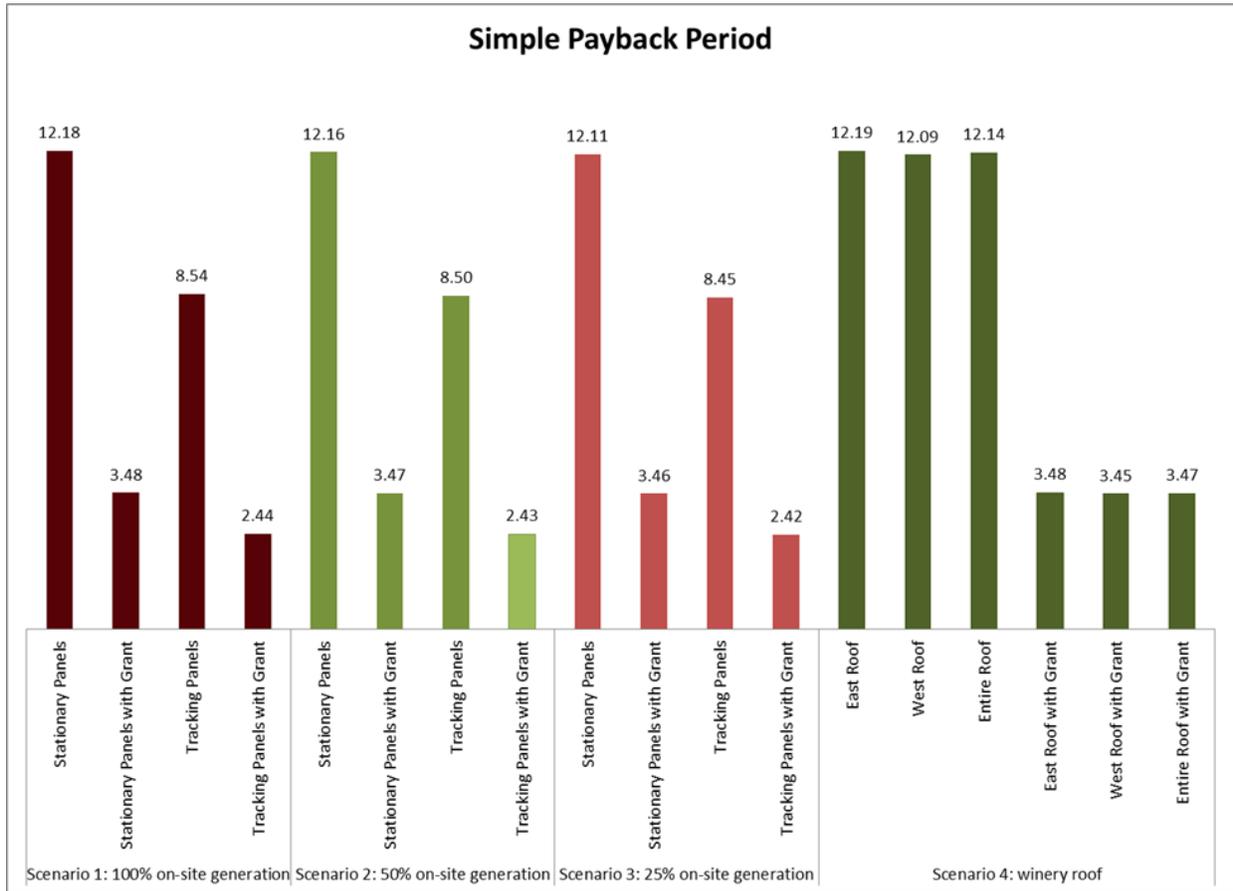


Figure 10. Comparison of the simple payback period for each solar scenario assessed

## Conclusion

This energy analysis of Shadow Springs Vineyard and Windsor Run Cellars produced two distinct outcomes: 1) a site specific energy analysis with recommendations for reducing energy consumption through energy efficiency projects and on-site solar photovoltaic electricity generation; and 2) findings that could be applied to other wineries across the state.

The energy analysis provides detailed information about historical energy use, site descriptions about current energy consumption, and a list of potential energy efficiency projects ranging from no-cost to capital-intensive investments. Prioritized recommendations for the two sites are included below. This prioritization was determined based on a balance of energy savings, project economics (investment and payback periods), and non-energy benefits. Table 13 summarizes the economics of the energy efficiency projects. Figure 11 displays a comparison of payback periods.

By assessing two sites, with different buildings types, sizes, and functions, some trends arose that can support the scaling up of energy saving projects across the North Carolina wine industry. These include some best practices, trends, and introductory information that can be used to aid other wineries pursue energy efficiency.

**Table 13. Summary analysis of energy efficiency project recommendations**

Projects	Initial Investment	Savings (\$/year)	Savings (kWh/yr)	Simple Payback Period (years)
LED retrofit - Winery	\$14,688	\$1,209	17,273	12.1
CFL retrofit - WRC tasting room	\$(190)	\$341	3,096	0.0
LED retrofit - WRC tasting room	\$248	\$350	3,184	0.7
CFL retrofit - SSV tasting room	\$(107)	\$110	1,223	0.0
LED retrofit - SSV tasting room	\$843	\$426	4,735	2.0
Lighting occupancy sensors	\$990	\$29	324	34.0
Add blinds to SSV sunroom	\$1,440	\$72	797	20.1
Ceiling fans - Winery (heating only)	\$18,450	\$1,303	18,612	14.2
Ceiling fans - Winery (total savings)	\$18,450	\$3,473	49,612	5.3
Ceiling fans - Winery (with 25% grant)	\$13,838	\$3,473	49,612	4.0
Replace dishwasher - WRC tasting room	\$1,300	\$25	227	52.0
Replace water heater - Winery	\$2,200	\$75	1,071	29.3
<b>Total for all projects</b>	<b>\$40,158</b>	<b>\$5,659</b>	<b>77,223</b>	<b>7.1</b>

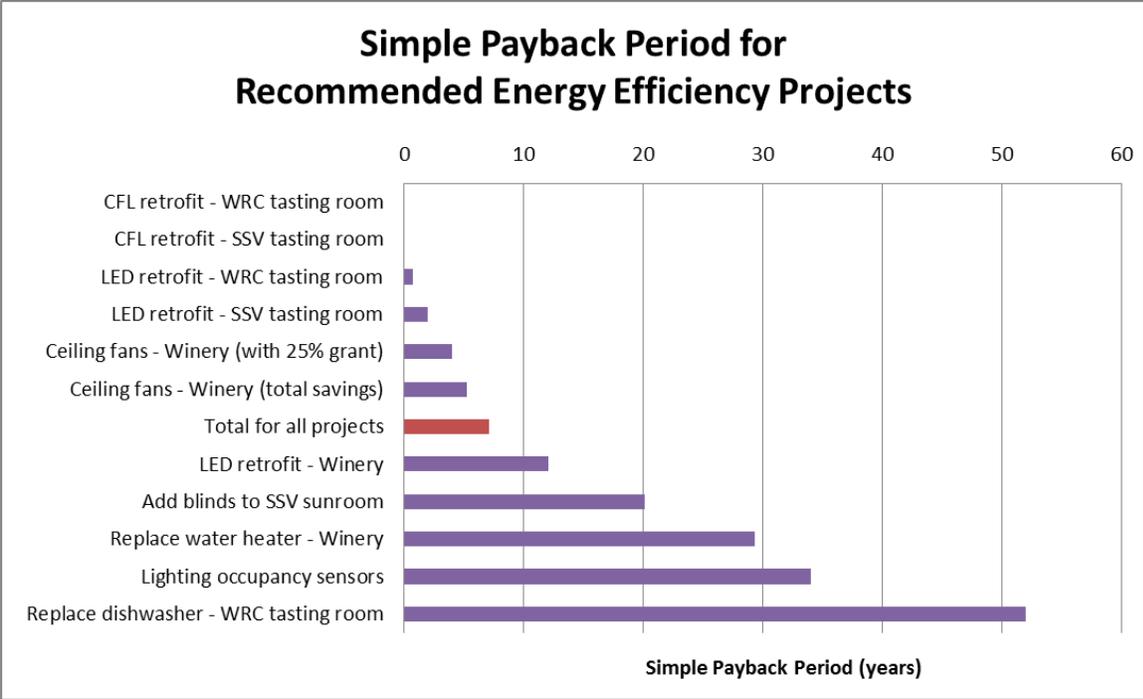


Figure 11. Comparison of payback periods for recommended energy efficiency projects

### Prioritized List of Recommendations

1. Energy Efficiency projects with a less than 2 year payback
  - i. Program thermostats
 

This no-cost project pays back instantly.
  - ii. LED retrofit of all light bulbs in the Windsor Run Cellars tasting room
 

While CFL retrofits have an instant payback, an LED retrofit represents a better opportunity for Windsor Run Cellars. Because the utility company’s incentive program rewards efficiency, an often expensive project, LEDs are very economical. This project would involve an investment of about \$250, which would be recovered in the energy savings in less than 9 months. LED have some technological capabilities over CFLs (e.g. they can fit in small fixtures and are capable of dimming) and last significantly longer, thereby reducing replacement costs.
  - iii. LED retrofit of all light bulbs in the Shadow Springs Vineyard tasting room
 

Similar to the previous project, an LED retrofit of this tasting room would result in improved light quality, reduced replacement costs, and reduced electricity costs. This project requires a larger initial investment of about \$843. With an estimated \$426 in annual electricity cost savings, this project has a payback period of 2 years.

If the upfront cost of this project is prohibitive, the halogen lightbulbs in the tasting room should be replaced with CFL alternatives. This project would only save about \$110 per year in avoided energy costs; however, it has an instant payback due to the utility company rebates.

iv. Conduct maintenance checks

Begin the process of routinely inspecting appliances, motors, HVAC systems, door sweeps and weather-stripping to ensure things are running in peak operating capacity. Make sure filters are clean and appliances are able to offload any produced heat, to avoid overheating and unnecessary energy consumption.

v. Air sealing

Seal up any leaks, cracks, or gaps that allows the movement of air between conditioned interior spaces and the exterior of the building. Specifically, in the Shadow Springs Vineyard tasting room door sweep should be installed on the sunroom door and the two doors to the wine cellar and weather stripping should be added to the middle door to the wine cellar. In the winery, gaps should be sealed around the damaged garage door in the winery. The open pipe in the wall of the distillery area should be sealed with spray foam insulation; and an exhaust fan in the area should be covered, with a cover or rigid foam board insulation box that is removable. The front door of the build could also benefit from a new door sweep and weather stripping.

2. Significantly reduce energy use in the winery

i. Replace winery lighting with LEDs

This lighting project would save more than 17,000 kWh and \$1,200 per year. Additionally, by reducing total energy use, monthly demand charges will decrease. New, open fixture lights that do not collect dirt and dust within a glass cover (as metal halides tend to do) should improve the lighting quality within the winery. Their longer lifespan will reduce replacement costs and the inconvenience of replacing lights on a 30 foot high ceiling.

ii. Install ceiling fans

This project represents the greatest opportunity for annual energy savings. The instillation of ceiling fans in the winery to destratify air and reduce the amount of energy required for space conditioning would save about 50,000 kWh and \$3,500 annually. This substantial reduction in energy use will further reduce demand charges as well.

iii. Coordinate projects simultaneously

Because of the tall ceilings and need to maneuver scaffolding around the winery equipment, coordinating implementation of these projects could save on labor and equipment costs. Both lights and ceiling fans will require the work of an electrician. Some companies also offer both product types, which can further reduce costs.

3. Explore on-site solar generation

- i. Seek estimates for installing a solar photovoltaic system on the roof of the winery.

The solar site assessment demonstrated that to meet the large energy demand of the winery, solar PV systems require a lot of space to meet the needs of 25% to 100 % of the sites' electricity demand. Because of the size and orientation of the winery roof, it has the ability to accommodate a very large rooftop solar PV system. This would significantly reduce the energy costs of the winery.

- ii. Seek information about the Rural Grant

This grant greatly improves the economic feasibility of on-site solar generation. Contacting this program can provide a 25% grant to reduce upfront investment costs, and access to a loan to pay off the investment costs for energy efficiency and renewable energy projects with the energy cost savings generated by these projects.

4. Improve the comfort of the Shadow Springs Vineyard tasting room

- i. Install window shades or blinds in the sunroom.

This project did not have the low payback periods of some of the other energy projects; however, it has the potential to improve the comfort for guests in the tasting room and save energy as well.

## Lessons Learned for the North Carolina Wine Industry

### **Tasting rooms are similar to residential construction.**

The analysis of historical electricity use data and on-site solar assessment revealed that tasting rooms are similar to residential construction. Building design, the types of technologies present, and trends in building energy consumption drive this similarity. As such, the types of energy efficiency improvements that one may consider or implement at home are directly transferable to winery tasting rooms. Because the vast majority of wineries in North Carolina are small operations, owned by individuals or families, this makes energy efficiency a much more understandable and approachable process for winery owners. Also, many projects can be Do-It-Yourself or pursued through local retailers or contractors, with whom owners are already familiar; this reduces costs and increases convenience and speed of implementation.

### **Lighting projects are highly economical.**

The sliding scale rebates for lighting efficiency improvements provided by the utility company Energy United makes lighting upgrades highly economical. Because these rebates reward higher

efficiency technologies, LED retrofits have quick payback periods and substantially lower investment costs; this overcomes what is often a cost prohibitive project.

The wineries have demonstrated that lighting does indeed fall within research estimates of 8% to 20% of site energy consumption (Snell, 2010); therefore, lighting energy consumption reduction of 60% to 90% can be achieved by replacing halogen or incandescent light bulbs with energy efficient alternatives.

Additionally, the ability for a winery owner to complete this type of project without a contractor reduces upfront costs, thereby increasing the economics of lighting retrofits.

Because of these considerations, it is possible to generalize a recommendation to any winery that if lighting is not currently efficient, this can be a first project that is low-cost, has quick payback periods, and has non-energy benefits, such as improved light quality and decreased replacement needs.

### **Space conditioning and winery equipment are the primary drivers of energy use in a winery.**

Analysis of the winery's historical electricity use revealed that space conditioning and winery equipment are the primary drivers of energy use in a winery. Projects that seal and insulate the building envelope, improve the efficiency of HVAC systems, reduce space conditioning needs, and increase the efficiency of winery equipment can greatly reduce energy consumption within wine production facilities. Thus, it is important for winery owners to investigate ways to achieve these goals within their facilities.

### **Several financial incentives exist for energy efficiency and renewable energy projects.**

The financial analysis for energy efficiency projects and onsite renewable electricity generation revealed that financial incentives dramatically improve the economics of these projects. These incentives require effort to find and in some instances to earn; however, their existence makes capital intensive projects much more affordable. Knowing that these incentives exist can make energy efficiency improvements or onsite renewable energy generation possible for the owners of small scale winery operations.

*Appendix B* summarizes information about the financial incentives included in this energy analysis.

## Acknowledgements

I would like to express my very great appreciation to Chuck Johnson, owner of Shadow Springs Vineyard and Windsor Run Cellars, for his interest in this project and providing me with the data and access necessary to conduct this study.

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## Literary Citations

- Alexrk2. (2009). USA North Carolina location map. Wikimedia Commons.
- Benedetto, G. (2013). The environmental impact of a Sardinian wine by partial Life Cycle Assessment. *Wine Economics and Policy*, 2(1), 33-41. doi: <http://dx.doi.org/10.1016/j.wep.2013.05.003>
- California Sustainable Winegrowing Alliance. (2014). About Sustainable Winegrowing Program. Retrieved 2/23/2014, from <http://www.sustainablewinegrowing.org/programqanda.php#question1>
- California Sustainable Winegrowing Program. (2013). 2012 Progress Report.
- Database of State Incentives for Renewables and Efficiency (DSIRE). (2013a). Business Energy Investment Tax Credit (ITC) Retrieved Sept. 1, 2013, from <http://energy.gov/savings/business-energy-investment-tax-credit-itc>
- Database of State Incentives for Renewables and Efficiency (DSIRE). (2013c, 04/09/2013). PV Incentive Program. Retrieved Sept. 1, 2013, from [http://dsireusa.org/incentives/incentive.cfm?Incentive\\_Code=NY10F&re=0&ee=0](http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=NY10F&re=0&ee=0)
- Desta, A. (2008). Conventional versus Environmentally-Sensitive Wines: The Status of Wine Production Strategies in California North Coast Counties *Journal of Business and Public Affairs*, 2(1).
- ENERGY STAR. (2008). Building Upgrade Manual: U.S. Environmental Protection Agency.
- Good, J. (2014). How Wine Is Made. Retrieved 2/23/2014, from <http://www.wineanorak.com/howwineismade.htm>
- Held, P. (2008). See Your Winery Through the Customer's Eyes.
- International Code Council, I. (2006). 2006 International Energy Conservation Code.
- International Code Council, I. (2009). North Carolina. Retrieved 9/13/2015, from <https://energycode.pnl.gov/EnergyCodeReqs/?state=North%20Carolina>
- Johnson, T. (2015, 3/2/15). [Conversation with Tim Johnson].
- Kelsey, J., & Pearson, D. (2011). Updated Procedures for Commercial Building Energy Audits: ASHRAE.
- Lawrence Berkeley National Laboratory. (2015). EnergyIQ. Retrieved 09/10/2014, from [energyiq.lbl.gov/EnergyIQ/index.jsp](http://energyiq.lbl.gov/EnergyIQ/index.jsp)
- Matulka, R. (2014). Resolve to Save Energy This Year. Retrieved 02/10/2015, from <http://www.energy.gov/articles/resolve-save-energy-year>
- McKee, L. J. (2009, 12/04/2009). North Carolina Has First Solar Winery. *Wines & Vines*. Retrieved from <http://www.winesandvines.com/template.cfm?section=news&content=69633>
- National Renewable Energy Laboratory. (2014a). PVWatts Calculator. Retrieved 3/30/2014, from <http://pvwatts.nrel.gov/>
- National Renewable Energy Laboratory. (2014c). System Advisor Model (SAM). Retrieved 03/30/2014, from <https://sam.nrel.gov/>
- Natural Resources Defense Council. (2010). Efficient Appliances Save Energy -- and Money. Retrieved 1/10/2015, from <http://www.nrdc.org/air/energy/fappl.asp>

- North Carolina Department of Commerce. (2013, 08/05/2013). Wine Industry Facts. Retrieved 3/30, 2014, from <http://media.visitnc.com/news/wine-industry-facts>
- Snell, E. (2010). Managing Energy in Wineries. In E Source Companies LLC (Ed.).
- U.S. Department of Agriculture. (2015). Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Loans & Grants. Retrieved 1/10/2015, from <http://www.rd.usda.gov/programs-services/rural-energy-america-program-renewable-energy-systems-energy-efficiency>
- Ueno, K. (2010). Building Energy Performance Metrics. Retrieved 2/11/2015, from <http://www.buildingscience.com/documents/digests/bsd152-building-energy-performance-metrics>
- Wilson Creek Winery. (2014). How Wine is Made. Retrieved 2/23/2014, from <http://www.wilsoncreekwinery.com/Wine-101/How-Wine-Is-Made.aspx>
- WineAmerica, & Winegrape Growers of America. (2008). Grape Facts 2008.
- Your Weather Service. (2015). Yadkinville weather averages. Retrieved 3/10/2015, from <http://www.usclimatedata.com/climate/yadkinville/north-carolina/united-states/usnc0774>

Appendix A: Recommendations Calculations Tables

Table A1. Lighting Upgrade Calculations

Lighting Upgrade	Space Type	Items	Qty	Retrofit (W/bulb)	Replacement (W/bulb)	Cost per unit (\$)	Capital Cost (\$)	Energy United Rebate	Total Cost	Original (kW)	Time in Use (hours)	Original Use (kWh)	Projected Use (kW)	Projected Energy Use (kWh)
Winery Metal Halides	Winery	Bulbs	34	400	160	\$ 280.00	\$ 9,520.00	\$ 1,632.00	\$ 7,888.00	13.60	2,117	28,789	5.44	11,515.4
	Total	Installation	34			\$ 200.00	\$ 6,800.00	\$ -	\$ 6,800.00	0.00			0.00	0.0
Replace Incandescents with CFLs (WRC)	Tasting room	Bulbs: Recessed	27	65	14	\$ 5.00	\$ 135.00	\$ 275.40	\$ (140.40)	1.8	2,136	3,749	0.38	807.5
		Bulbs: A-lamp	7	60	13	\$ 2.50	\$ 17.50	\$ 65.80	\$ (48.30)	0.4	188	79	0.09	17.1
	Total	Bulbs: Globe	8	50	14	\$ 7.00	\$ 56.00	\$ 57.60	\$ (1.60)	0.4	382	136	0.11	42.8
		Installation	1			\$ -	\$ -	\$ -	\$ -	0	1	0	0.00	0.0
Replace Incandescents with LEDs (WRC)	Tasting room	Bulbs: Recessed	27	65	9.5	\$ 20.00	\$ 540.00	\$ 299.70	\$ 240.30	1.8	2,136	3,749	0.26	547.9
		Bulbs: A-lamp	7	60	9.5	\$ 10.00	\$ 70.00	\$ 70.70	\$ (0.70)	0.4	188	79	0.42	78.9
	Total	Bulbs: Globe	8	50	5	\$ 10.00	\$ 80.00	\$ 72.00	\$ 8.00	0.4	382	136	0.40	152.9
		Installation	1			\$ -	\$ -	\$ -	\$ -	0	1	0	0.00	0.0
Replace Incandescents with CFLs (SSV)	Tasting room	Bulbs: Ceiling fans	9	60	13	\$ 2.50	\$ 22.50	\$ 84.60	\$ (62.10)	0.54	2,586	1,397	0.12	302.6
		Bulbs: Wall Sconces	2	60	13	\$ 2.50	\$ 5.00	\$ 18.80	\$ (13.80)	0.12	180	22	0.03	4.7
	Total	Bulbs: Recessed exterior	6	65	14	\$ 5.00	\$ 30.00	\$ 61.20	\$ (31.20)	0.39	365	142	0.08	30.7
		Installation	1			\$ -	\$ -	\$ -	\$ -	0	1	0	0.00	0.0
Replace all Lightbulbs with LEDs (SSV)	Tasting room	Bulbs: ICL Ceiling fans	9	60	9.5	\$ 10.00	\$ 90.00	\$ 90.90	\$ (0.90)	0.54	2,586	1,397	0.09	221.1
		Bulbs: ICL Wall Sconces	2	60	9.5	\$ 10.00	\$ 20.00	\$ 20.20	\$ (0.20)	0.12	180	22	0.02	3.4
	Total	Bulbs: Recessed replacements	80	24	9.5	\$ 20.00	\$ 1,600.00	\$ 232.00	\$ 1,368.00	1.92	1,094	2,100	0.76	831.4
		Bulbs: Tube	40	224	18	\$ 25.00	\$ 1,000.00	\$ 66.60	\$ 53.40	0.39	365	142	0.06	20.8
Total	Tasting room	Bulbs: CFL Wall Sconce	14	65	9.5	\$ 10.00	\$ 140.00	\$ 155.40	\$ (15.40)	0.18	1,504	274	0.13	200.0
		Bulbs: Halogen Pendant Lighting	10	100	2	\$ 8.00	\$ 80.00	\$ 196.00	\$ (116.00)	0.5	1,624	812	0.02	32.5
	Total	Bulbs: Halogen Track Lighting	12	50	9	\$ 25.00	\$ 300.00	\$ 98.40	\$ 201.60	0.6	2,586	1,552	0.11	279.3
		Installation	1			\$ -	\$ -	\$ -	\$ -	0	1	0	0.00	0.0
<b>Total</b>						\$ 3,350.00	\$ 2,507.50	\$ 842.50	\$ 15,480.70			44,632.89		15,121.78

**Table A2.** Ceiling fan calculation inputs

Height of ceiling	30 feet
Height of thermostat	4 feet
Avg thermostat temp	50 feet
Average outside temp during the heating season	38 °F
# days heating season	120
U-value of ceiling	0.077
area of ceiling	14,700 square
Avg outdoor temp	68.2 °F
# days cooling season	200

**Table A3.** Ceiling fan project energy savings

<b>Heating</b>	
63,504,000	Btu/yr
18,611.96	kWh/yr
<b>Cooling</b>	
105,840,000	Btu/yr
31,019.93	kWh/yr
<b>Total</b>	
169,344,000	Btu/yr
49,632	kWh/yr

**Table A4.** Ceiling fan installation calculations

Space Type	# Devices	Device	Cost per unit (\$)	Capital Cost (\$)	Grant	Total Cost	Time in Use (hours)	Fan Energy Use (kWh)	Estimated Savings (kWh)	Projected Savings (kWh)
Winery	3	Fans	\$ 4,250.00	\$12,750.00	\$4,612.50	\$8,137.50	8,760	20	49,632	49,612
	3	Installation	\$ 1,900.00	\$5,700.00		\$5,700.00				
<b>Total</b>				<b>\$18,450.00</b>	<b>\$4,612.50</b>	<b>\$13,837.50</b>			<b>49,632</b>	<b>49,612</b>

**Table A5.** Window covering calculations

Space Type	# Devices	Device	Cost per unit (\$)	Total Cost	Current Use (kWh)	Projected Use (kWh)
Tasting Room	8	Window covering	180	\$1,440.00	1,770	974
				\$0.00	0	0
<b>Total</b>				<b>\$1,440.00</b>	1,770	974

**Table A6.** Occupancy sensors calculations

Space Type	Qty	Device	Cost per unit (\$)	Total Cost	Current Use (kWh)	Projected Use (kWh)
SSV-upstairs	2	Decora Passive Infrared Wall Switch Occupancy Sensor	65	\$130.00	507	253
SSV-downstairs	2	Decora Passive Infrared Wall Switch Occupancy Sensor	65	\$130.00	9	4
WRC	2	Decora Passive Infrared Wall Switch Occupancy Sensor	65	\$130.00	131	66
	6	Installation	100	\$600.00		
<b>Total</b>				<b>\$990.00</b>	647	324

**Table A7.** Dishwasher replacement calculations

Space Type	# Devices	Device	Cost per unit (\$)	Total Cost	Estimated Savings (kWh)
WRC tasting room	1	Standard dishwasher	\$ 1,200.00	\$1,200.00	227
	1	Installation	\$ 100.00	\$100.00	
<b>Total</b>				<b>\$1,300.00</b>	227

**Table A8.** Dishwasher replacement calculations

Space Type	# Devices	Device	Cost per unit (\$)	Capital Cost (\$)	Projected Savings (kWh)
Winery	1	Tankless Water Heater	\$ 1,000.00	\$1,000.00	1,071
	1	Installation	\$ 1,200.00	\$1,200.00	
<b>Total</b>				<b>\$2,200.00</b>	1,071

## *Appendix B: Financial Incentives*

### **Federal Tax Incentive**

**Name:** Business Energy Investment Tax Credit (ITC)  
**Incentive:** 30% tax credit for business that install onsite renewable energy systems  
**Expiration:** Expires December 31, 2016  
**Website:** <http://energy.gov/savings/business-energy-investment-tax-credit-itc>

### **State Tax Incentive**

**Name:** Renewable Energy Tax Credit (Corporate)  
**Incentive:** 35% tax credit for business that install onsite renewable energy systems  
**Expiration:** December 31, 2015  
**Website:** <http://programs.dsireusa.org/system/program/detail/540>

### **Rural Energy Grant**

**Name:** Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Loans & Grants  
**Incentive:** 25% grant for project costs, up to \$500,000; loan for up to 75% project costs and \$25 million  
**Expiration:** Unknown  
**Website:** <http://www.rd.usda.gov/programs-services/rural-energy-america-program-renewable-energy-systems-energy-efficiency>

### **Energy United Rebate**

**Name:** Commercial Energy Efficiency Rebate  
**Incentive:** \$0.20 per Watt saved  
**Expiration:** Unknown  
**Website:** [https://www.energyunited.com/energy\\_efficiency\\_rebates.asp](https://www.energyunited.com/energy_efficiency_rebates.asp)

## Appendix C: Energy Efficiency Maintenance Check List

- Check for sources of air leaks.
  - Check doors leading outside the building or refrigerated spaces.
    - Look for light under doors.
    - Check condition of door sweeps.
    - Look for light around doors.
    - Check condition of weather stripping .
  - Look for pipes leading between conditioned and unconditioned spaces.
    - Inspect plumbing and propane pipes.
  - Inspect around any object that has been installed into exterior walls, e.g. exhaust fans.
- Maintain the HVAC system.
  - Ensure regular cleaning and service by an HVAC contractor.
  - Replace air filters regularly.
  - Prevent obstruction to thermostat.
  - Remove heat-generating appliance from near thermostats.
- Inspect motors and fans
  - Ensure appropriate set-points and programming.
  - Clean motors and fans regularly.
- Check heat generation sources on appliances
  - Check exhaust coils for dust, dirt, debris.
  - Clean coils regularly.
  - Ensure proper ventilation for appliance.
    - Evaluate the spacing between appliances and walls, cabinets, and other obstructions, so that heat can proper ventilate, thereby, reducing unnecessary energy consumption.