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SOLAR-ASSISTED GAS HOT WATER HEATING SYSTEMS FOR SMALL FOOD PROCESSORS

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PREFACE

The California Energy Commission Energy Research and Development Division supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

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Solar-Assisted Gas Hot Water Heating Systems for Small Food Processors is the final report for the Solar-Assisted Gas Hot Water Heating Systems for Small Food Processors project PIR-09-008 conducted by Gas Technology Institute. The information from this project contributes to Energy Research and Development Division's Industrial/Agricultural/Water End-Use Energy Efficiency Program.

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ABSTRACT

The Gas Technology Institute (GTI), along with its partners Solar Usage Now and Knecht's Plumbing & Heating, Inc., demonstrated an advanced solar-assisted gas hot water heating system for advanced solar-assisted hot water generation at Courtside Cellars, San Miguel, California. This system reduces the material, manufacturing, and installation cost of solar-assisted water heating systems. The system is a combination of an atmospheric storage tank, a highly efficient natural gas-fired tankless water heater, and a highly efficient solar thermal collector. This system takes the most efficient technologies on the market and integrates them into an energy efficient package. The modular design of the hot water storage tank makes them ideal to be linked together to replace boilers used for large commercial applications such as breweries, soft drink production, hotels, schools and hospitals. GTI validated the ability of the system to achieve an energy cost savings of 40 percent and a corresponding reduction in greenhouse gases in small commercial agricultural businesses. This solar-assisted gas hot water heating system makes advanced water heating implementation more attractive, mitigating greenhouse gas emissions, improving the competitiveness of California industry, and increasing the reliability of hot water at end-user sites.

Keywords: renewables, solar, solar thermal, solar-assisted, water heating, evacuated tube, tankless water heater, field test

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EXECUTIVE SUMMARY

Introduction

The California wineries generate almost 90 percent of all wine produced in the United States. The industry consumes more than 400 GWh of electricity annually and is the second largest electricity consuming food industry in California after fruit and vegetable processing. Much of the electricity used in winemaking is for refrigeration for cooling and cold storage. Hot water is essential for sanitizing barrels, bottles and equipment, for maintaining tank temperature during red wine fermentation and yeast generation.

Energy and water costs continue to increase rapidly for wineries located in California, making energy and water efficiency improvement an essential part of the business. To reduce hot water consumption, California winemakers are implementing various efficiency measures. These measures include but are not limited to using treated wastewater for irrigation and landscaping, frost protection, fire protection, and dust abatement; high-pressure spray nozzles for tank and barrel cleaning; and leak detection and repair. These measures have the added benefit of eliminating energy costs associated with pumping and heating the water that has been saved.

Project

Gas Technology Institute (GTI) partnered with Solar Usage Now to design and demonstrate an advance solar-assisted gas hot water heating system at Courtside Cellars, San Miguel, California. Together GTI and Solar Usage Now have addressed the commercial market identifying and resolving solar-assisted water heating technologies and market issues to assist industry in the identification of a viable gas-fired water heating option capable of meeting customer expectations for cost, safety, reliability, and performance. Knecht's Plumbing & Heating, Inc. was instrumental in the installation of the system.

The design of a highly efficient and robust solar thermal system, "Equinox Heating System", was completed, and permanently installed at the Courtside Cellars production facility. The system has operated continuously under actual commercial hot water load profiles for this production facility. An acquisition system collected data simultaneously to record the system variation.

The Equinox Heating System is a combination of an atmospheric storage tank, a highly efficient natural gas-fired tankless water heater, and a very efficient solar thermal collector. This system takes the most efficient technologies on the market and integrates them into an energy efficient package. The system is very flexible and can operate under many temperature setting combinations depending on how the system is applied.

Installing enough capacity to replace both existing boilers was estimated to be larger than what was economically possible. It was determined to augment the existing boiler capacity with the Equinox Heating System. A year of monitoring has revealed the average daily load as 1.6 million Btu. The Equinox Heating System daily load ranged between 0.5 million Btu and 5.0 million Btu. An appropriately sized solar collector would be 128 meters^2, or 45 collectors.

Overall, the Equinox Heating System performed extremely well; at peak conditions the fuel efficiency was more than 95 percent, generating more than 1,700 gallons of hot water daily. Compared to the standard baseline efficiency gas boiler, the system saved approximately 1190 therms of natural gas during the year of monitoring. This energy savings corresponds to a potential reduction of 17,500 lbs of greenhouse gas emissions per year.

The estimated payback period for the Equinox Heating System was 7.3 years, including incentives provided by state and federal governments. This payback period includes equipment and installation. As more installations occur, this payback is expected to improve as firms learn to install the system at lower costs. Addidionally, payback periods are dependent upon the solar fraction and available incentives. Solar-assisted systems provide a non-complex technology that is a financially viable alternative over traditional water heating systems. With incentives, the 15 year lifecycle cost is less than traditional water heating systems.

In reducing energy costs, boilers are the heart of the hot water generation system at larger wineries, and substantial efficiency improvements are feasible here (i.e. improved boiler maintenance, low emission burners, reduced excess air, reduce flue gas volume, etc.). Hot water storage is another factor to consider when so much hot water is used and needed on demand. Most large wineries have tanks with capacities ranging from 500 to 3,000 gallons. In smaller wineries, investments in equipment are kept low by purchasing readily available commercial hot water heaters, small boilers, and conventional storage tanks that are less than 199 gallons. At 200 gallons the storage tank must be an approved pressure vessel adding significantly to the initial cost.

Benefits

The opportunity for substantial energy costs savings in smaller wineries comes at a higher purchase cost and longer payback. By reducing the purchase cost and increasing the potential savings, quicker paybacks can be realized. An improved solar-assisted gas fired hot water system, such as the Equinox Heating System, may realize such a payback. A solar-assisted gas fired hot water system uses solar energy to pre-heat the boiler feedwater in a solar thermal collector. Until recently, solar-assist has mainly been designed for residential applications or to heat pool water. However, for small wineries a solar-assisted boiler may be a good alternative. The harvesting season sees a major part of the water use for cleaning (excluding year-round operation of a bottling facility), and this is also a time with large availability of sunlight. A solar-assisted boiler may reduce the costs of hot water supply between 40 to 80 percent, depending on the current hot water supply.

CHAPTER 1:
Value of the Technology

Today many Americans face higher energy prices, compounded by supply related fluctuations and even power outages. Small commercial businesses can be most affected by price fluctuation and power outages. Reducing the energy needs of these small businesses improves positive cash flow and provides benefit to the greater economy, the environment, and increases energy security. This can best be achieved through a combination of conservation and efficiency with small businesses. Small wineries, those producing 50,000 cases of wine per year or less, make-up greater than 90 percent of the in the Unites States. Predominantly small family-based operations, according to 2006 U.S. Census statistics, 78 percent of these wineries have has less than 20 employees. Improving their energy outlook provides direct benefit to the local economy.

Solar-assisted water heating has evolved around the world in nations with tropical and temperate climates. These market transformations have been driven by high energy costs, unreliable infrastructure, incentives, and technological advancements. While the technology exists, it has only recent begun to make inroads in the U.S. markets. Research is needed to ensure that these systems are able to meet the price and performance U.S. commercial business require for an acceptable payback.

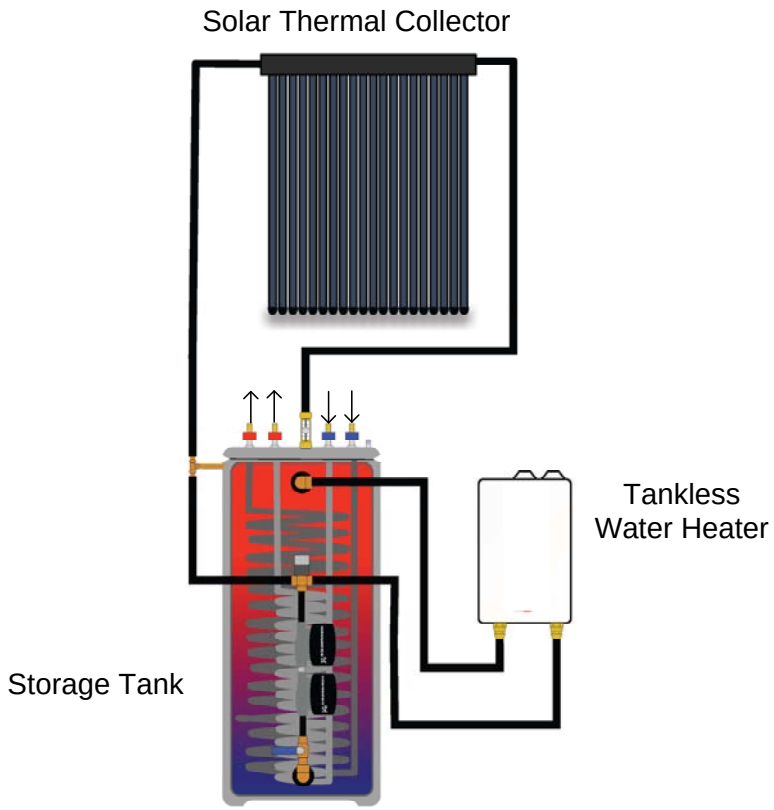
This program advances state-of-the-art solar-assisted gas water heating at California wineries. In small winery operations, where capital investment and cash flow is limited, technology transformation is slow without demonstrated proof of field performance. A dramatic increase in market penetration for solar-assist water heating is possible and would benefit the California Food Processing Industry; however, the industry is wary regarding the performance of this technology. Validated installation methods that significantly reduce required equipment size and energy consumption will help these technologies gain the necessary recognition for significant market impact. GTI's research and development team has joined forces with Solar Usage Now to develop an advanced solar-assisted water heating system to meet the growing needs of the California wine industry.

1.1 Solar System Overview

The solar-assisted gas hot water heating system, Equinox Heating System, reduces the material, manufacturing, and installation costs of solar-assisted natural gas water heating systems for small commercial, industrial, and agricultural applications (Figure 1). This highly efficient hot water delivery system is designed to meet the reliability and performance requirements for hot water found in California's small to mid-size wineries. The major components of the Equinox Heating System include an atmospheric storage tank, a highly efficient natural gas-fired tankless water heater, and an efficient solar thermal collector. The design reduces and eliminates major components and associated costs, such as a second storage tank for solar, but affords maximum flexibility for installation and utility business considerations. Implementing a

high-efficient drainback solar collector expands the market for solar water heating, particularly to areas where freeze protection is required.

Figure 1: Equinox Heating System



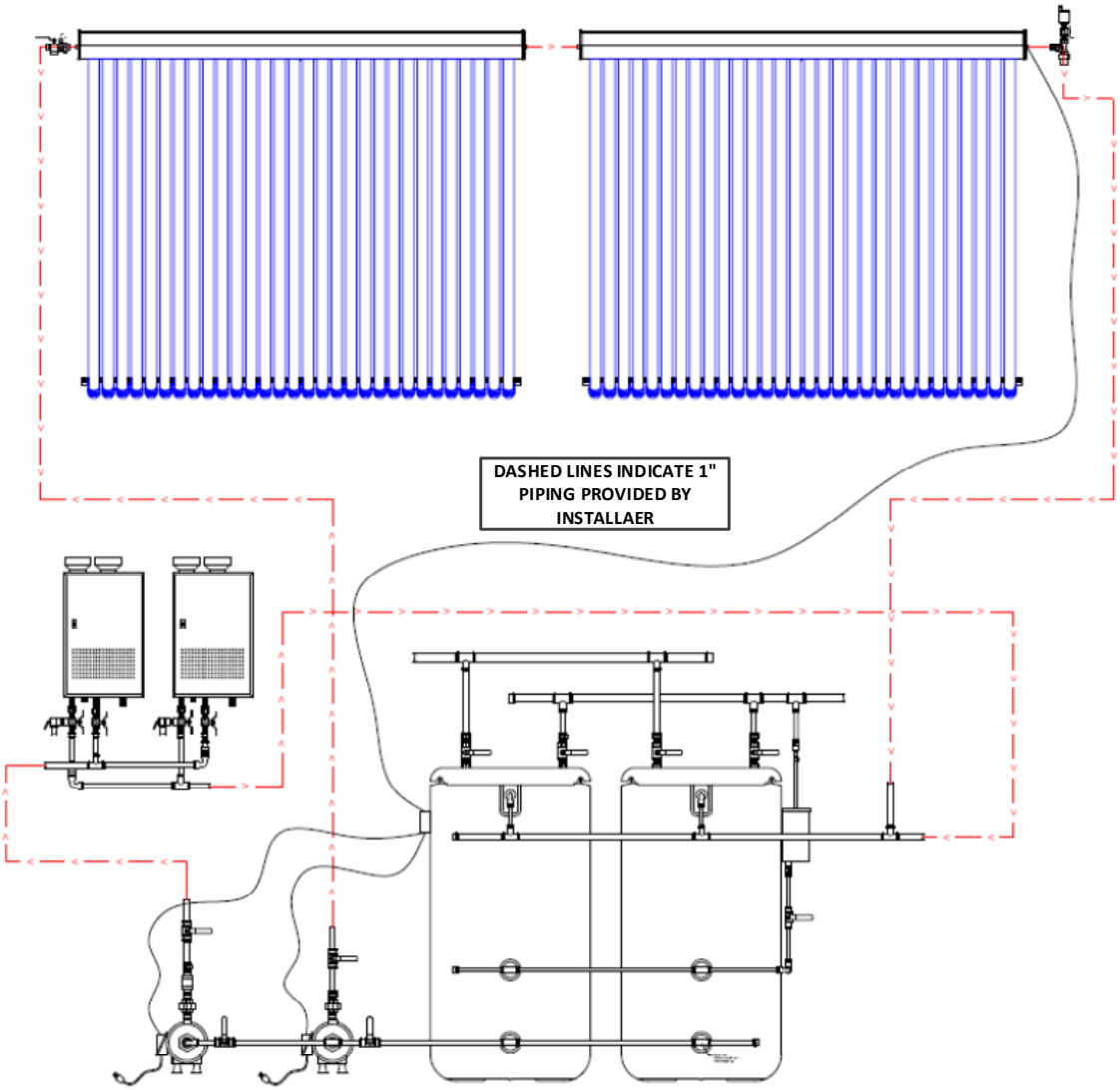
The Equinox Heating System is a pressure-free and environmentally friendly solar installation. Water is the heat transfer fluid, thus eliminating the use of ethyl glycol as a heat transfer fluid as it is a listed hazardous substance in California, and the systems will not experience the issues of overheating associated with glycol fluid systems. The system is "active" and relies on pumps and controllers to circulate water, the heat transfer fluid, through the solar collectors. The collector is installed at a slope of ¼" per foot of collector, so when the pumps stop, the water will drainback to the tank, and not be left in the pipes to freeze and burst. This will expand the market for solar water heating, particularly to areas where freeze protection is required.

The Equinox Heating System was conceived in accordance with the latest thermal technology and water hygiene requirements. Fundamentally different from normal large volume hot water storage tanks, the storage tank water is filled once during commissioning, and is circulated between the tank and the solar collector. Internal to the tank, is a stainless steel corrugated heat exchanger which is immersed in the storage tank water where domestic hot water is indirectly heated. The coils carry the fresh water supply providing separation of the fresh water from the

water heated by the solar array and used for thermal storage ensuring that no germs or diseases can be born through the water.

The modular design of the hot water storage tank makes them ideal to be linked together to replace boilers used for large wineries, multi-family housing, and commercial applications such as hotels, schools, hospitals, etc (Figure 2). This highly efficient hot water delivery system is designed to meet the reliability and performance needs of most residential/commercial applications throughout the U.S.

Figure 2: Modular Design for Commercial Hot Water Systems



The project partner, Solar Usage Now, is also a distributor for Solarhot USA, Califfei Solar, Rotex, Quietside, and Apricus solar products. Products are marketed, installed, and serviced by over 250 certified dealers and installers nationwide in both the residential and commercial

1.2 Atmospheric Storage Tank

The hot water storage tank is a corrosion-free plastic atmospheric tank, the inner and outer walls are impact resistant polypropylene, and the space in-between is filled with high insulating foam (Figure 3). This design provides for very good heat insulation values and minimum surface losses. The circulation water for the solar collector held in the tank is used not stored, so there is never a chance for particles and sediments to settle in the tank. This means no germs or diseases can be born through the water. The storage tank water is filled once during commissioning and is circulated between the storage tank and the solar collectors. It is neither replaced nor consumed. The heat from the solar collectors is transferred to the storage tank and warms the storage tank water. Internal to the tank is a stainless steel corrugated heat exchanger which is immersed in the storage tank water where domestic hot water is indirectly heated. This ensures optimum inherent water-hygienic properties since the water to be heated is ducted and heated through a stainless steel heat exchanger.

Any low flow sections or sections that are not heated properly on the hot water side are completely eliminated in the design. The commercial hot water is entirely contained in a piping system so that any deposits such as sediment and rust which can arise in large volume tanks are not produced. Water that is charged first is also the first to be removed. The water hygiene advantages of the atmospheric hot water storage tank are thus considerable. The storage tank is available in 80 and 132 gallon capacities.

Figure 3: Atmospheric Storage Tanks with Cut Away View

1.3 Tankless Water Heater

The Noritz tankless water heater provides exceptional performance and efficiency coupled with the comfort of on demand hot water. Revolutionary heat exchangers provide an energy factor of 0.95. These efficiency levels are achieved by utilizing two heat exchangers, including a wet recuperative heat exchanger, manufactured from stainless steel. This heat exchanger condenses water from the combustion gases which is used to preheat the water. The tankless water heater is another key component in the system charging the storage tank water when no solar energy is available. The temperature of the gas-fired tankless water heater is set at 180 °F for fast recovery of the tank temperature.

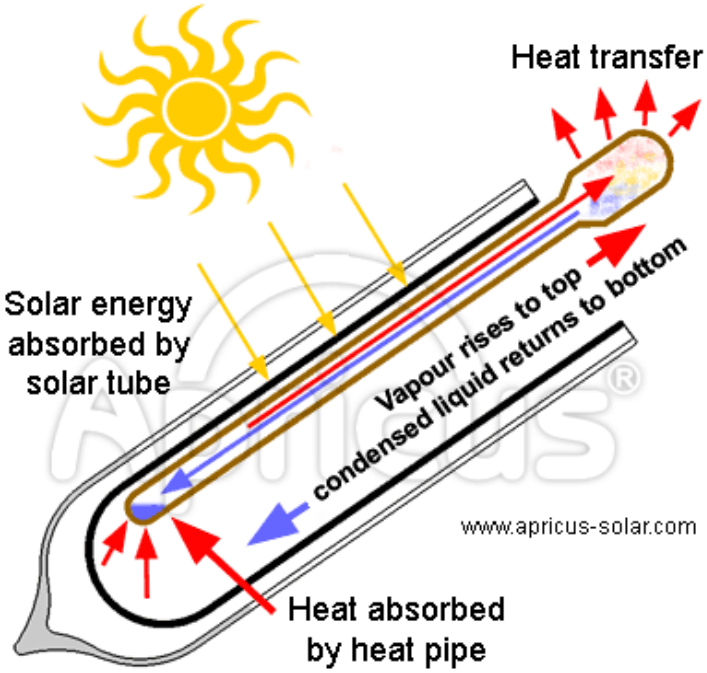
1.4 Solar Thermal Collector

The Equinox Heating System used the Apricus solar collector (Model No. AP-30). The collector is an array of 30 twin-glass evacuated tubes, chosen for its reliability, performance, and low manufacturing cost. The tubes aligned in parallel and join into a common header where the heat transfer fluid (i.e. water) is transported. The evacuated tubes consist of two glass tubes made from extremely strong borosilicate glass. The outer tube is transparent, allowing light rays to pass through with minimal reflection while the inner tube is coated with a special selective coating which features excellent solar radiation absorption and minimal reflection properties (Figure 4). The top of the two tubes are fused together after the air contained in the space between the two layers of glass is removed. This "evacuation" of the gasses forms a vacuum and provides an insulating barrier inside the tube. The insulation properties are so good that while the inside of the tube may be ~300°F, the outer tube is cold to touch. In order to maintain the vacuum between the two glass layers, a barium getter is used. During manufacture of the evacuated tube, the getter is exposed to high-temperatures which results in the bottom of the tube being coated with a pure layer of barium. This barium layer actively absorbs any out-gasses from the tube during storage and operation, thus helping to maintain the vacuum. The barium layer also provides a clear visual indicator of the vacuum status. The silver colored barium layer will turn white if the vacuum is ever lost. This makes it easy to determine whether or not a tube is in good condition.

Each evacuated tube contains a heat pipe transporting the heat by conduction to the common header (Figure 5). The purpose for evacuation of the heat pipe is to alter the state of a small quantity of purified water and some special additives inside so that the mixture will boil at a lower temperature ~86 °F. When the heat pipe is heated above 86 °F, the water vaporizes. This vapor rapidly rises to the top of the heat pipe transferring heat to the thermal fluid (i.e. water) at the common header. As the heat is lost at the condenser, the vapor condenses to form a liquid and returns to the bottom of the heat pipe to once again repeat the process. The angle of mounting for the solar array depends upon the latitude at a given installation location. In a North or South orientation, the tubes can passively track heat from the sun all day. In an East or West orientation, they can track the sun all year round.

Figure 4: Close Up of the Evacuate Tube

Figure 5: Evacuated Tube with Heat Pipe Technology



1.5 Circulation System

The circulation system is "active" and relies on pumps and controllers to circulate water, the heat transfer fluid, through the solar collectors returning to the storage tank to heat the tank water.

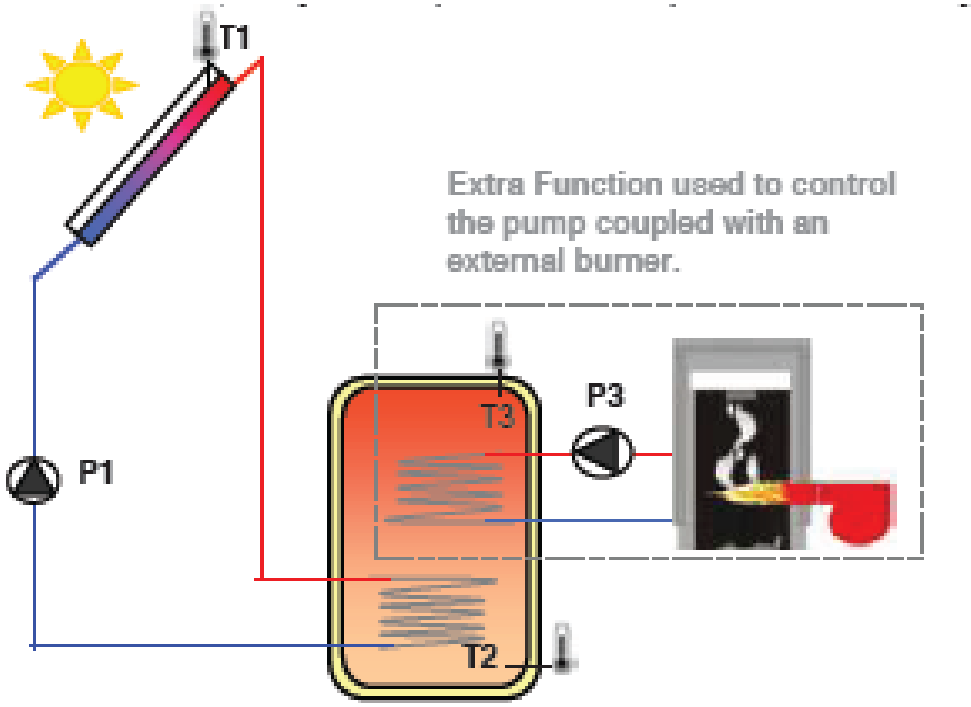
1.5.1 Controller

The Equinox circulation system uses a Watts Controller (Figure 6). The controller measures temperatures at three locations in the system and activates water flow at the pump to the solar collector and tankless water heater at the optimum time. The three locations (T1, T2, and T3), shown in Figure 7, are:

1. T1: Return-side of the solar array header;
2. T2: 54" from the top of the storage tank. This controls the solar pump (P1 in Figure 7); and
3. T3: 33" from the top of the storage tank. This controls the tankless water heater pump (P3 in Figure 7).

Figure 6: Watts Advanced Solar Controller

Figure 7: Location of Watts Controller Sensors: T1, T2, and T3



If T1 is 30 °F greater than T2, the solar pump “P1” will initiate. As water is pumped to the collector, heat will be absorbed at across the header, the temperature of the collector will cool, and the heat will transfer to the storage tank where the tank water temperature will rise. When a five degree delta in temperature is achieved, the pump will shut down, and the water will drainback to the storage tank. This continues until the solar radiation levels are too low to achieve the set points, or until the storage tank water has reached 180 ºF.

When T3 falls below 129 °F, the controller will initiate the tankless water heater pump “P3”, until the storage tank water has reached 145 ºF.

To achieve this performance, SUN’s recommended settings are listed in Table 1

Table 1: Solar Usage Now Recommended Settings

Information Screen		
Service Menu		
English		
Time & Date		
US Version:	Yes	
System		
System 1		
Extra	Thermostat	
External Sensor:	Yes	
Protection Func.		
Collector Max Temp:		248°F
Cooling	No	
Recooling	No	
Overheat Prot.	No	
Freeze Prot.	No	
Sensor Options		
Imp. Meter:	No	
Flow(gal/min)	1.0	
GDS1	NC	
GDS2	NC	
Energy Measurement		
Temperatures		
warm sensor		auto
cold sensor		auto
flow		auto
Pump P1	NO SC	
Pump P2	NO SC	
Glycol	NO	
Facotry Settings	NO	
Reset OP Time	NO	
Time graf temp	5m	
Time graf op		1h
Calib Sensors		
Sensor T1		0°F
Sensor T2		0°F
Sensor T3		0°F
Sensor T4		0°F
Sensor T5		0°F

Settings Menu	
Maxtemp tank 1	179°F
dTMax tank 1	30°F
dTMin tank 1	5°F
Min Rev Pump	100%
dT FS	50°F
Min temp. coll.	50°F
Thermostat	
Start	129°F
Hysteresis	12°F
Operation Menu	
Automatic(active)	
Off	
Manual Testing	
Operation H Menu	
SD Card ON/Off Setting.	
No other parameters only graph readings	
Temperatures Menu	
No parameters only sensor temperature readings	

1.5.2 Pump

The Equinox Heating System uses two Grundfos pumps for circulation of water on commercial systems. Each is a 1/6 Horsepower (HP) hydronic circulation pump. One pump is used to supply water to the solar collectors, and the other supplies water to the tankless water heaters. In each case, the water is returned back to the top of the storage tank.

CHAPTER 2:
Equinox Heating System

The Equinox Heating System combines an atmospheric storage tank, a highly efficient natural gas-fired tankless water heater, and a very efficient solar thermal collector. This system takes the most efficient technologies on the market and integrates them into an energy efficient package. The system provides hot water to the facility relying on solar thermal energy when available during the daytime or supported by the tankless water heater on cloudy days or evenings.

2.1 Host Site

The site for demonstration of the Equinox Heating System was Courtside Cellars located in San Miguel, California. Courtside Cellars is a full service winery providing existing winery brands with the ability to expand their own winery's capacity by providing extensive crushing and press capacity, tank/barrel fermentation, tank/barrel storage, satellite offices for their winemakers, sophisticated laboratories, and an experienced winery staff. The 300,000-square-foot facility located in San Miguel began making wine in 2001 and is owned by the E. & J. Gallo Winery, a family-owned Modesto-based firm that holds 60 brands of beverages.

Figure 8: Aerial View of Courtside Cellars San Miguel Production Facility

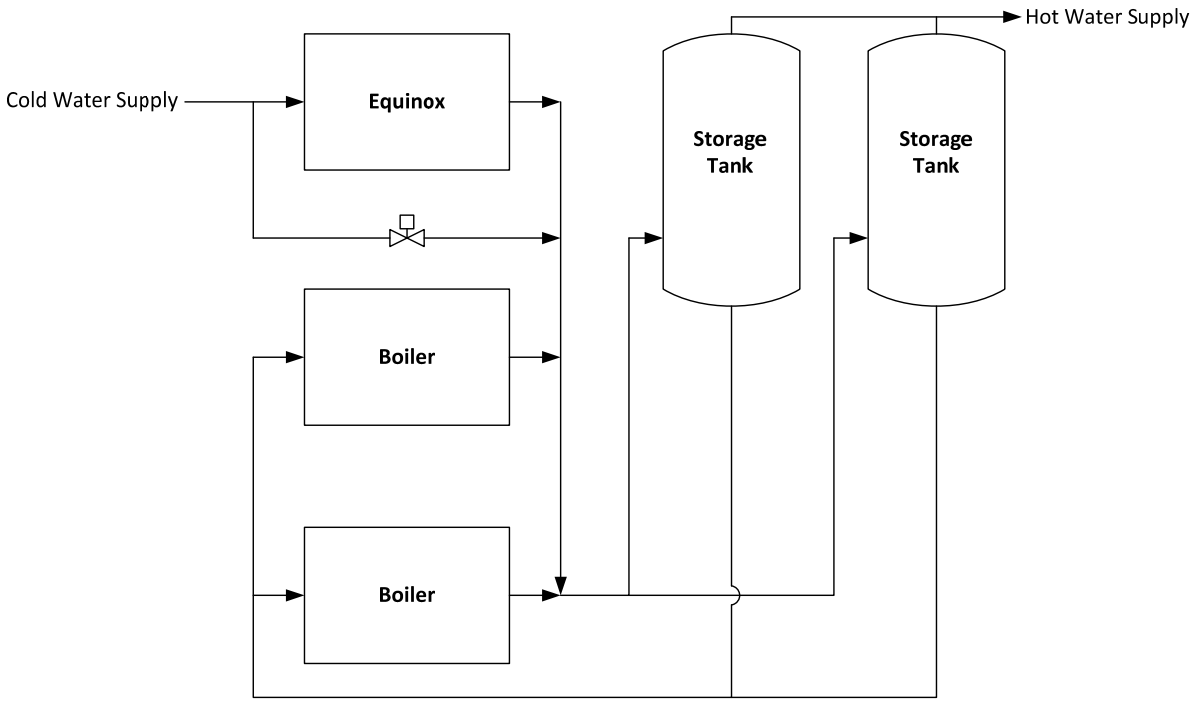
Red Arrow Indicates Location of Solar Collectors

2.2 Design

The pre-retrofit system at the facility satisfied hot water load with two existing Raypak natural gas-fired boilers (Model Number W9-1262). Each boiler capacity was rated at 1 million Btu/h and the hot water generated was stored on-site in two 600 gallon insulated tanks (Figure 9). In discussion with support staff, the total facility hot water demand was unclear. Operational data was not available and methods to characterize flow of natural gas or water were not installed. Under the context of the Energy Commission grant, installing enough capacity to replace both boilers was estimated to be larger than what was economically possible. The path forward was determined to augment the existing boiler capacity with the solar-assisted system. Therefore, the Equinox Heating System at the Courtside Cellars site is not a standalone system providing the only hot water to the site. There are actually two systems operating in a parallel mode servicing the site. This was done to insure uninterrupted hot water availability for production and allowed for more flexibility in operation and maintenance for the end user. A block diagram of the two systems is presented in Figure 10.

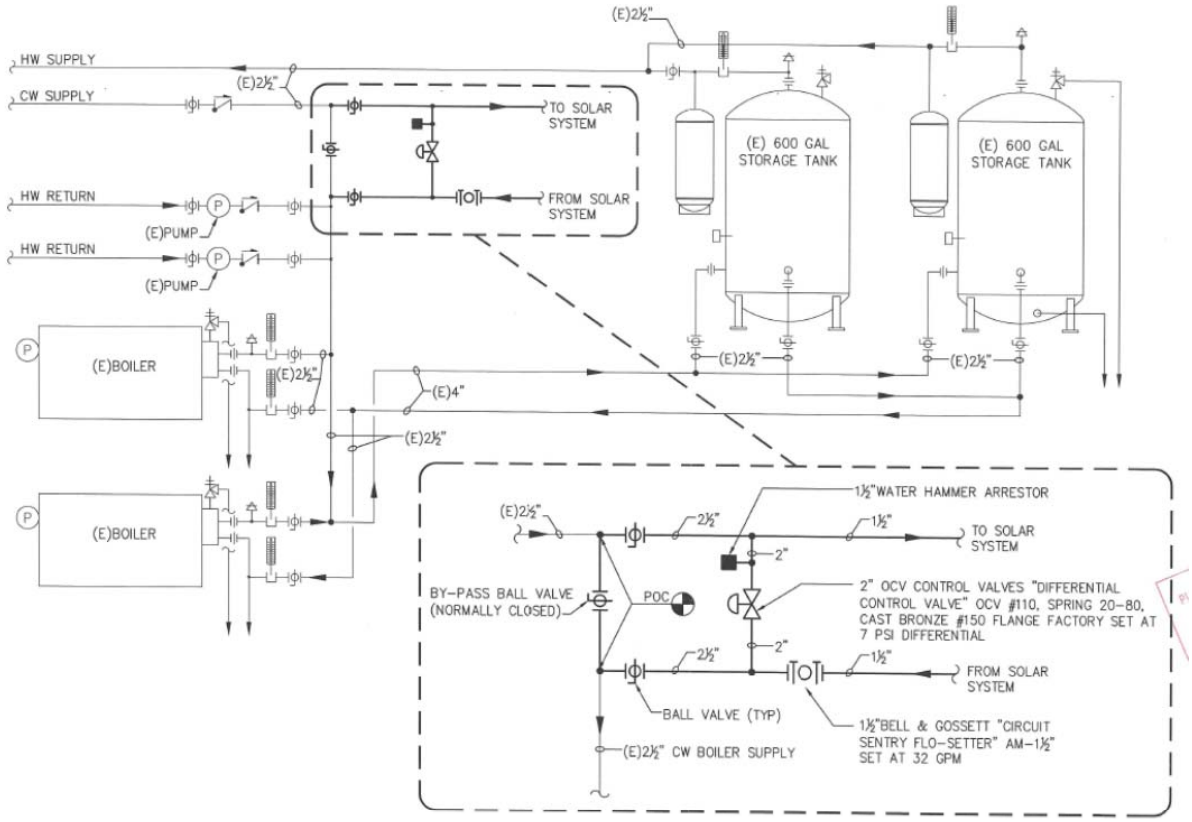
Figure 9: Pre-Retrofit System, Existing Boiler (Top) and Storage Tanks (Bottom)

Figure 10: Equinox and Redundant Boiler System at Courtside Cellars



In the post-retrofit system the primary heat for generation of hot water was supplied from the Equinox Heating System. A 2-inch differential control valve on the cold water supply determines when and how much water bypasses the Equinox Heating System during high water usage. The Equinox Heating System supplied hot water to the storage tanks during low water demand and the existing boilers maintain the storage tank temperatures and provide the necessary heating capacity during high water usage periods. A 1/5" Bell & Gossett Circuit Sentry Flow-Setter was set to handle a maximum flow of 32 gpm from the Equinox (Figure 11). Under high hot water demands of the production facility, greater than 32 gpm, under the post-retrofit system, the existing Raypak boilers provided back up for the Equinox Heating System. Flexibility was installed in the piping that allows for the solar loop to be completed isolated if necessary.

Figure 11: Process Hot Water Schematic



2.3 Equipment Layout Plan

The Equinox Heating System was installed in the boiler room of the winery and in a small annex next to the main production facility (Figure 12). The majority of components (i.e. atmospheric storage tanks and tankless water heaters) where located internal to the boiler room near the existing boilers. A small roof covered area outside of this boiler room was used to mount the solar thermal collectors. Under this roof is located two six hundred gallon hot water storage tanks that supply hot water to the production facility. In addition, the system package includes all manifold piping, solar controller, pumps, and hardware for system installation. The system manifolds were completely fabricated and leaked tested at the Solar Usage Now production facility prior to shipment.

A Piping and Instrumentation Diagram (P&ID) was created to document the piping loops and crucial measurement locations for performance validation. Natural gas flow rate to the tankless water heaters was measured using a standard diaphragm gas meter. A larger rotary gas meter was used to measure the natural gas flow to the existing hot water boilers. Water flow rates were measured utilizing turbine meters at the required locations for system analysis. System temperatures were measured using thermocouples located within the piping system. A drawing of instrumentation deployed for testing and analysis of this system is presented in Figure 13.

Figure 12: Site Layout at Courtside Cellars

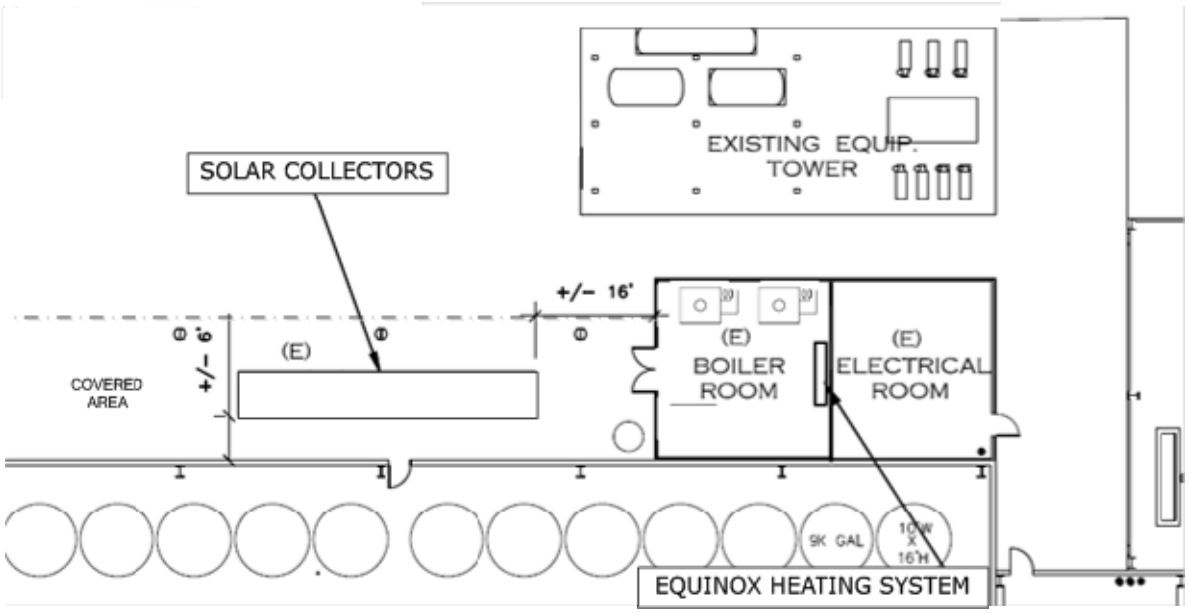
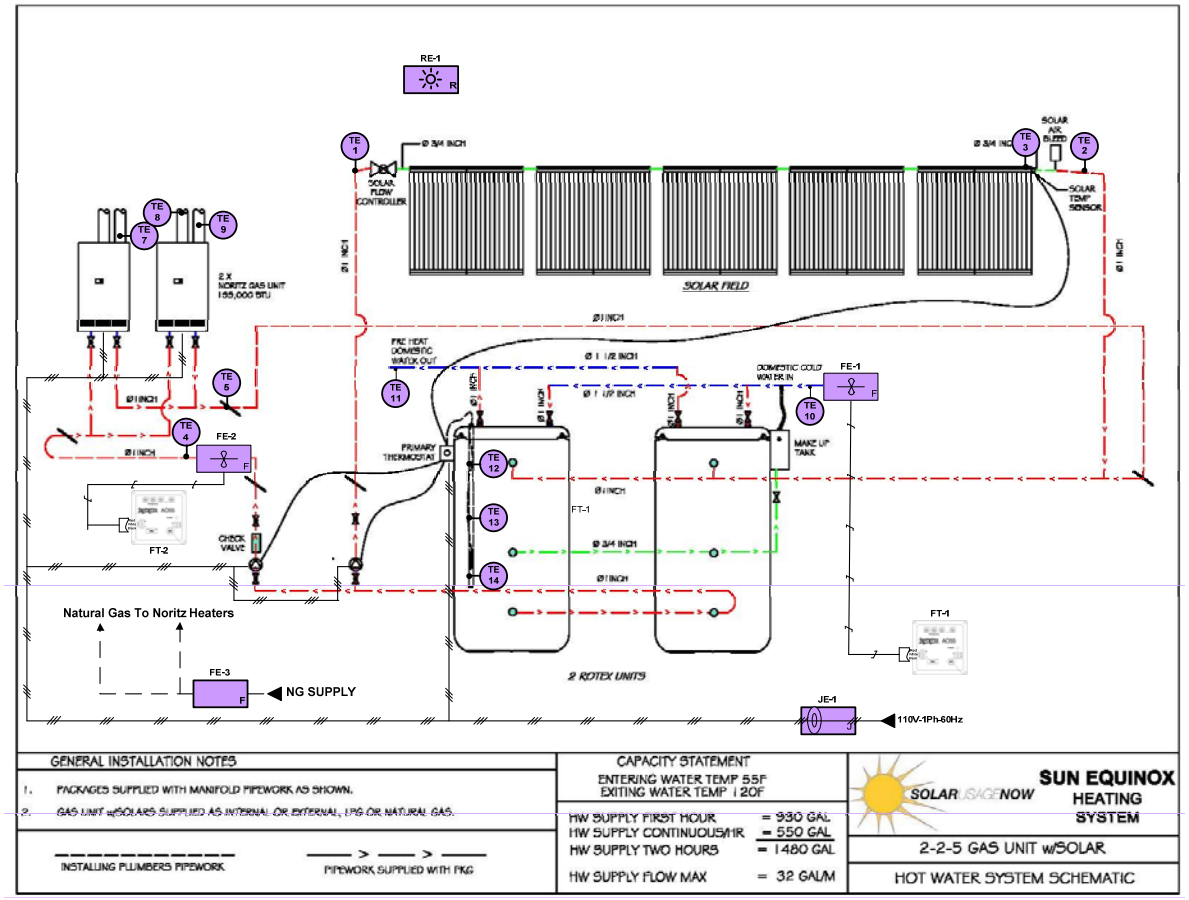


Figure 13: System Piping and Instrumentation Diagram



A list of measurement points was generated to characterize system and individual component performance, see Table 2. The approach allowed for a thermodynamic envelope to be drawn around individual components of the system or total system itself. Sufficient measurement points allow for identification of operation and calculation of efficiency.

Table 2: Relevant Measurement Devices

Instrument				Specification	
Tag Number			Service Description	Manufacturer	Model #
RE	1		Pyranometer	Hukseflux	IP02
FT	1		Water Supply to Solar System	Seametrics	AO55M
FE	1			Seametrics	TX81B/TF81TC-B-150
FT	2		Water Flow to Heaters	Seametrics	AO55W
FE	2			Seametrics	SEB-075
FT	5		Water Flow to Boilers	Seametrics	AO55M
FE	5			Seametrics	TX81B/TF81TC-B-200
FT	3		NG Supply to Heaters	Itron	400A
FT	4		NG Supply to Boilers	Romet	RM3000-DCID
JT	1		Electric Power	Continental Control Systems	ACT-0750-020
TE	1		Solar Array Inlet	Omega Eng	HTMQSS-125U-6
TE	2		Solar Array Outlet	Omega Eng	HTMQSS-125U-6
TE	3		Solar Array Header	Omega Eng	HTMQSS-125U-6
TE	4		Heaters Inlet	Omega Eng	HTMQSS-125U-6
TE	5		Heaters Outlet	Omega Eng	HTMQSS-125U-6
TE	7		Heater #1 Flue	Omega Eng	HTMQSS-125U-6
TE	8		Heater #2 Air Inlet	Omega Eng	HTMQSS-125U-6
TE	9		Heater #2 Flue	Omega Eng	HTMQSS-125U-6
TE	10		Water Supply	Omega Eng	HTMQSS-125U-6
TE	11		Hot Water Outlet	Omega Eng	HTMQSS-125U-6
TE	12		Tank #1 Top	Omega Eng	HTMQSS-125U-12
TE	13		Tank #1 Middle	Omega Eng	HTMQSS-125U-30
TE	14		Tank #1 Bottom	Omega Eng	HTMQSS-125U-53
TE	18		Boiler #1 Flue	Omega Eng	HTMQSS-125U-6
TE	19		Boiler #1 Inlet	Omega Eng	SA1-T
TE	20		Boiler #1 Outlet	Omega Eng	SA1-T
TE	21		Boiler #2 Flue	Omega Eng	HTMQSS-125U-6
TE	22		Boiler #2 Inlet	Omega Eng	SA1-T
TE	23		Boiler #2 Outlet	Omega Eng	SA1-T

Equinox Heating System uses a prebuilt modular flexible design that can meet any hot water demand. The system is configured so it can be torn down, shipped and wheeled right through most common doorways. The system can be configured to fit in a straight line, back to back and corner configurations. Solar Usage Now carries a large inventory of all key components (solar panels, water heater, storage tank, pump and controller) for a quick turnaround. Solar Usage Now sizes, designs and manufactures the system to precisely fit the customer needs and field installations requirements. The components are preassembled and pressure tested in Solar Usage Now's 30,000 ft^2 facility in Hamilton, Indiana in the final field application configuration. All copper plumbing components are assembled using ProPress fittings (Figure 14). The assembled system is then broken down into color coded modules prior to shipment, to facilitate assembly at the jobsite.

Figure 14: Copper Plumbing using ProPress Fittings

2.4 Calculations and Analysis of Data

An energy balance outline has been developed in order to analyze the energy consumption of each system component in detail. Based upon this outline the following equations have been used by GTI in developing a performance analysis spreadsheet that can be used for evaluation of commercial systems utilizing the Equinox Heating System.

Equation 1: System Fuel Efficiency

$$\frac{E_{(\text{hot water})}}{E_{(\text{natural gas})} + E_{(\text{electric})}\ E_{(\text{natural gas boilers})}}$$

Equation 2: Natural Gas Efficiency

$$\frac{E_{(\text{hot water})}}{E_{(\text{natural gas})} + E_{(\text{natural gas boilers})}}$$

where

$E_{(\text{hot water})}$ = Energy delivered to hot water

$E_{(\text{hot water})} = C_{p(\text{water})} \times \rho_w \times \Delta T_{\text{hot water}} \times F_{\text{hot water}}$

where $C_{p(\text{water})}$ = Specific heat of water (heat transfer fluid)

ρ_w = Density of water (heat transfer fluid)

$\Delta T_{\text{hot water}}$ = Hot water outlet [TE-11] – City water inlet [TE-10]

$F_{\text{hot water}}$ = Hot water flow rate [FE-1 + FE-5]

$E_{(\text{natural gas})}$ = Natural gas energy consumed by tankless water heater [FT-3]

$E_{(\text{natural gas boilers})}$ = Natural gas energy consumed by natural gas boilers [FT-4]

$E_{(\text{natural gas})/(\text{natural gas boilers})}$ = 1 scf of natural gas = 1027 Btu / scf

$E_{(electric)}$ = Electricity energy consumed [JT-1]

The Noritz Model NCC199 tankless water heater lists an Energy Factor (EF) 0.95. These efficiency levels are achieved by utilizing two heat exchangers, including a wet recuperative heat exchanger, manufactured from stainless steel. This heat exchanger condenses water from the combustion gases which is used to preheat the water. Equation 3 is used to see the gas efficiency of the tankless water heater in the field demonstration.

Equation 3: Tankless Water Heater Gas Efficiency

$$\frac{E_{(\text{water heater})}}{E_{(\text{natural gas})}}$$

where

$E_{(water\ heater)}$ = Energy delivered by the tankless water heater to the storage tank

$E_{(water\ heater)} = C_{p(water)} \times \rho_w \times \Delta T_{water\ heater} \times F_{water\ heater}$

where $C_{p(water)}$ = Specific heat of water (heat transfer fluid)

ρ_w = Density of water (heat transfer fluid)

$\Delta T_{water\ heater}$ = Tankless water heater loop outlet water [TE-4] – Tankless water heater loop inlet water [TE-5]

$F_{water\ heater}$ = Tankless water heater flow rate [FE-2]

Equation 4 summarizes the energy distribution of the solar thermal system.

Equation 4: Equinox Energy Balance

$$E(solar) + E(natural\ gas) + E(electric) = E(hot\ water) + E(loss)$$

where

$E_{(solar)}$ = Collected solar energy, measured at the level of the heat transfer

$E_{(solar)} = C_{p(water)} \times \rho_w \times \Delta T_{solar} \times F_{solar}$

where $C_{p(water)}$ = Specific heat of water (heat transfer fluid)

ρ_w = Density of water (heat transfer fluid)

ΔT_{solar} = Solar collector loop inlet water [TE-1] – Solar collector loop outlet water [TE-2]

F_{solar} = Solar collector water loop flow rate [FE-5]

$E_{(loss)}$ = Energy loss of tankless water heater and system standby heat loss

Equation 5: Efficiency of Solar Input

$$\frac{E_{(solar)}}{E_{(SA)}}$$

- $E_{(solar\ available)}$ = Total flux x total area of solar collector
- Total flux: MJ/m2 (IKJ = 0.9478 Btu)

2.5 Data Acquisition Systems

A data acquisition system based upon the Campbell Scientific CR1000 was used to collect data continuously at one-minute intervals during year-long evaluation of the solar hot water system. The CR1000 measures voltage and pulse signals, representing the magnitudes numerically or in specified engineering units from field instrumentation such as flow meters and thermocouples. All of data acquired by the CR1000 is stored in internal memory until transfer via cell modem to GTI. The Data Acquisition Systems (DAS), includes the CR1000 data logger, multiplexer, rechargeable battery, Verizon Raven XT Wireless Modem, and watt-node Meter, (Figure 15).

Two bundles of terminal (Yellow – thermocouple inputs, black – analog signal inputs) are pigtailed out of the enclosure, for easy to access, to connect thermocouples and other analog signal inputs at the site. Three power cords are also wired out of the enclosure, one is a main power cord connecting to the wall outlet for power and another two plugs are for connecting the Equinox Heating System and tankless water heater to monitor their power consumption (Figure 16).

Figure 15: System Assembly inside the Enclosure

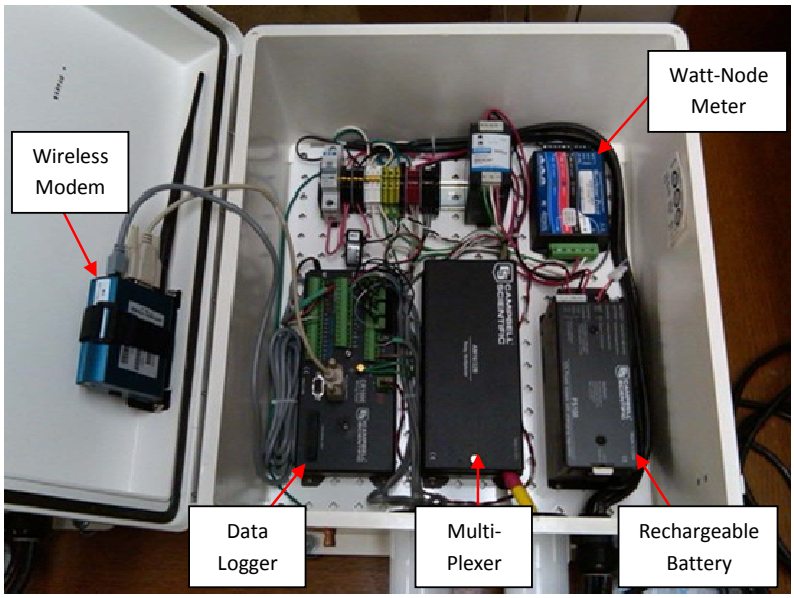


Figure 16: Enclosure for DAS

Pigtails for Thermocouples (Yellow) and Analog (Black) Inputs

2.6 Project Requirements

Basic requirements for implementation of the system at the host site included electric and mechanical interconnections, structural review of the site roof loading and the need for any modifications to accommodate the new system or to accommodate local code requirements,

addition of new stacks for the tankless water heaters, mechanical additions and modifications, and compliance with local permits. A comprehensive engineering drawing package was compiled for the site and is presented below.

2.6.1 Mechanical

PLUMBING LEGEND

SYMBOL	ABBREV.	DESCRIPTION
	BV	BALL VALVE
	CV	CHECK VALVE
		DIFFERENTIAL PRESSURE CONTROL VALVE
		CIRCUIT SETTER
		PIPE UP
		PIPE DOWN
		PIPE CONNECTION
	POC/POD	POINT OF CONNECTION OR DISCONNECTION
G	G	GAS (NATURAL OR PROPANE)
PCW	PCW	PROCESS COLD WATER
PHW	PHW	PROCESS HOT WATER
SCW	SCW	SOFT/REVERSE OSMOSIS COLD WATER

GENERAL

All work shall comply with current adopted state and local codes including CMC, CBC, CPC, and all applicable California Title-24 requirements.

Furnish all labor, materials, transportation, and perform all required operations to provide a complete and operable system, in accordance with the full intent and meaning of the Drawings, Specifications, and per standard trade practices.

The installation of piping and equipment shall be made in such a manner to clear beams and obstructions. Do not cut into or reduce the size of plates or any load carrying members without approval of the Architect. Check drawings and work of others to prevent interference.

PLUMBING

All locations of piping and equipment are shown diagrammatically. Adhere to locations as closely as possible. Vary runs or arrangement of piping as required to meet structural and other interferences or as required by Architect.

Pipe sizes shown on drawings shall be installed as shown. Branch line sizes to fixtures when not indicated shall be per minimum branch line size as indicated on fixture schedule. Equipment and appliance supply piping shall be as indicated on drawings. Contractor shall verify size of equipment or appliance connection and provide reducing fittings to suit.

No product will be accepted on the job site without prior approval by the Architect. The Contractor shall submit catalog sheets of all plumbing equipment.

PLUMBING MATERIALS

Domestic Water Piping:

Piping above ground and within building shall be type "L" hard drawn copper tube made up with copper press fittings with EPDM o-rings by Viega, Rigid or equal. No type "M" copper water piping is permitted within the building.

Gas Piping:

Piping exposed to the weather shall be standard weight Schedule 40 pipe made up with standard weight welded fittings. Pipe and fittings shall be primed and painted.

Gas piping within the building shall be standard weight Schedule 40 T&C black pipe made up with banded black malleable iron fittings.

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BMA JOB #12137.00

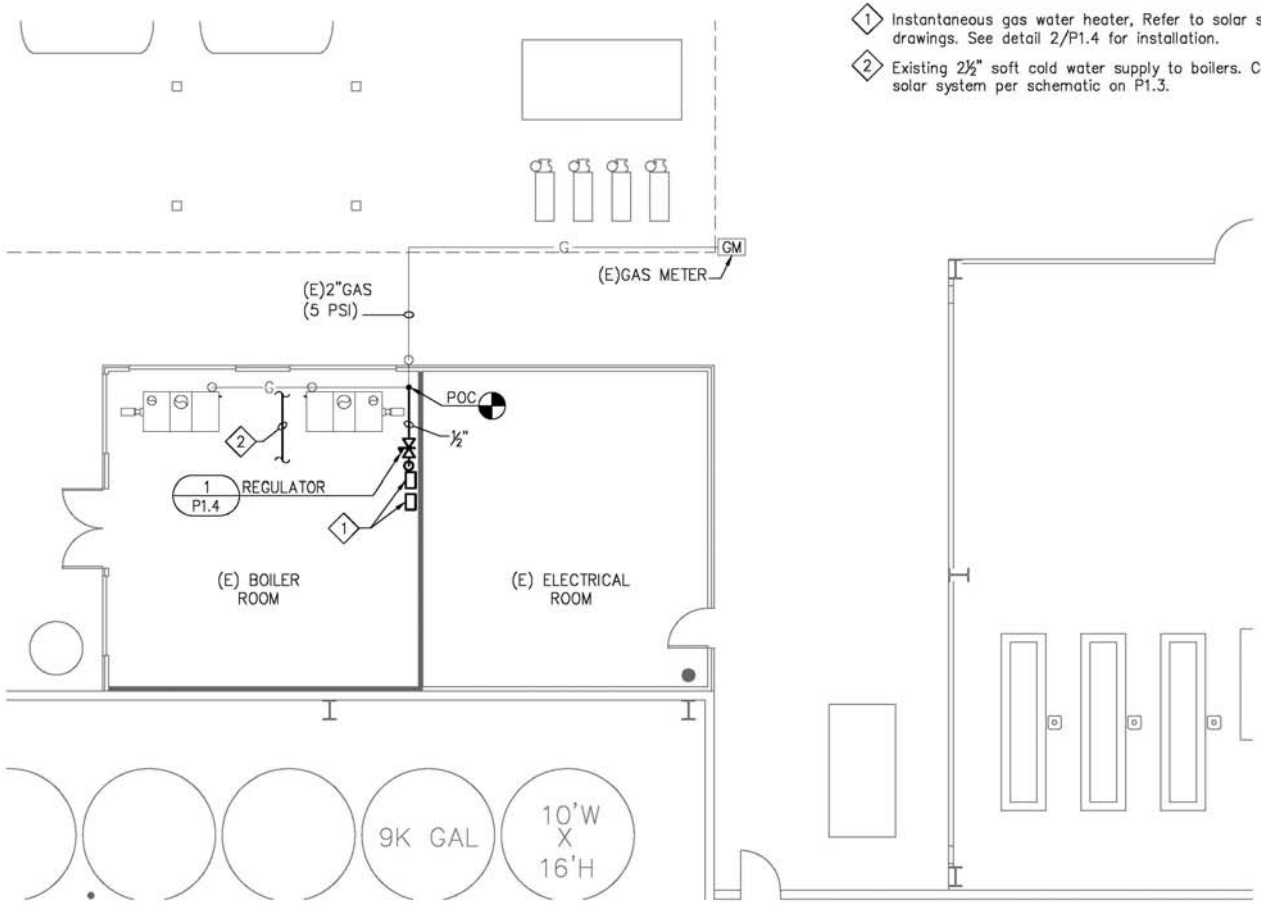
REGISTERED PROFESSIONAL ENGINEER
BRANDON ROGERS
M-35,682
EXP 6/30/13
MECHANICAL
STATE OF CALIFORNIA

Project

Courtside Cellars Solar Hot Water

Date: May 4, 2012

P1.1



REFERENCE NOTES

1. Instantaneous gas water heater, Refer to solar system drawings. See detail 2/P1.4 for installation.
2. Existing 2½" soft cold water supply to boilers. Connect to solar system per schematic on P1.3.

PLUMBING FLOOR PLAN

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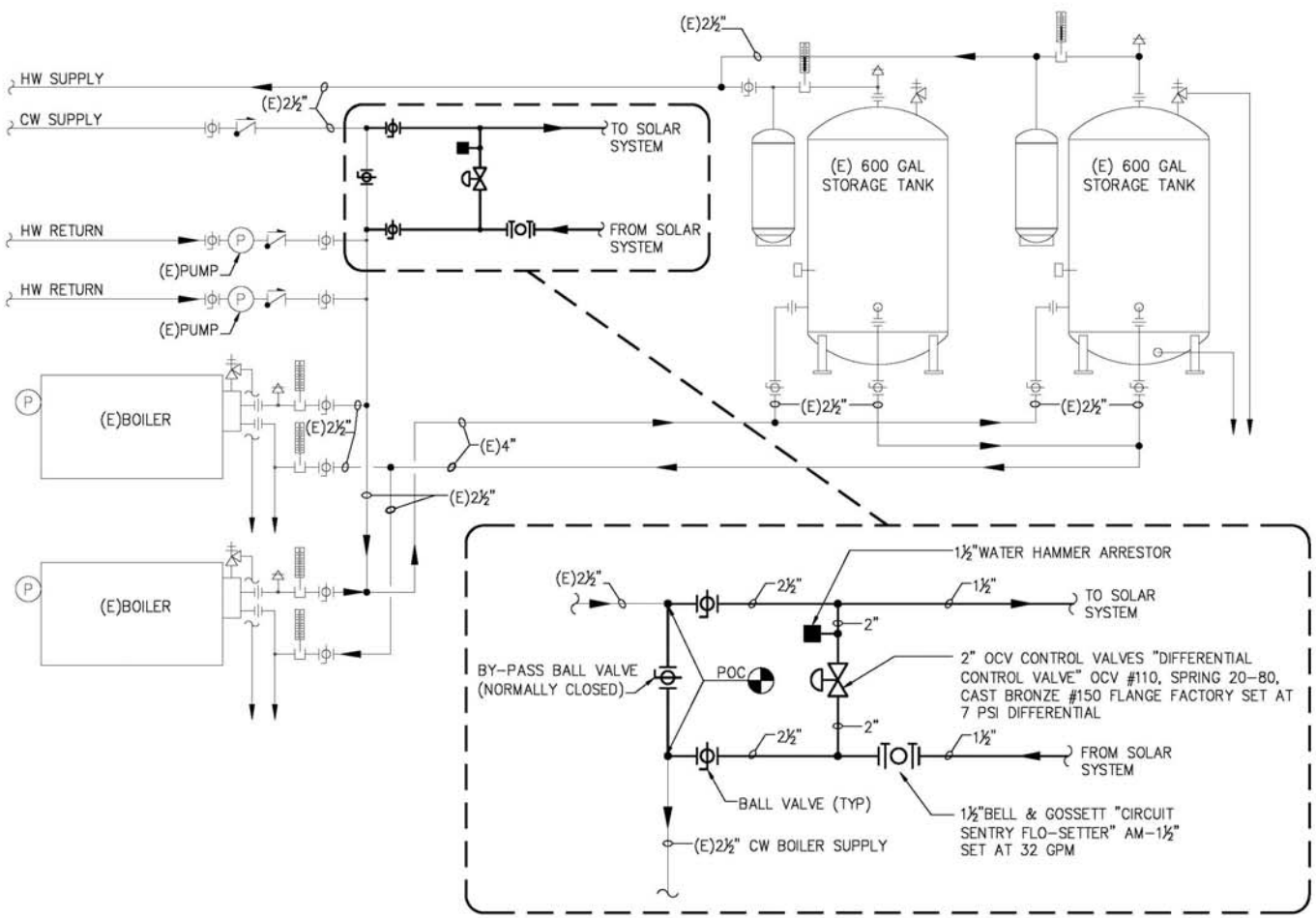
Project

Courtside Cellars Solar Hot Water

Date: May 4, 2012

P1.2



PROCESS HOT WATER SCHEMATIC

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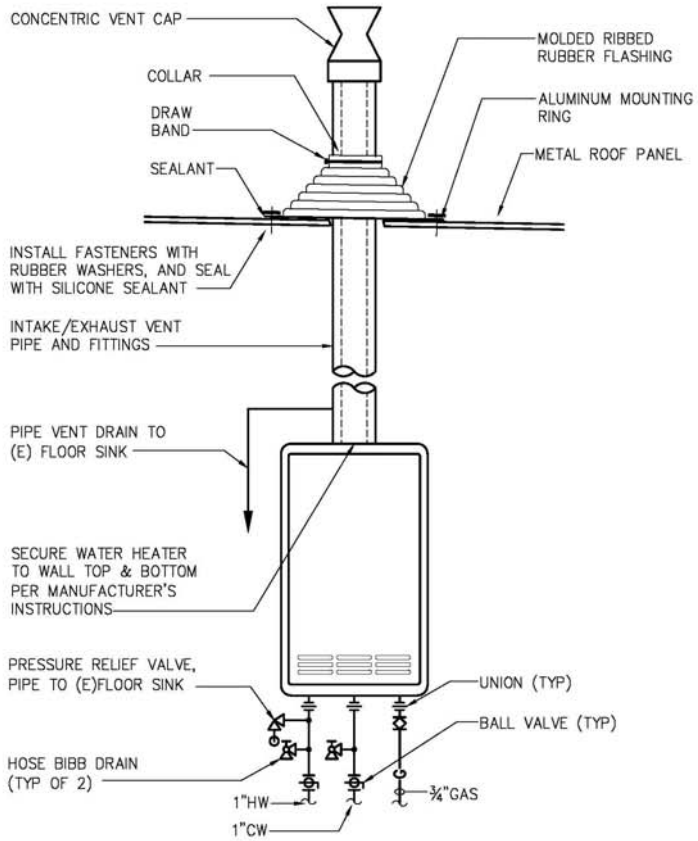
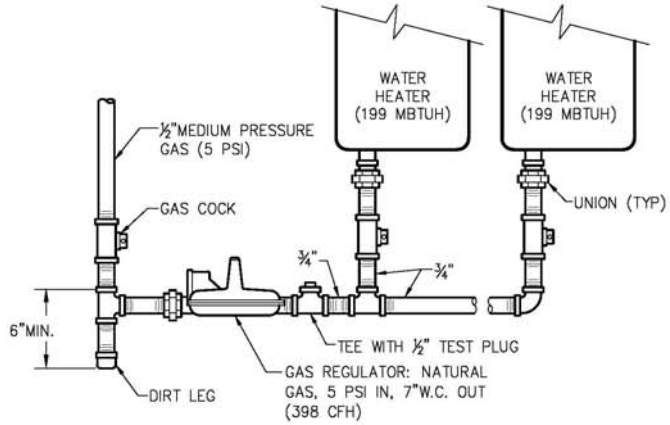
Project
Courtside Cellars Solar Hot Water

Date: May 4, 2012

P1.3



2 WATER HEATER



1 GAS REGULATOR

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Project

Courtside Cellars Solar Hot Water

Date: May 4, 2012

P1.4

2.6.2 Electrical

GENERAL NOTES

1. CODE COMPLIANCE: ALL WORK SHALL CONFORM TO AND BE PERFORMED IN ACCORDANCE WITH CODES, STANDARDS, AND ORDINANCES AS SET FORTH BY THE AUTHORITIES HAVING JURISDICTION AND THEIR LATEST ADOPTED EDITIONS (IN EFFECT AT TIME OF BUILDING PERMIT APPLICATION) OF THE FOLLOWING PUBLICATIONS:

   A. CALIFORNIA CODE OF REGULATIONS TITLE 24; INCLUDES 2008 NATIONAL ELECTRICAL CODE, 2010 INTERNATIONAL FIRE CODE, 2010 INTERNATIONAL BUILDING CODE, ETC. WITH CALIFORNIA AND OTHER LOCAL AMENDMENTS AS APPLICABLE.

   B. AMERICANS WITH DISABILITIES ACT (ADA).

2. SAFETY: THE ELECTRICAL CONTRACTOR IS RESPONSIBLE TO MAINTAIN ALL EQUIPMENT IN A SAFE AND RESPONSIBLE MANNER. KEEP DEAD FRONT EQUIPMENT IN PLACE WHILE EQUIPMENT IS ENERGIZED. CONDUCT ALL CONSTRUCTION OPERATIONS IN A SAFE MANNER FOR EMPLOYEES AS WELL AS OTHER WORKPERSONS OR ANYONE VISITING THE JOB SITE. PROVIDE BARRIERS, FLAGS, TAPE, ETC. AS REQUIRED FOR SAFETY. THE CONTRACTOR SHALL HOLD ALL PARTIES HARMLESS OF NEGLIGENT SAFETY PRACTICES, WHICH MAY CAUSE INJURY TO OTHERS ON OR NEAR THE JOB SITE.

3. FIRE RATED ASSEMBLIES SHALL MAINTAIN RATINGS AS SPECIFIED IN THE CALIFORNIA BUILDING CODE CHAPTER 7. CONTRACTOR SHALL PROVIDE AND INSTALL PHYSICAL ENCLOSURE AROUND FIXTURES, PANELS, ETC. AS REQUIRED. ALL ASSEMBLIES TO BE PENETRATED SHALL BE INSTALLED WITH APPLICABLE THROUGH-PENETRATION FIRESTOP SYSTEM AS DETERMINED BY UL CLASSIFICATION. BEFORE CONSTRUCTION, VERIFY AND COMPLY WITH REQUIREMENTS OF LOCAL AUTHORITY HAVING JURISDICTION.

4. PENETRATIONS MADE TO THE EXISTING BUILDING SHALL BE PROPERLY SEALED AND REPAIRED IN A METHOD ACCEPTABLE TO THE CIVIL ENGINEER AND FACILITY MANAGER.

5. MOUNTING HEIGHTS SHALL BE AS FOLLOWS UNLESS OTHERWISE NOTED:

   +15" AFF: RECEPTACLES, TELEPHONE, TV & DATA OUTLETS. (MEASURED BOTTOM OF OUTLET BOX)
   +48" AFF: LIGHT SWITCHES. (MEASURED TOP OF OUTLET BOX)
   +48" AFF: FIRE ALARM MANUAL PULL STATIONS, T-STATS. (MEASURED TOP OF OUTLET BOX)
   THE LOWER OF +80" AFF TO BOTTOM OF LENS, OR 6" BELOW CEILING: FIRE ALARM VISUALS.

   ELECTRICAL SWITCHES: CONTROLS AND SWITCHES INTENDED TO BE USED BY THE OCCUPANT OF THE ROOM OR AREA TO CONTROL LIGHT AND RECEPTACLE OUTLETS, APPLIANCES OR COOLING, HEATING AND VENTILATING EQUIPMENT, SHALL BE LOCATED NO MORE THAN 48 INCHES MEASURED FROM THE TOP OF THE OUTLET BOX NOR LESS THAN 15 INCHES MEASURED FROM THE BOTTOM OF THE OUTLET BOX TO THE LEVEL OF THE FINISH FLOOR OR WORKING PLATFORM. [CBC 1117B.6, ITEM 5.1]

   ELECTRICAL RECEPTACLE OUTLETS: ELECTRICAL RECEPTACLE OUTLETS ON BRANCH CIRCUITS OF 30 AMPERES OR LESS AND COMMUNICATION SYSTEM RECEPTACLES SHALL BE LOCATED NO MORE THAN 48 INCHES MEASURED FROM THE TOP OF THE RECEPTACLE OUTLET BOX OR RECEPTACLE HOUSING NOR LESS THAN 15 INCHES MEASURED FROM THE BOTTOM OF THE RECEPTACLE OUTLET BOX OR RECEPTACLE HOUSING TO THE LEVEL OF THE FINISH FLOOR OR WORKING PLATFORM [CBC 1117B.6, ITEM 5.2]

   BEFORE ROUGH-IN, VERIFY ALL MOUNTING HEIGHTS AND EXACT LOCATIONS FOR ALL EQUIPMENT ELECTRICAL CONNECTIONS, STUB-UPS, RECEPTACLES, OUTLETS, ETC. WITH ARCHITECT OR OWNER. PLACE DEVICES LOCATED ABOVE COUNTERS, SHELVING, ETC. AND IN BATHROOMS SO AS NOT TO CONFLICT WITH EDGES OF WAINSCOTING, COUNTER SPLASH, SHELVING, ETC. ARCHITECTURAL SHEETS SHALL GOVERN.

6. EQUIPMENT ANCHORAGE NOTE
   ALL MECHANICAL AND ELECTRICAL EQUIPMENT SHALL BE ANCHORED OR BRACED TO MEET THE HORIZONTAL AND VERTICAL FORCES PRESCRIBED IN THE 2010 CBC, SECTION 1615A.1.20 AND ASCE 7-05 SECTIONS 13.3, 13.4 & 13.6.

   THE ATTACHMENT OF THE FOLLOWING ITEMS SHALL BE DESIGNED TO RESIST THE FORCES PRESCRIBED ABOVE, BUT NEED NOT BE DETAILED ON THE PLANS:

   A. EQUIPMENT WEIGHING LESS THAN 400 POUNDS SUPPORTED DIRECTLY ON THE FLOOR OR ROOF.
   B. FURNITURE REQUIRED TO BE ATTACHED IN ACCORDANCE WITH PART 2, TITLE 24, C.C.R..
   C. TEMPORARY OR MOVABLE EQUIPMENT.
   D. EQUIPMENT WEIGHING LESS THAN 20 POUNDS SUPPORTED BY VIBRATION ISOLATORS.
   E. EQUIPMENT WEIGHING LESS THAN 20 POUNDS SUSPENDED FROM A ROOF OR FLOOR OR HUNG FROM A WALL.

   FOR THOSE ELEMENTS THAT DO NOT REQUIRE DETAILS ON THE APPROVED DRAWINGS, THE INSTALLATION SHALL BE SUBJECT TO THE APPROVAL OF THE MECHANICAL/ELECTRICAL ENGINEER.

   PIPING, DUCTWORK, AND ELECTRICAL DISTRIBUTION SYSTEM BRACING NOTE

   PIPING, DUCTWORK, AND ELECTRICAL DISTRIBUTION SYSTEMS SHALL BE BRACED TO RESIST THE FORCES PRESCRIBED IN ASCE 7-05 SECTION 13.3 AS DEFINED IN ASCE 7-05 SECTION 13.6.8, 13.6.7, AND 13.6.5.5, ITEM 6, RESPECTIVELY.

   THE STRUCTURAL ENGINEER OF RECORD SHALL VERIFY THE ADEQUACY OF THE STRUCTURE TO SUPPORT THE HANGER AND BRACE LOADS.

7. PULLROPES: ANY RACEWAY WITHOUT CABLE OR WIRE SHALL BE INSTALLED WITH MINIMUM 200 POUND TEST PULL LINE.

EXISTING BUILDINGS

8. EXISTING CONDITIONS: INFORMATION SHOWN FOR EXISTING CONDITIONS WAS PRIMARILY GAINED FROM "AS BUILT" DRAWINGS AND/OR LIMITED FIELD INVESTIGATION. BEFORE BID, VISIT SITE TO VERIFY EXISTING CONDITIONS AND MAKE ALLOWANCE FOR VARIATIONS FROM THAT SHOWN.

9. CLOSELY COORDINATE OUTAGE AND FACILITY DISRUPTION TIME WITH ARCHITECT AND OWNER. MINIMUM 72-HOUR NOTICE IS REQUIRED BEFORE ANY CIRCUIT SHUTDOWN OR DISRUPTION OF FACILITY PERSONNEL FUNCTIONING.

LEGEND

NOTE: INTERPRET IN CONTEXT

POWER/COMM.

- JUNCTION BOX
- SAFETY DISCONNECT

MISCELLANEOUS

- MOTOR
- THERMOSTAT
- CIRCUIT BREAKER
- FUSIBLE SWITCH
- PHASE
- GROUND

CONDUIT/WIRE

- NEW
- UNDERGROUND
- NEW POWER HOMERUN (3 HOTS & NEUT SHOWN)
- ISOLATED GROUND
- EXISTING TO REMAIN
- (E) POWER HOMERUN
- CONDUIT STUB (W/MARKER)
- VERTICAL CONDUIT RUN
- CONDUIT SEAL
- FLEXIBLE CONNECTION
- LOW VOLTAGE
- SURFACEMOUNT RACEWAY

ABBREVIATIONS

A	AMPERE
AF	AMP FUSE RATING
AFF	ABOVE FINISH FLOOR
AFG	ABOVE FINISH GRADE
AIC	AMPERES INTERRUPT CAPACITY
AS	AMP SWITCH RATING
BFG	BELOW FINISH GRADE
CB	CIRCUIT BREAKER
CEC	CA. ELECTRICAL CODE
CKT	CIRCUIT
C	CONDUIT
(E)	EXISTING
EC	ELECTRICAL CONTRACTOR
EF-#	EXHAUST FAN
(EXN)	(E) IN (N) LOCATION
(EXR)	(E) TO BE (R)
(F)	FUTURE
FA	FIRE ALARM
FACP	FIRE ALARM CONTROL PANEL
G	GROUNDING CONDUCTOR
GC	GENERAL CONTRACTOR
GFI	GROUND FAULT CKT INTERRUPTER
GND	GROUND
GRS	GALVANIZED RIGID STEEL
GWS	GANGED WITH SWITCH
IG	ISOLATED GROUND
KW	KILO-WATT
KVA	KILO-VOLTAMPERE
LTG	LIGHTING
MC	MECHANICAL CONTRACTOR
MCB	MAIN CIRCUIT BREAKER
MLO	MAIN LUGS ONLY
MSB	MAIN SWITCHBOARD
MTTB	MAIN TELEPHONE TERMINAL BOARD
(N)	NEW
NIC	NOT IN CONTRACT
NL	NIGHT LIGHT
NEC	NATIONAL ELECTRICAL CODE
P	POLE
(R)	RELOCATE(D)
TBR	TO BE REMOVED
TYP	TYPICAL
UC	UNDERCABINET
UG	UNDERGROUND
UON	UNLESS OTHERWISE NOTED
V	VOLT
VA	VOLT AMPERES
W	WATT, WIRE
WP	WEATHERPROOF (NEMA 3R)

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THOMA #12-8064

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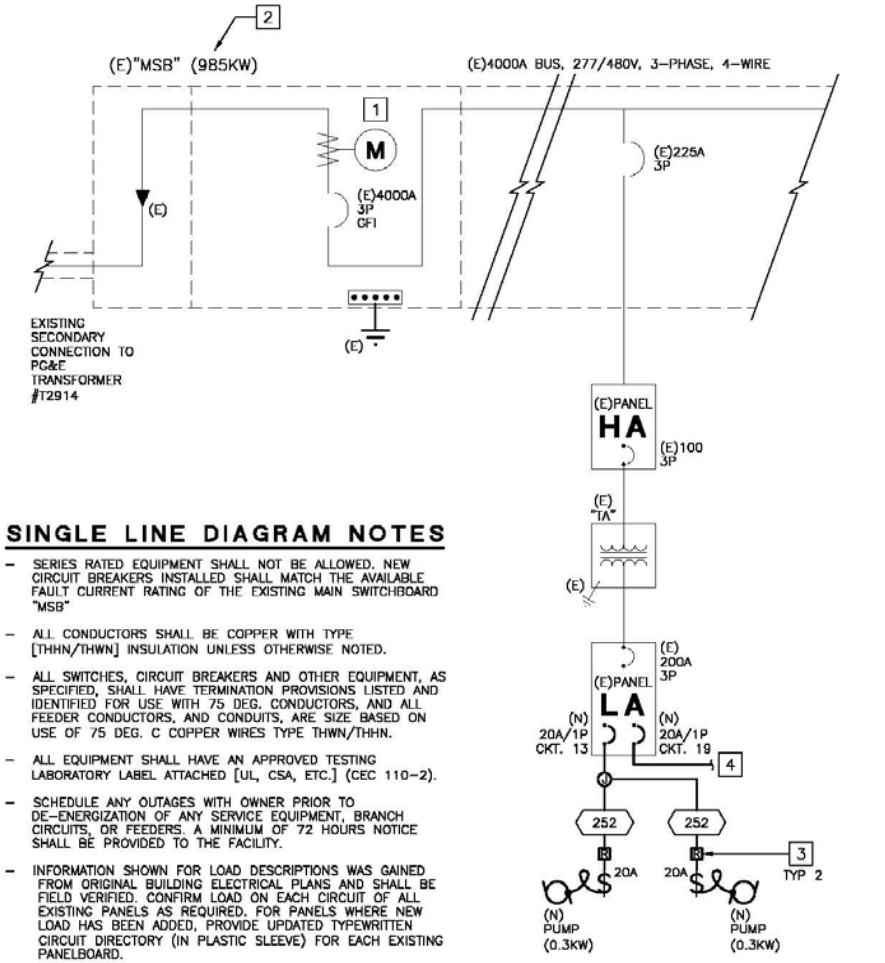
E-1

SOLAR WATER HEATING EQUIPMENT



SINGLE LINE DIAGRAM NOTES

- SERIES RATED EQUIPMENT SHALL NOT BE ALLOWED. NEW CIRCUIT BREAKERS INSTALLED SHALL MATCH THE AVAILABLE FAULT CURRENT RATING OF THE EXISTING MAIN SWITCHBOARD "MSB"
- ALL CONDUCTORS SHALL BE COPPER WITH TYPE [THHN/THWN] INSULATION UNLESS OTHERWISE NOTED.
- ALL SWITCHES, CIRCUIT BREAKERS AND OTHER EQUIPMENT, AS SPECIFIED, SHALL HAVE TERMINATION PROVISIONS LISTED AND IDENTIFIED FOR USE WITH 75 DEG. CONDUCTORS, AND ALL FEEDER CONDUCTORS, AND CONDUITS, ARE SIZE BASED ON USE OF 75 DEG. C COPPER WIRES TYPE THWN/THHN.
- ALL EQUIPMENT SHALL HAVE AN APPROVED TESTING LABORATORY LABEL ATTACHED [UL, CSA, ETC.] (CEC 110-2).
- SCHEDULE ANY OUTAGES WITH OWNER PRIOR TO DE-ENERGIZATION OF ANY SERVICE EQUIPMENT, BRANCH CIRCUITS, OR FEEDERS. A MINIMUM OF 72 HOURS NOTICE SHALL BE PROVIDED TO THE FACILITY.
- INFORMATION SHOWN FOR LOAD DESCRIPTIONS WAS GAINED FROM ORIGINAL BUILDING ELECTRICAL PLANS AND SHALL BE FIELD VERIFIED. CONFIRM LOAD ON EACH CIRCUIT OF ALL EXISTING PANELS AS REQUIRED. FOR PANELS WHERE NEW LOAD HAS BEEN ADDED, PROVIDE UPDATED TYPEWRITTEN CIRCUIT DIRECTORY (IN PLASTIC SLEEVE) FOR EACH EXISTING PANELBOARD.

SINGLE LINE DIAGRAM

REFERENCE NOTES

1. EXISTING PG&E METER NO. 1003746124.
2. PG&E DEMAND LOAD. SEE LOAD SUMMARY (THIS SHEET).
3. CONTROL RELAY (BY OTHERS). SEE WIRING SCHEMATIC ON SHEET E-3.
4. CONTINUATION TO SYSTEM LOADS. SEE SHEET E-3.

LOAD SUMMARY

PG&E CALCULATED DEMAND LOAD = 985 KW

DEMAND LOAD AT 125% + 1231 KW
(PER CEC REQUIREMENTS)

CONNECTED LOAD ADDITION: + 223 KW
(THOMA PROJ. 12-8063)

NET LOAD ADDITION: + 1 KW

TOTAL CONNECTED LOAD: = 1455 KW
= 1,751 AMPS
AT 277/480V, 3-PHASE

(E) PV SYSTEM: = 1 MW
= 1,504 AMPS CONT.
AT 277/480V, 3-PHASE

MSB TOTAL AT BUS: = 3,255 AMPS
AT 277/480V, 3-PHASE

*NET LOAD ADDITION DOES NOT EXCEED SERVICE RATING.

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REGISTERED PROFESSIONAL ENGINEER
WILLIAM A. THOMA
NO. 10757
ELECTRICAL
STATE OF CALIFORNIA

EXPIRES: 06/30/13
THOMA #12-8064

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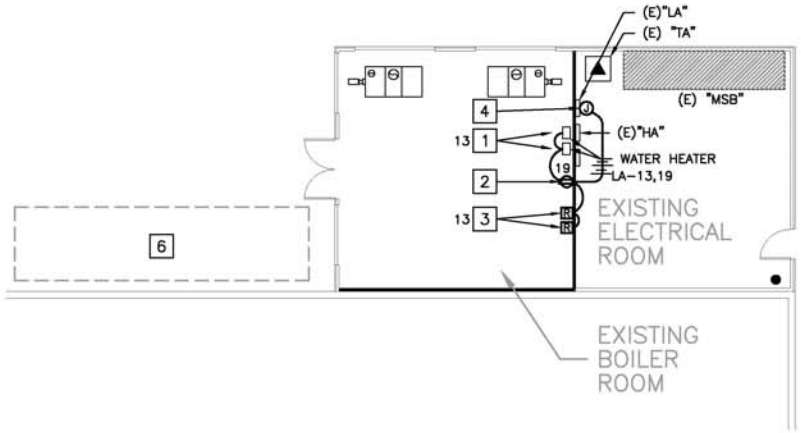
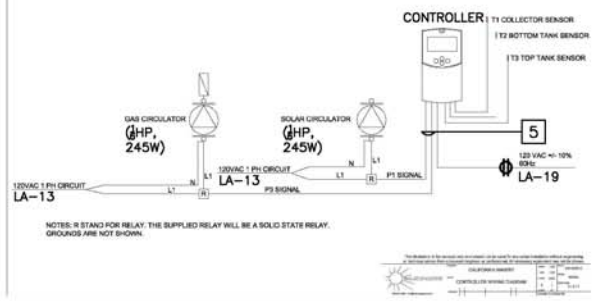
COPPER FEEDER SCHEDULE

FEEDER NO.	RACEWAY QUANTITY/SIZE	CONDUCTORS
252	(1) 3/4"C	(2) #12 THWN & (1) #12 GND.

E-2

SOLAR WATER HEATING EQUIPMENT





WIRING SCHEMATIC

NOTE: SHOWN FOR REFERENCE ONLY. FIELD VERIFY LOCATION OF SYSTEM COMPONENTS WITH OWNER/INSTALLER PRIOR TO ROUGH IN.

☐REFERENCE NOTES

1. INSTANTANEOUS GAS HOT WATER HEATER. SEE PLUMBING PLANS.
2. DUPLEX CONVENIENCE RECEPTACLE FOR SYSTEM CONTROLLER AND D/A SYSTEM. FIELD VERIFY LOCATION WITH SYSTEM INSTALLER PRIOR TO ROUGH-IN.
3. CONTROL RELAYS TO SOLAR WATER HEATING SYSTEM PUMPS (BY OTHERS). SEE SINGLE LINE DIAGRAM (SHEET E-2) AND WIRING SCHEMATIC (THIS SHEET). MOUNT RELAYS IN A NEMA 1 CABINET, SIZE AS REQUIRED. PROVIDE CABINET WITH HINGED, LOCKING COVER.
4. PROVIDE J-BOX ADJACENT TO EXISTING PANEL "LA" FOR CURRENT TRANSDUCER (BY OTHERS). ALL POWER WIRING (EXCLUDING THE D/A SYSTEM) SHALL ROUTE THROUGH THE CURRENT TRANSDUCER PRIOR TO TERMINATING AT PANEL "LA". FIELD COORDINATE WITH SYSTEM INSTALLER/MANUFACTURER REQUIREMENTS.
5. MINIMUM (1) 3/4" CONTROL CONDUIT. FIELD VERIFY ROUTING.
6. APPROXIMATE LOCATION OF SOLAR FIELD ARRAY ON ROOF. SHOWN FOR REFERENCE ONLY.

GENERAL NOTES

- ALUMINUM RIGID METAL CONDUIT AND / OR ALUMINUM ELECTRICAL METALLIC TUBING SHALL BE INSTALLED WITHIN INDOOR WET OR DAMP LOCATIONS (I.E. FACILITY PROCESSING AREAS, BARREL STORAGE, WASH DOWN, BOTTLING AREAS, ETC.). THE INSTALLATION SHALL BE IN ACCORD WITH CEC ARTICLES 344 AND 358 RESPECTIVELY. ALUMINUM BOXES, FITTINGS AND ENCLOSURES SHALL BE USED WITH ALUMINUM CONDUIT AT LOCATIONS SUBJECT TO CORROSIVE INFLUENCES. AVOID THE USE OF DISSIMILAR METALS TO PREVENT GALVANIC ACTION. ALUMINUM RIGID CONDUIT SHALL EMPLOY THREADED COUPLINGS. ALUMINUM METALLIC TUBING SHALL EMPLOY EITHER THREADED COUPLINGS OR USE ALUMINUM COMPRESSION COUPLINGS.
- ALUMINUM RIGID METAL OR GALVANIZED RIGID STEEL CONDUIT SHALL BE USED WHERE EXPOSED AND SUBJECT TO PHYSICAL DAMAGE NO LESS THAN 8' ABOVE FINISHED FLOOR.
- FINAL CONNECTIONS TO EQUIPMENT SHALL BE MADE IN AN APPROVED MANNER PER CODE AND MANUFACTURER REQUIREMENTS.
- GROUNDING CONDUCTORS SHALL BE INSTALLED IN ALL CONDUIT. GROUNDING CONDUCTORS SHALL BE SIZED PER THE SINGLE LINE DIAGRAM, SHEET E-2 OR CODE MINIMUM (IF NOT NOTED).
- FUSING: ALL FUSIBLE SAFETY DISCONNECT SWITCHES SHALL BE PROVIDED WITH DUAL-ELEMENT TIME DELAY TYPE FUSES SIZED AND RATED PER EQUIPMENT MANUFACTURERS' RECOMMENDATIONS. VERIFY WITH EQUIPMENT NAMEPLATE BEFORE INSTALLATION.
- INSTALL SEPARATE NEUTRALS FOR EACH BRANCH CIRCUIT/FEEDER.
- MOTOR OVERLOAD PROTECTION: WHERE REQUIRED BY NEC ARTICLE 430 PART C AND NOT SHOWN ON PLAN OR PROVIDED INTEGRAL WITH EQUIPMENT, PROVIDE AND INSTALL THERMAL OVERLOAD PROTECTION FOR ALL MOTORS.
- DEVICE LOCATIONS SHOWN ARE SCHEMATIC AND APPROXIMATE. EXACT LOCATIONS SHALL BE FIELD VERIFIED WITH EXISTING CONDITIONS DURING ROUGH-IN AND SHALL BE COORDINATED WITH OTHER TRADES TO AVOID CONFLICT WITH OTHER EQUIPMENT.

ELECTRICAL SITE PLAN

NORTH

SCALE: 3/32"=1'-0"

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E-3

SOLAR WATER HEATING EQUIPMENT

2.6.3 Structural

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(626) 793.7438 (626) 793.7439 fax

STRUCTURAL NOTES, DETAILS, & CALCULATIONS

PREPARED FOR:

PROJECT TYPE:

Solar Collector Addition to
Existing Structure

PROJECT ADDRESS:

Courtside Cellars LLC
2425 Mission Street
San Miguel, CA

CIVIL:

Wallace Group
612 Clarion Court
San Luis Obispo, CA 93401

COUNTY OF SAN LUIS OBISPO
PLANNING AND BUILDING DEPARTMENT
APPROVED WITH NOTED CORRECTIONS
DATE: 5.25.12
BY: STEVE HICKS
SUBJECT TO: ____
COMMENT: ____
THE APPROVAL OF THESE PLANS SHALL NOT BE CONSTRUED TO PERMIT VIOLATIONS OF ANY COUNTY ORDINANCE OR STATE LAW, AND SHALL NOT PREVENT THE COUNTY OF SAN LUIS OBISPO FROM REQUIRING CORRECTION OF ERROR OR OMISSIONS IN PLANS, SPECIFICATIONS OR CONSTRUCTION. A SET OF THESE APPROVED PLANS SHALL BE KEPT ON JOB SITE AT ALL TIMES. SUCH APPROVED PLANS SHALL NOT BE CHANGED, MODIFIED OR ALTERED WITHOUT AUTHORIZATION.

PROJECT ENGINEERS:

Joel Micek, P.E.
Nathan B. White, P.E., S.E., LEED AP BD+C

REGISTERED PROFESSIONAL ENGINEER
NATHANIEL B. WHITE
S 4818
Exp. 09-30-12
STRUCTURAL
STATE OF CALIFORNIA

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Job No.: *12042*
Job Name: *San Miguel Winery – Wallace Group*

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1.01

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STRUCTURAL SPECIFICATIONS

GENERAL

1. Do not scale drawings. Contractor shall use dimensions on architectural plans to lay out mechanical equipment, pads and other elements. If dimensional questions occur, Wallace Group must be consulted.

2. The contractor shall verify all dimensions and conditions and report any discrepancies to the engineer before proceeding with work. All dimensions on the plans are to be verified with the architect.

3. All construction and materials shall comply with and be installed in accordance with all the requirements of all legally constituted public authorities having jurisdiction, including all county and local ordinances, and the Safety Orders of the State Industrial Accident Commission, OSHA.

4. The Contractor shall be responsible for shoring and providing bracing during construction and/or erection to support all loads to which the structure may be subjected.

5. The Engineer will not be responsible for and will not have control or charge of construction means, methods, techniques, sequences, or procedures, or for safety precautions and programs in connection with the construction delineated by these plans. It should be understood that the contractor or his/her agent(s) shall supervise and direct all work and shall be solely and completely responsible for all construction means, methods, techniques, sequences, procedures, and conditions on the job site, including safety of all persons and property during the entire period of construction. Periodic observations by Taylor & Syfan Consulting Engineers Incorporated (or "Taylor & Syfan" typ.) personnel or representatives are not intended to include verification of dimensions or review the adequacy of the contractors safety measures on or near the construction site.

6. Substitutions of specified products (e.g. Simpson Strong-Tie) for equivalent products are not recommended. Substitutions shall be considered provided that the contractor follows the following steps prior to any substitutions being made:
   a) Contractor shall provide Taylor & Syfan with satisfactory evidence of product equivalence.
   b) If satisfactory, Taylor & Syfan shall revised plans and reprint at the contractors expense.
   c) Contractor shall resubmit plans to the Building Enforcement Agency for approval.

7. See architectural notes and specifications for additional requirements.

8. No deviations are allowed from the structural details without the written approval of the Engineer. Approval by Building Enforcement Agency, Inspector, Special Inspector, or any other party does not constitute authority to deviate from plans or specifications. All plan changes or addenda are subject to approval of the Building Enforcement Agency. The processing of changes, assembly of permit documents, and acquisition of permits is the responsibility of the Contractor.

9. Special Inspectors shall obtain Building Enforcement Agency clearance prior to any work commencement. Copies of the inspection report(s) to be filed by the special inspector(s) shall be given to the Engineer. The Contractor is responsible for scheduling, coordination, and expenses involved in any and all inspections.

1.02

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STRUCTURAL SPECIFICATIONS

10. Taylor & Syfan's drawings are prepared to convey only specific structural aspects of each detail. Non-structural information, including but not limited to fenestrations, fire-resistance, corrosion protection, insulation, finishes, waterproofing, drainage and flashing may not be included in the structural drawings. Taylor & Syfan is not responsible for non-structural information. The Contractor shall obtain the non-structural information for each detail from others.

11. The Building Inspector shall inspect and approve all construction for conformance to the construction documents and building code. Additionally, structural observation by Taylor & Syfan is recommended to verify general conformance.

12. All construction projects require inspection and maintenance following completion.. Operation, inspection, and maintenance are the sole responsibility of the Owner. The Engineer shall have no responsibility for any failures due to deviance from or neglect of the proper installation procedures, or for any failures by the Owner or Others to properly operate, inspect, or maintain the project.

13. The drawings, calculations, notes and specifications contained herein and provided herewith are the exclusive property of Taylor & Syfan, Copyright © 2012. The use of these calculations and specifications shall be restricted to this specific project and publication thereof is expressly limited to such use. Reproduction or publication by any method, in whole or in part, is prohibited without written permission of Taylor & Syfan. Title to these drawings, calculations, notes and specifications shall remain with Taylor & Syfan without prejudice.

WOOD

1. Lumber: shall be Douglas Fir-Larch, S4S, unless noted otherwise (this does not include Douglas Fir-Larch-North or Douglas Fir-South), and it shall be manufactured, graded, and bear the grade mark of WCLIB Standard Grading Rules 16 or WWPA Grading Rules; moisture content at time of installations shall not be over 19% or less than 7%.
   a) Light framing: 1x, 2x and 3x shall be Douglas Fir-Larch #2 or better UNO; 4x and larger shall be Douglas Fir-Larch #1 or better UNO.
   b) Preservative Treatment: Lumber exposed to weather or moisture shall be preservative pressure-treated per AWPA Standards and 2010 CBC Section 2304.11. Each piece of lumber shall bear the mark of an approved testing agency. ACQ-treated shall be used when it is exposed to weather or may come into contact with moisture or "liquid" water (e.g. rain, seepage, surface run-off, etc.). The maximum moisture content of treated wood is 14%. When necessary to cut, notch, bore or splice treated lumber, thoroughly paint newly cut surfaces with same preservative used in the original treatment of the lumber.

2. Rough Hardware:
   a) Nails: Provide common wire nails as indicated in the Fastening Schedule (2010 CBC Table 2304.9.1) and the Structural Plans. See requirements below for fasteners in treated wood.
   b) Bolts, Nuts, Washers, Lag & Wood Screws shall be of standard manufacture, conforming to the National Design Specification (NDS) of the American Forest & Paper Association (AF&PA), 2005 Edition.
   c) Framing Connectors:
      i. Metal connectors for wood construction shall be Simpson Strong-Tie or approved equal, unless noted otherwise. Approved Equals may only be used with prior approval from the Building Department and the Engineer.
      ii. Connectors shall be galvanized or have another factory-applied protective finish.

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STRUCTURAL SPECIFICATIONS

iii. Connectors and hardware exposed to weather shall have minimum G185 factory galvanized coating (or equivalent) or shall be post hot-dip galvanized or shall be stainless steel.

3. General Installation Requirements: Fabricate, size, install, connect, fasten, bore, notch, and cut wood and plywood with joints true, tight, and well-nailed, screwed or bolted as required, members to have solid bearing without being shimmed, unless noted otherwise. Set horizontal members subject to bending with the crown up. Install framing plumb, square, true and cut for full bearing. Splices are not permitted between bearings. Use full lengths unless otherwise specified. Notching, drilling, splicing, or cutting of any structural member is not permitted without prior approval. Reinforce or replace wood framing members damaged by erroneous cutting as directed by the engineer. Perform cutting for other trades under the direction of trade involved. Whenever necessary to avoid splitting, sub-drill for nails and screws with the diameter of the hole smaller than that of nails or screws.

4. Simpson SDS Screws: Install per manufacturer's specifications.

5. Special inspection requirements are per the Building Enforcement Agency.

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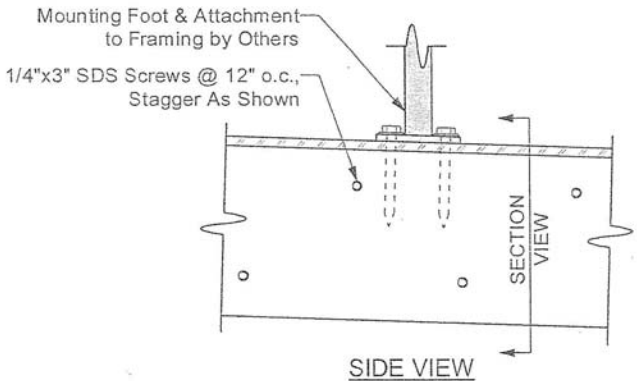
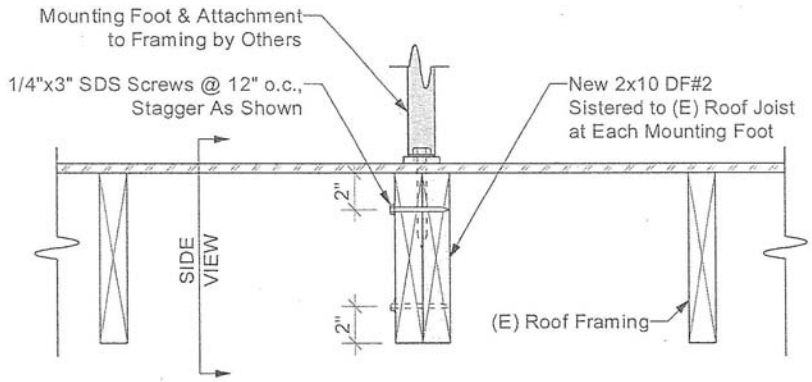
Page: 1.04

Job No.: 12042

Job Name: San Miguel Winery - Wallace Group



SIDE VIEW



SECTION VIEW

ROOF FRAMING REINFORCEMENT (1)

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Job No.: *12042*
Job Name: *San Miguel Winery – Wallace Group*

DESIGN PARAMETERS

General Design Parameters:

Governing Building Code	**2010 CBC**
Construction Type	Non-structural Component
Occupancy Category	II

Seismic Design Parameters:

See Lateral Calcs

Wood: Douglas Fir-Larch

Refer to the Structural Specifications for additional information

Note:
The intention of the structural calculations and drawings is to provide the structure with a minimum level of resistance to earthquake, wind, and gravity forces conforming to the requirements of the 2010 California Building Code (CBC), based upon the 2009 International Building Code (IBC). Taylor & Syfan Consulting Engineers, Inc. (the Engineer) provides no guarantees, expressed or implied, as to the adequacy of the CBC or IBC provisions.

These calculations, specifications, details and drawings are instruments of service and are the property of Taylor & Syfan Consulting Engineers, Inc. The information contained herein is for use on the specific project referenced above and shall not be used otherwise without the express written authorization of the Engineer.

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2010 CBC / 2009 IBC Load Sheet - Version 4.22

Project: **12042 – San Miguel Winery – Wallace Group**

ROOF LOADS

Roof Live Loads	
Flat Roof (<4:12) Live Loads	20.0 psf
Roof Dead Loads	
Standing Seam Metal Roofing	2.3 psf
1/2" Plywood	1.7 psf
Wood Framing	3.0 psf
Misc. Loads	1.0 psf
Total Dead Load	**8.0 psf**

Apricus AP-30 Collector Unit Wt. (gross dry wt.)	209 lbs
Apricus AP-30 Collector Unit Wt. X 5 Total Units on Roof	1045 lbs
Collector Wt. Distributed Over Affected Roof Area (16.5' x 40')	1.6 psf

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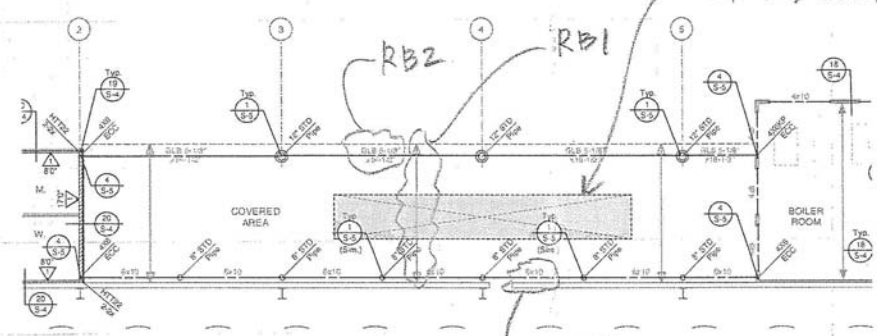
12042	2.03
PROJECT	SHEET
PROJECT ADDRESS	
JDM	
ENGINEER	DATE

ROOF FRAMING LAYOUT

APPROXIMATE LOCATION OF (N) SOLAR COLLECTORS

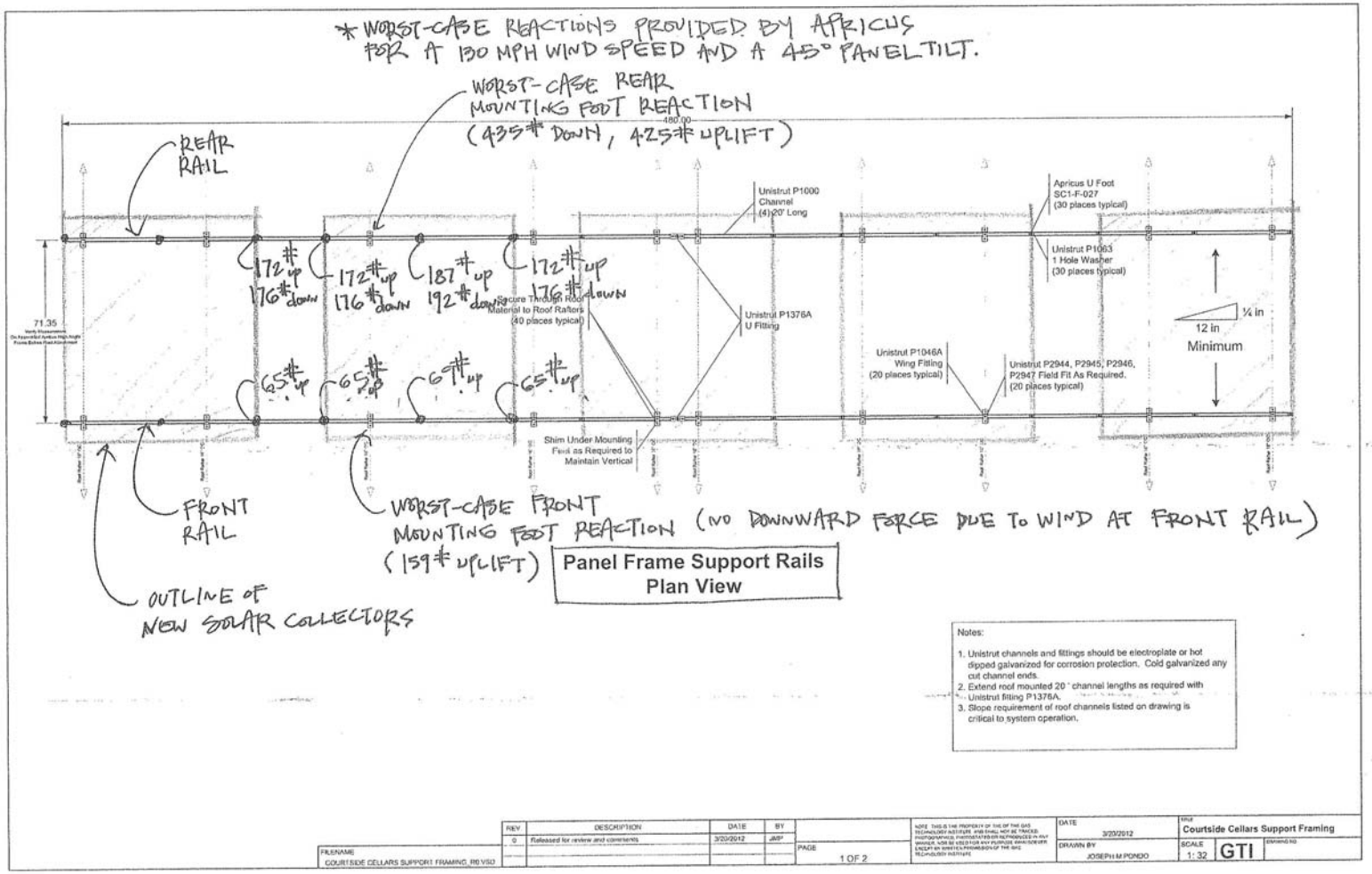


ROOF FRAMING PLAN

RB1 : TYP. SUPPORT BEAM FOR MOUNTING FOOT OF NEW SOLAR COLLECTOR FRAME

RB2 : (E) $5\frac{1}{8}" \times 16\frac{1}{2}"$ GLULAM

RB3 : (E) 6 x 10



Notes:

1. Unistrut channels and fittings should be electroplate or hot dipped galvanized for corrosion protection. Cold galvanized any cut channel ends.
2. Extend roof mounted 20 ' channel lengths as required with Unistrut fitting P1376A.
3. Slope requirement of roof channels listed on drawing is critical to system operation.

REV	DESCRIPTION	DATE	BY
0	Released for review and comments	3/20/2012	JMP

FILENAME: COURTSIDE CELLARS SUPPORT FRAMING_R0.VSD

PAGE 1 OF 2

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DATE: 3/20/2012

DRAWN BY: JOSEPH M PONDO

TITLE: Courtside Cellars Support Framing

SCALE: 1:32

GTI

DRAWING NO:

2-04

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2010 CBC / 2009 IBC – Beam-Joist Input Data – Version 5.10

Project: **12042 – San Miguel Winery – Wallace Group**

Description of Variables:			DL	LL	LLr	
	3r = 3 ft of roof trib w/out solar	Roof	8	0	20	psf
	2s = 2 ft of roof trib w/ solar	Roof	9.6	0	20	psf
	w = wall above and/or self wt.	Wall	12	0	0	psf

ROOF FRAMING

BEAM	TRIB (ft)	SPAN (ft)	W_{DL} (plf)	W_{LL} (plf)	W_{LLr} (plf)	Trib/Cant. (ft) / End	W_{DL} (plf)	W_{LL} (plf)	W_{LLr} (plf)	P_X (ft)	P_{DL} (lbs)	P_{LL} (lbs)	P_{LLr} (lbs)	P_W (lbs)	P_E (lbs)	Notes
RB 1	1.3 r		11	0	27											2-2x10 DF#2
	0.0 s		0	0	0					5.3	84			435/-159		comp/uplift at standoff
	0.0 w		0	0	0					11.3	84			0/-425		comp/uplift at standoff
	TL	**16.5**	**11**	**0**	**27**											
RB 2	0.0 r		0	0	0											(E) 5.125"x16.5" GLB OK
	9.5 s		91	0	190											
	1.5 w		18	0	0											
	TL	**27.0**	**109**	**0**	**190**											
RB 3	0.0 r		0	0	0											(E) 6x10 DF#1 OK
	9.5 s		91	0	190											
	1.0 w		12	0	0											
	TL	**13.5**	**103**	**0**	**190**											

2-05

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INNOVATIVE STRUCTURAL DESIGNS

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2.06

Page:

Job No:12042

Engr:JDM

Beam/Joist Design
Version 14.61 - 2009 IBC

MEMBER DATA:

Beam ID: RB1 - DL only
Type: Beam

Sds = 1.500
Ω = 2.500

SPAN DATA:	Span (ft)	Dead (plf)	Floor LL (plf)	Roof LL (plf)	1.0 W (plf)	Lu (ft)
Simple Span:	16.5	11.0	0.0	27.0	0.0	16.5

POINT LOADS:	X (ft)	DL (lbs)	Floor LL (lbs)	Roof LL(lbs)	1.0 W (lbs)	1.0 E (lbs)
P1	5.3	84.0	0.0	0.0	0.0	0.0
P2	11.3	84.0	0.0	0.0	0.0	0.0

LINEAR LOADS: No Linear Loads on Beam

REACTIONS: (Factored)

Load Combo	Left	Right	
1	174.2	175.3	D
3	397.0	398.0	D + Lr
4	341.3	342.3	D + .75L + .75Lr

STRESSES:

	Shears at Supports (lbs)		Maximum Moments (ft-lbs)	
Load Combo	V1R	V2L	Mx	X
1	174.2	-175.3	815.4	8.2
3	397.0	-398.0	1,734.2	8.2
4	341.3	-342.3	1,504.5	8.2

SOLUTIONS:

Member	fv / Fv	fb / Fb	Ireq / I	Gov. Combo	Δdl	Δll	x
2 - 2 x 8 DF 2	0.111	0.658	0.616	fv=3, fb=3, I=14	0.24	0.27	8.3
2 - 2 x 8 DF 1	0.111	0.493	0.548	fv=3, fb=3, I=14	0.21	0.24	8.3
2 - 2 x 10 DF 2	0.089	0.432	0.329	fv=3, fb=3, I=14	0.13	0.14	8.3
2 - 2 x 10 DF 1	0.089	0.324	0.292	fv=3, fb=3, I=14	0.11	0.13	8.3
2 - 9-1/2" TJI 110	0.969	0.540	0.743	fv=3, fb=3, I=14	0.29	0.32	8.3
2 - 9-1/2" TJI 210	0.969	0.485	0.623	fv=3, fb=3, I=14	0.24	0.27	8.3
2 - 9-1/2" TJI 230	0.969	0.437	0.568	fv=3, fb=3, I=14	0.22	0.25	8.3
2 - 2 x 12 DF 2	0.072	0.292	0.183	fv=3, fb=3, I=14	0.07	0.08	8.3
2 - 2 x 12 DF 1	0.072	0.219	0.162	fv=3, fb=3, I=14	0.06	0.07	8.3
2 - 11-7/8" TJI 110	0.351	0.202	0.218	fv=3, fb=3, I=14	0.09	0.09	8.3

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Job No:12042

Engr:JDM

Beam/Joist Design
Version 14.61 - 2009 IBC

MEMBER DATA:

Beam ID: RB1 - DL + WL downward
Type: Beam

Sds = 1.500
Ω = 2.500

SPAN DATA:	**Span** (ft)	**Dead** (plf)	**Floor LL** (plf)	**Roof LL** (plf)	**1.0 W** (plf)	**Lu** (ft)
Simple Span:	16.5	11.0	0.0	27.0	0.0	16.5

POINT LOADS:	**X** (ft)	**DL** (lbs)	**Floor LL** (lbs)	**Roof LL(lbs)**	**1.0 W** (lbs)	**1.0 E** (lbs)
P1	5.3	0.0	0.0	0.0	435.0	0.0

LINEAR LOADS: No Linear Loads on Beam

REACTIONS: (Factored)

Load Combo	Left	Right	
1	90.8	90.8	D
3	313.5	313.5	D + Lr
4	257.8	257.8	D + .75L + .75Lr
5	386.0	230.5	D + W
6	479.3	362.6	D + .75L + .75Lr + .75W
7	349.7	194.2	.6D + W

STRESSES:

	Shears at Supports (lbs)		Maximum Moments (ft-lbs)	
Load Combo	V1R	V2L	Mx	X
1	90.8	-90.8	374.3	8.3
3	313.5	-313.5	1,293.2	8.3
4	257.8	-257.8	1,063.5	8.3
5	386.0	-230.5	1,891.4	5.3
6	479.3	-362.6	2,101.2	5.3
7	349.7	-194.2	1,760.8	5.3

SOLUTIONS:

Member	fv / Fv	fb / Fb	Ireq / I	Gov. Combo	ΔdI	ΔlI	x
2 - 2 x 8 DF 2	0.106	0.623	0.485	fv=6, fb=6, I=13	0.11	0.27	8.3
2 - 2 x 8 DF 1	0.106	0.467	0.431	fv=6, fb=6, I=13	0.10	0.24	8.3
2 - 2 x 10 DF 2	0.085	0.409	0.259	fv=6, fb=6, I=13	0.06	0.14	8.3
2 - 2 x 10 DF 1	0.085	0.307	0.230	fv=6, fb=6, I=13	0.05	0.13	8.3
2 - 9-1/2" TJI 110	0.935	0.511	0.585	fv=6, fb=6, I=13	0.13	0.32	8.3
2 - 9-1/2" TJI 210	0.935	0.459	0.490	fv=6, fb=6, I=13	0.11	0.27	8.3
2 - 9-1/2" TJI 230	0.935	0.414	0.447	fv=6, fb=6, I=13	0.10	0.25	8.3
2 - 2 x 12 DF 2	0.069	0.277	0.144	fv=6, fb=6, I=13	0.03	0.08	8.3
2 - 2 x 12 DF 1	0.069	0.208	0.128	fv=6, fb=6, I=13	0.03	0.07	8.3
2 - 11-7/8" TJI 110	0.341	0.191	0.172	fv=6, fb=6, I=13	0.04	0.09	8.3

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Engr:JDM

Beam/Joist Design
Version 14.61 - 2009 IBC

MEMBER DATA:

Beam ID: RB1 - 0.6DL + WL uplift
Type: Beam

Sds = 1.500
Ω = 2.500

SPAN DATA:	**Span** (ft)	**Dead** (plf)	**Floor LL** (plf)	**Roof LL** (plf)	**1.0 W** (plf)	**Lu** (ft)
Simple Span:	16.5	11.0	0.0	27.0	0.0	16.5

POINT LOADS:	**X** (ft)	**DL** (lbs)	**Floor LL** (lbs)	**Roof LL(lbs)**	**1.0 W** (lbs)	**1.0 E** (lbs)
P1	5.3	0.0	0.0	0.0	-159.0	0.0
P2	11.3	0.0	0.0	0.0	-425.0	0.0

LINEAR LOADS: No Linear Loads on Beam

REACTIONS: (Factored)

Load Combo	Left	Right	
1	90.8	90.8	D
3	313.5	313.5	D + Lr
4	257.8	257.8	D + .75L + .75Lr
5	-151.1	-251.4	D + W
6	76.4	1.2	D + .75L + .75Lr + .75W
7	-187.4	-287.7	.6D + W

STRESSES:

Load Combo	Shears at Supports (lbs) V1R	V2L	Maximum Moments (ft-lbs) Mx	X
1	90.8	-90.8	374.3	8.3
3	313.5	-313.5	1,293.2	8.3
4	257.8	-257.8	1,063.5	8.3
5	-151.1	251.4	1,455.9	11.3
6	76.4	-1.2	416.2	11.3
7	-187.4	287.7	1,585.2	11.3

SOLUTIONS:

Member	fv / Fv	fb / Fb	Ireq / I	Gov. Combo	Δdl	Δll	x
☐ 2 - 2 x 8 DF 2	0.086	0.490	0.485	fv=3, fb=3, I=13	0.11	0.27	8.3
☐ 2 - 2 x 8 DF 1	0.086	0.368	0.431	fv=3, fb=3, I=13	0.10	0.24	8.3
■ 2 - 2 x 10 DF 2	0.068	0.322	0.259	fv=3, fb=3, I=13	0.06	0.14	8.3
☐ 2 - 2 x 10 DF 1	0.068	0.242	0.230	fv=3, fb=3, I=13	0.05	0.13	8.3
☐ 2 - 9-1/2" TJI 110	0.746	0.403	0.585	fv=3, fb=3, I=13	0.13	0.32	8.3
☐ 2 - 9-1/2" TJI 210	0.746	0.362	0.490	fv=3, fb=3, I=13	0.11	0.27	8.3
☐ 2 - 9-1/2" TJI 230	0.746	0.326	0.447	fv=3, fb=3, I=13	0.10	0.25	8.3
☐ 2 - 2 x 12 DF 2	0.043	0.218	0.144	fv=7, fb=3, I=13	0.03	0.08	8.3
☐ 2 - 2 x 12 DF 1	0.043	0.163	0.128	fv=7, fb=3, I=13	0.03	0.07	8.3
☐ 2 - 11-7/8" TJI 110	0.214	0.151	0.172	fv=7, fb=3, I=13	0.04	0.09	8.3

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Beam/Joist Design
Version 14.61 - 2009 IBC

MEMBER DATA:
Beam ID: RB2
Type: Beam

Sds = 1.500
Ω = 2.500

SPAN DATA:	**Span** (ft)	**Dead** (plf)	**Floor LL** (plf)	**Roof LL** (plf)	**1.0 W** (plf)	**Lu** (ft)
Simple Span:	27.0	109.0	0.0	190.0	0.0	27.0

POINT LOADS: No Point Loads on Beam

LINEAR LOADS: No Linear Loads on Beam

REACTIONS: (Factored)

Load Combo	Left	Right	
1	1,471.5	1,471.5	D
3	4,036.5	4,036.5	D + Lr
4	3,395.3	3,395.3	D + .75L + .75Lr

STRESSES:

	Shears at Supports (lbs)		Maximum Moments (ft-lbs)	
Load Combo	V1R	V2L	Mx	X
1	1,471.5	-1,471.5	9,932.6	13.5
3	4,036.5	-4,036.5	27,246.4	13.5
4	3,395.3	-3,395.3	22,917.9	13.5

SOLUTIONS:

Member	fv / Fv	fb / Fb	Ireq / I	Gov. Combo	Δdl	Δll	x
GLB 3.13" x 18.00"	0.289	0.646	0.969	fv=3, fb=3, I=14	0.48	0.83	13.5
GLB 3.13" x 19.50"	0.264	0.550	0.762	fv=3, fb=3, I=14	0.37	0.65	13.5
GLB 3.13" x 21.00"	0.242	0.474	0.610	fv=3, fb=3, I=14	0.30	0.52	13.5
GLB 3.13" x 22.50"	0.224	0.413	0.496	fv=3, fb=3, I=14	0.24	0.43	13.5
GLB 3.13" x 24.00"	0.208	0.363	0.409	fv=3, fb=3, I=14	0.20	0.35	13.5
GLB 5.13" x 16.50"	0.194	0.469	0.767	fv=3, fb=3, I=14	0.38	0.66	13.5
GLB 5.13" x 18.00"	0.176	0.394	0.591	fv=3, fb=3, I=14	0.29	0.51	13.5
GLB 5.13" x 19.50"	0.161	0.336	0.465	fv=3, fb=3, I=14	0.23	0.40	13.5
GLB 6.75" x 15.00"	0.164	0.431	0.775	fv=3, fb=3, I=14	0.38	0.66	13.5
GLB 5.13" x 21.00"	0.148	0.289	0.372	fv=3, fb=3, I=14	0.18	0.32	13.5

* All members assumed to be DF Grade 24F - 1.8E

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MEMBER DATA:
Beam ID: RB3
Type: Beam

Sds = 1.500
Ω = 2.500

SPAN DATA:	**Span** (ft)	**Dead** (plf)	**Floor LL** (plf)	**Roof LL** (plf)	**1.0 W** (plf)	**Lu** (ft)
Simple Span:	13.5	103.0	0.0	190.0	0.0	13.5

POINT LOADS: No Point Loads on Beam

LINEAR LOADS: No Linear Loads on Beam

REACTIONS: (Factored)

Load Combo	Left	Right	
1	695.3	695.3	D
3	1,977.8	1,977.8	D + Lr
4	1,657.1	1,657.1	D + .75L + .75Lr

STRESSES:

	Shears at Supports (lbs)		Maximum Moments (ft-lbs)	
Load Combo	V1R	V2L	Mx	X
1	695.3	-695.3	2,346.5	6.7
3	1,977.8	-1,977.8	6,674.9	6.7
4	1,657.1	-1,657.1	5,592.8	6.7

SOLUTIONS:

Member	fv / Fv	fb / Fb	Ireq / I	Gov. Combo	Δdl	Δll	x
4x10 DF 1	0.361	0.892	0.781	fv=3, fb=3, I=14	0.19	0.34	6.8
4x10 DF SS	0.361	0.713	0.740	fv=3, fb=3, I=14	0.18	0.32	6.8
4x12 DF 1	0.288	0.658	0.434	fv=3, fb=3, I=14	0.10	0.19	6.8
4x12 DF SS	0.288	0.526	0.411	fv=3, fb=3, I=14	0.10	0.18	6.8
6x 8 DF SS	0.301	0.887	0.978	fv=3, fb=3, I=14	0.23	0.43	6.8
4x14 DF 1	0.238	0.527	0.266	fv=3, fb=3, I=14	0.06	0.12	6.8
4x14 DF SS	0.238	0.422	0.252	fv=3, fb=3, I=14	0.06	0.11	6.8
6x10 DF 1	0.230	0.681	0.497	fv=3, fb=3, I=14	0.12	0.22	6.8
6x10 DF SS	0.230	0.545	0.471	fv=3, fb=3, I=14	0.11	0.21	6.8
4x16 DF 1	0.201	0.404	0.174	fv=3, fb=3, I=14	0.04	0.08	6.8

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2010 CBC / 2009 IBC Lateral Force Analysis - Version 3.43

Project: **12042 – San Miguel Winery – Wallace Group**

SPECTRAL ACCELERATIONS (ASCE 7-05)

(2010 CBC Section 1613.5)

S_S =	**1.178**	*per USGS**	Zip Code =	93451	
S_1 =	**0.523**	*per USGS**	Deg. Lat. =	35.7633	*per Google Earth*
F_a =	**1.0**	*per Table 1613.5.3(1)*	Deg. Long. =	-120.6986	*per Google Earth*
F_V =	**1.5**	*per Table 1613.5.3(2)*	Site Class =	**D**	*per Soils Report / per 2010 CBC 16*

2010 CBC Table 1613.5.3(1)

F_a = Site Coefficient (short period – 0.2 sec.)

Site Class	S_s <= 0.25	0.50	0.75	1.00	>= 1.25
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	Values per ASCE 7-05 Section 11.4.7				

a. Use straight-line interpolation for intermediate values

2010 CBC Table 1613.5.3(2)

F_V = Site Coefficient (long period – 1 sec.)

Site Class	S_1 <= 0.1	0.2	0.3	0.4	>= 0.5
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	Values per ASCE 7-05 Section 11.4.7				

a. Use straight-line interpolation for intermediate values

MAXIMUM CONSIDERED SPECTRAL RESPONSE

S_{MS} = $S_S F_a$ = 1.212 *per Equation 16-37*

S_{M1} = $S_1 F_V$ = 0.785 *per Equation 16-38*

DESIGN-LEVEL SPECTRAL RESPONSE

S_{DS} = $^2/_3 S_{MS}$ = **0.808** *per Equation 16-39*

S_{D1} = $^2/_3 S_{M1}$ = **0.523** *per Equation 16-40*

OCCUPANCY CATEGORY

Use Category = **II** *per Table 1604.5*

SEISMIC DESIGN CATEGORY

(2010 CBC Section 1613.5.6)

Is $S_1 \geq 0.75g$? **NO** *(SDC is limited to A,B,C or D)*

SDC = D based on S_{DS} per Table 1613.5.6(1)

SDC = D based on S_{D1} per Table 1613.5.6(2)

Use SDC = D *(more restrictive of values listed above)*

** S_S & S_1 per 2009 IBC "Seismic Design Values for Buildings" data at http://earthquake.usgs.gov/hazards/designmaps/*

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EQUIVALENT LATERAL FORCE PROCEDURE* (ASCE 7-05 Section 12.8)

$I =$	1.00	*per Table 11.5-1*
$R =$	1.25	*per Table 12.2-1*
$\Omega_o =$	1.25	*per Table 12.2-1 (reduced by subtracting 1/2 for flexible diaphragm structures per Footnote g)*
$C_d =$	1.25	*per Table 12.2-1*
$T_L =$	8.0	*per Figure 22-15*

FUNDAMENTAL PERIOD & k FACTOR (ASCE 7-05 Section 12.8.2.1)

$C_t =$	0.020	*per ASCE 7-05 Table 12.8-2*
$x =$	0.75	*per ASCE 7-05 Table 12.8-2*
$h_n =$	10.5	*Height in feet above the base to the highest 'level' of the structure (e.g. avg. ht. of roof diaphragm)*
$T_a =$	$C_t\ h_n^x$	*per Equation 12.8-7 ($T_a = T$)*

$T_a =$ 0.117 sec.		$k =$ 1.00	*per Equation 12.8-12*

BASE SHEAR (ASCE 7-05 Section 12.8.1)

$V =$ $C_s W$ *per Equation 12.8-1*

$C_S =$	$S_{DS} / (R/I) =$	0.646	*Equation 12.8-2 (Shall be this value) – Acceleration Plateau*
$C_S =$	$S_{D1} / T(R/I) =$	3.586	*Equation 12.8-3 (Maximum, $T \le T_L$) – Velocity Curve*
$C_S =$	$S_{D1}T_L / T^2(R/I) =$	N/A	*Equation 12.8-4 (Maximum, $T > T_L$) – Long Period*
$C_S =$	$0.044S_{DS} =$	0.036	*Equation 12.8-5 (0.01 Minimum)*
$C_S =$	$0.5S_1 / (R/I) =$	N/A	*Equation 12.8-6 (Minimum if $S_1 \ge 0.6g$)*
	$C_S =$	0.646	*Governing C_S*

STRENGTH:	$V_{Str.} =$ 0.646 W	*(Strength Level Loads ~ E)*
ASD:	$V_{ASD} =$ 0.453 W	*(ASD Level Loads ~ 0.7E)*

** THIS TYPE OF ANALYSIS IS ONLY PERMITTED IN SDC D-F IN THE FOLLOWING CONDITIONS (per Table 12.6-1):*

1) Occupancy Category I or II buildings of light-framed construction not exceeding 3 stories in height

2) Other Occupancy Category I or II buildings not exceeding 2 stories in height

3) Regular structures with T<3.5Ts (=2.27 sec.) and all structures of light frame construction

4) Irregular structures with T<3.5Ts (=2.27 sec.) and having only horizontal irregularities Type 2, 3, 4, or 5 of Table 12.2-1 or vertical irregularities Type 4, 5a, or 5b of Table 12.3-1

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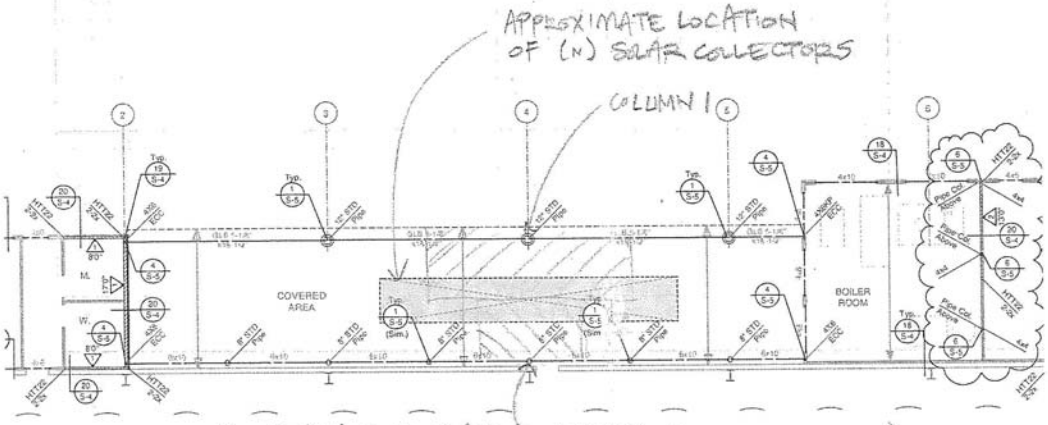
PROJECT: 12042 SHEET: 2.13

PROJECT ADDRESS:

ENGINEER: JDM DATE:

LATERAL SYSTEM LAYOUT



ROOF FRAMING PLAN

COLUMN 1: (E) 12" STD. PIPE
ROOF TRIB. AREA = 265 FT²

COLUMN 2: (E) 8" STD PIPE
ROOF TRIB. AREA = 120 FT²

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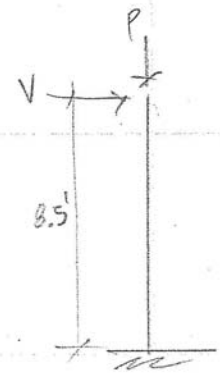
PROJECT: 12042 SHEET: 2.14

PROJECT ADDRESS:

ENGINEER: JDM DATE:

COLUMN 1 ANALYSIS



$P_{DL} = 1472^{\#}$

$P_{RLL} = 2565^{\#}$

$V_{1.0E} = 0.646W$

$= 0.646[(9.6\,PSF)(265\,ft^2) + (49.6\,\frac{\#}{ft})(\frac{8.5'}{2})]$

$= 1780^{\#}$

$P_r = 1.2DL + 1.6RLL = 1.2(2944^{\#}) + 1.6(5130^{\#}) = 11.74^k$

$KL = (2.1)(8.5') = 17.9' \sim 18'$

$P_c = \phi P_n = 49^k$ $\quad P_r/P_c = 0.02 < 0.2$

$M_r = 1780^{\#} \times 8.5' = 15.1\,k\cdot ft$

$M_c = \phi M_n = 141\,k\cdot ft$

AISC Eq. H1-1b: $\frac{P_r}{2P_c} + \frac{M_r}{M_c} \le 1.0$

$\frac{11.74^k}{(2)(49^k)} + \frac{15.1\,k\cdot ft}{141\,k\cdot ft} = 0.12 < 1.0$ ok ✓

CHECK DRIFT

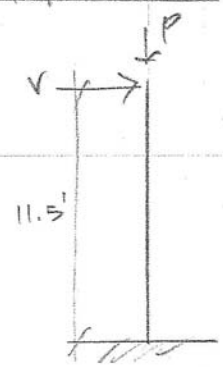
$\delta_{xe} = \frac{(1.78^k)(8.5')^3(1728\,\frac{in^3}{ft^3})}{(3)(29000\,\frac{k}{in^2})(262\,in^4)} = 0.088''$

$\delta_x = \frac{C_d\delta_{xe}}{I} = \frac{(1.25)(0.088'')}{1.0} = 0.10''$

$0.025h = (0.025)(8.5')(12\,\frac{''}{ft}) = 2.55'' > 0.10''$ ✓ ok

∴ 12" STD. PIPE ok FOR ADD'L LOAD

COLUMN 2 ANALYSIS



$P_{DL} = 1390^{\#}$

$P_{RLL} = 2566^{\#}$

$V_{1.0E} = 0.646W$

$= 0.646[(9.6\,PSF)(120\,ft^2) + (28.6\,\frac{\#}{ft})(11.5'/2)]$

$= 850^{\#}$

$P_r = 1.2\,DL + 1.6\,RLL = 1.2(1390^{\#}) + 1.6(2566^{\#}) = 5.77\,k$

$kL = (2.1)(11.5') = 24.2$

$P_c = \phi P_n = 152\,k \qquad P_r/P_c = 0.04 < 0.2$

$M_r = 850^{\#} \times 11.5' = 9.8\,k\cdot ft$

$M_c = \phi M_n = 54.6\,k\cdot ft$

AISC Eq H1-1b : $\frac{P_r}{2P_c} + \frac{M_r}{M_c} \le 1.0$

$\frac{5.8k}{(2)(152k)} + \frac{9.8k\cdot ft}{54.6k\cdot ft} = 0.20 < 1.0$ ✓ ok

CHECK DRIFT

$\delta_{xe} = \frac{(0.85k)(11.5')^3(1728\,\frac{in^3}{ft^3})}{(3)(29000\,\frac{k}{in^2})(68.1\,in^4)} = 0.38''$

$\delta_x = \frac{C_d\,\delta_{xe}}{I} = \frac{(1.25)(0.38'')}{1} = 0.47''$

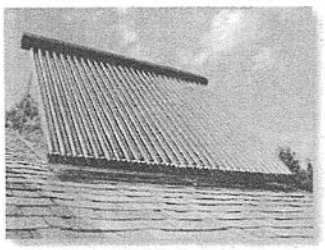
$0.025h = (0.025)(11')(12''/ft) = 3.45'' > 0.47''$ ✓ ok

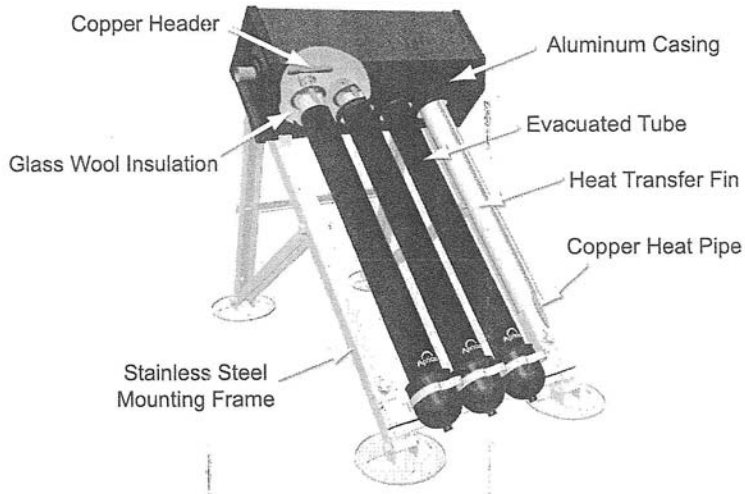
∴ 8" STD. PIPE ok FOR ADD'L LOAD

A.01

Apricus Submittal File

AP-30 Solar Collector





Submittal

Solar collectors shall be as manufactured by Apricus Solar Co., Ltd, Model No. AP-30 and shall be a twin-glass evacuated tube & dry plug heat pipe system.

Collector shall be 1980mm / 80" in length, 2196mm / 86.4" in width and 156mm / 6.14" in height. The enclosure casing shall be 0.8mm / 0.03" thick 1060-H16 grade aluminum with enamel paint finish. The copper header (water flow pipe) shall be of C11000 grade copper. Two contoured copper pipes of ∅18mm / ∅0.7" OD x 1mm / 0.04" shall form the header assembly, with all potable water connections brazed with BAg45CnZn brazing material. Each header must be factory tested to 1000kPa / 145psi. The header shall be insulated with compressed glass wool of no less than 60kg/m^3 / 3.7lbs/ft^3 density and average thickness of 50mm / 2".

Evacuated tubes shall be twin glass, with outer tube wall thickness no less than 1.8mm / 0.07" and outside diameter of 58mm / 2.28". The absorber coating shall be AL/N on a aluminum base with a minimum absorptive of 0.92% and maximum emissivity of 8%.

Collector instantaneous efficiency curve shall not have less than a first order Y-intercept (based on gross area of 4.05m^2 / 43.63ft^2) of 0.418, and a slope of not more than 1.17W/(m^{2}K.°C) / 0.206 Btu/hr.ft^2.°F

Heat pipes shall use a non-toxic heat transfer liquid and provide protection against freeze related heat pipe damage, have a minimum wall thickness of 0.7mm / 0.027" and be grade C10200 "oxygen free" copper.

The mounting frame shall be 439 grade stainless steel (1.5mm / 0.06" thick) and when installed in accordance with the installation instructions, shall withstand a wind load of 130mph.

Collectors shall have a design life of 20 years and shall be warranted for not less than 10 years. Collectors shall be certified to IAPMO USEC, FSEC, SRCC OG-100, AS/NZS2712 and EN12975-2.

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A.02

Physical Specifications

Overall Length	1980mm / 80"
Overall Height	156mm / 6.14"
Overall Width	2196mm / 86.4"
Aperture Area	2.83m² / 30.45ft²
Gross Area	4.26m² / 45.83ft²
Gross Dry Weight	95kg / 209lb
Fluid Capacity	710ml / 24fl oz
Max Operating Pressure	800kPa / 116psi
Stagnation Temperature	< 220°C / 432°F

Key Material Specifications

Evacuated Tubes	Borosilicate 3.3 Glass
Absorber	Al-N on Al on Glass
Heat Pipes	High Purity Copper
Heat Transfer Fins	Aluminum
Rubber Components	HTV Silicone Rubber
Mounting Frame	439 Stainless Steel
Manifold Casing	5005-H16 Aluminum

Performance Variables (1)

Eta0 (y-intercept)	0.687
a1 [W/(m²K)]	1.505
a2 [W/(m²K²)]	0.011
Heat Capacity [kJ/)(m²/K)]	52.44
Peak Power Output (2)	1944W / 6632Btu

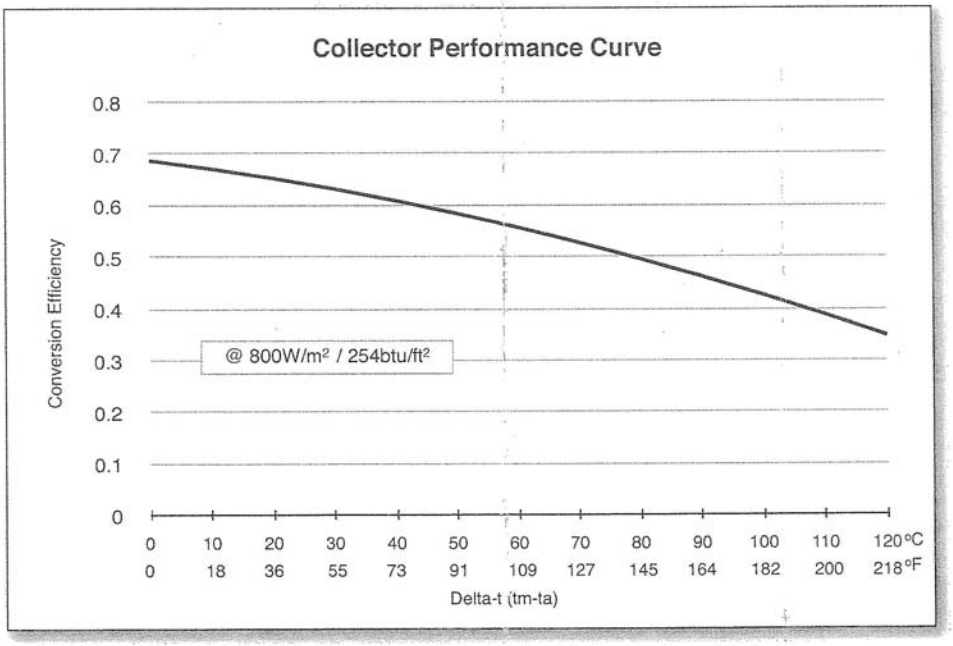
Incidence Angle Modifier (passive tracking):

Angle	0	20	40	50	60	70	90
Long	1.00	1.00	0.97	0.92	0.84	0.70	0.00
Trans	1.00	1.08	1.35	1.47	1.39	1.57	0.00

Installation Guidelines

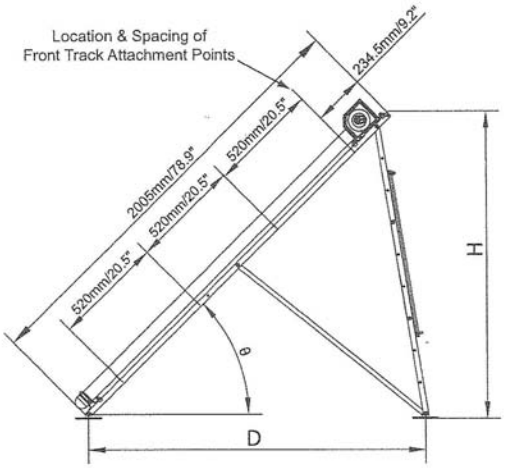
Max Flow Rate	15L/min / 3.9 US gpm
Max Tubes in Series	150 tubes
Install Angle Range	20-80°
Maximum Pressure Drop(3)	10kPa / 3ft / 1.3psi

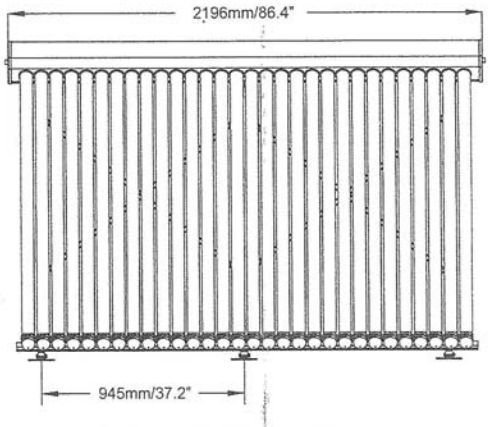
(1) Data from ITW test report 09COL805
(2) G=1000W/m², IAM angle = 0°
(3) @20°C/68°F & 15L/min / 4US gpm



A.03

Mounting Frame Dimensions





Angle	Type	D	H
57°	High Angle (Round Feet)	1278mm / 50.3"	1674mm / 31.3"
51°		1427mm / 56.2"	1551mm / 61.1"
44°		1581mm / 62.2"	1393mm / 54.8"
38°		1709mm / 67.3"	1236mm / 48.7"
33°		1814mm / 71.4"	1078mm / 42.4"
51°	High Angle (Roof Track)	1900mm / 74.8"	1562mm / 61.5"
46°		1900mm / 74.8"	1448mm / 57.0"
41°		1900mm / 74.8"	1326mm / 52.2"
37°		1900mm / 74.8"	1196mm / 47.1"
32°		1900mm / 74.8"	1059mm / 41.7"
27°	Mid Angle (Round Feet)*	Variable	~ 918mm / 36.1"
27°	Mid Angle (Roof Track)*	1900mm / 74.8"	918mm / 36.1"
13°	Low Angle (Round Feet)*	Variable	~ 450mm / 17.7"
13°	Low Angle (Round Track)	1900mm / 74.8"	450mm / 17.7"

Certifications

North America: SRCC OG100 AP-30 Report # 100-2007033A
IAPMO USEC Report # S-5995
FSEC AP-30 Report # 00204N

Europe: Dincertco Solarkeymark # 011-7S161 R

Australia/NZ: Global Mark (AS/NZSAS2712) Client # 100633

ISO9001-2008: Global Mark Client # 100633

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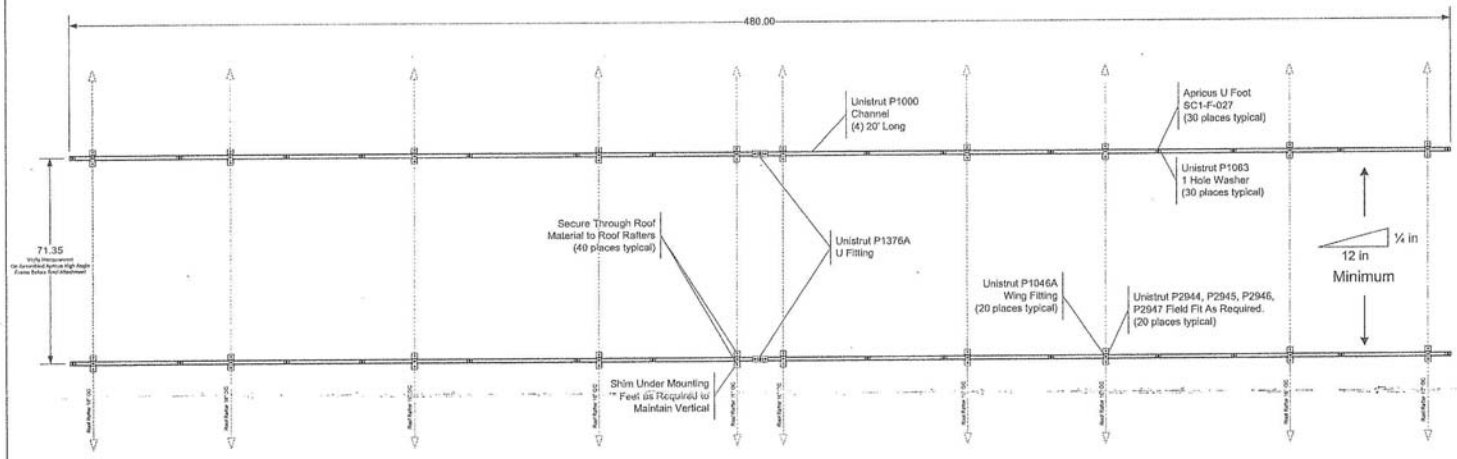

Panel Frame Support Rails
Plan View

Notes:

1. Unistrut channels and fittings should be electroplate or hot dipped galvanized for corrosion protection. Cold galvanized any cut channel ends.
2. Extend roof mounted 20 ' channel lengths as required with Unistrut fitting P1376A.
3. Slope requirement of roof channels listed on drawing is critical to system operation.

REV.	DESCRIPTION	DATE	BY
0	Released for review and comments	3/20/2012	JMP

FILENAME
COURTSIDE CELLARS SUPPORT FRAMING_R0.VSD

PAGE 1 OF 2

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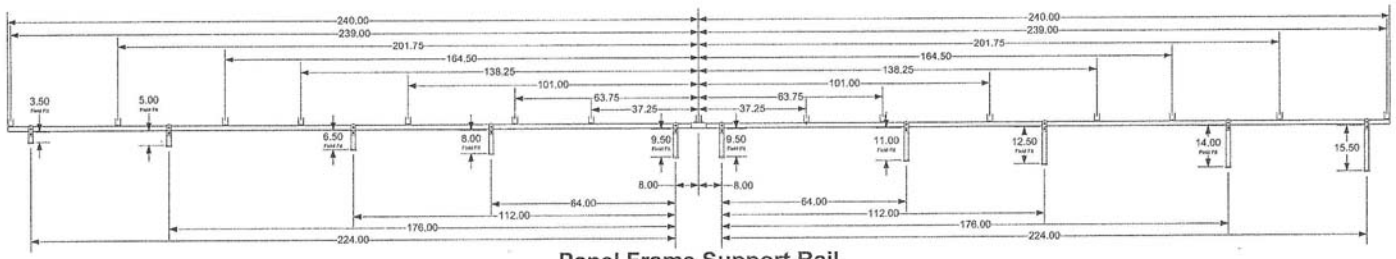
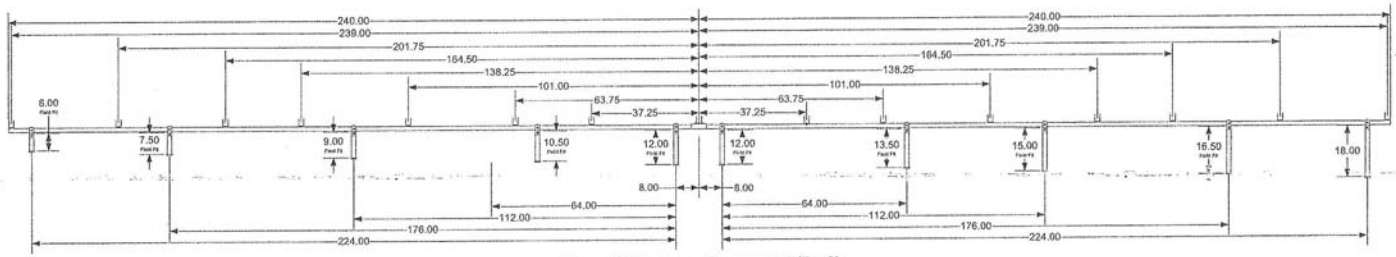
DATE 3/20/2012
DRAWN BY JOSEPH M PONDO

TITLE Courtside Cellars Support Framing
SCALE 1: 32
GTI
DRAWING NO

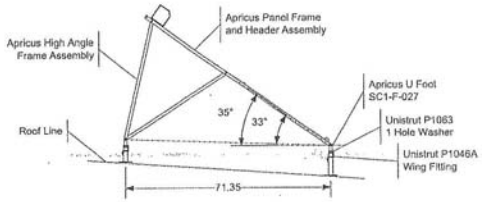
A-04



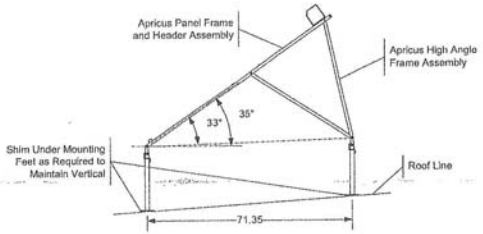
Panel Frame Support Rail
Rear



Panel Frame Support Rail
Front



Angle Supports Left Side View
(15 places typical)



Angle Supports Right Side View
(15 places typical)

REV.	DESCRIPTION	DATE	BY
0	Released for review and comments	3/20/2012	JMP

FILENAME: COURTSIDE CELLARS SUPPORT FRAMING_R0.VSD

PAGE 2 OF 2

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DATE: 3/20/2012
DRAWN BY: JOSEPH M PONDO
TITLE: Courtside Cellars Support Framing
SCALE: 1:32
GTI
DRAWING NO.

A.05

2.6.4 Permitting

A construction permit for the "Roof Mounted Solar Water Heating System for Existing Wine Processing Building" was issued by the San Luis Obispo County Department of Planning and Building. Permit Number PMT2011-02036 was issued May 25, 2012. The following applicable codes applied:

2008 California Energy Code
2010 California Building Code, Vols 1 &2 (2009 IBC)
2010 California Electric Code (2008 NEC)
2010 California Fire Code (2009 IFC)
2010 California Green Building Code (New)
2010 California Mechanical Code (2009 UMC)
2010 California Plumbing Code (2009 UPC)
2010 California Reference Standards Code
2010 California Residential Code (New) (2009 IRC)
County Building and Construction Ordinance – Title 19
County Coastal Zone Land Use Ordinance – Title 23
County Fire Code Ordinance – Title 16
County Land Use Ordinance – Title 22

CHAPTER 3: Installation

Commissioning Consultant:
Dave Hammontree,
Solar Usage Now

Installation Contractor:
Knecht's Plumbing & Heating, Inc.

System Installation:
August 10, 2012

> **Insulation:**
> Insulation of exterior piping was delayed following the installation. The insulation package was completed on October 6, 2012.

DAS Commissioned:
August 2012

The installation began with the structural reinforcement of the roof joists per the structural analysis. A 2 x 10 inch #2 Douglas Fir was sistered to each roof joist at each solar collector frame mounting foot location. Figure 18 shows the structural reinforcements dictated by the structural analysis.

On top of the lower tier roof a mounting platform was constructed to install the solar collectors at the specified pitch (Figure 19). The mounting platform accounts for the slope of the roof and the appropriate (1/4 inch per foot) slope towards the atmospheric storage tanks (located to the left). The slope

Figure 17: Atmospheric Storage Tanks, Tankless Water Heaters, Data Acquisition System, Controller, and Pumps

Figure 18: Structural Reinforcements to the Roof Joists

towards the storage tanks is crucial for maintaining the required drainback function. When the temperature set point is achieved in the atmospheric storage tanks the pump shuts off and the water drainsback to the storage tanks. Water is circulating through the system only when there is a call for heat (i.e. to satisfy the temperature setpoint). Once the setpoint was satisfied the solar collectors sit idle. Figure 20 shows a detailed view of the framing platform.

The solar collectors are shown in Figure 21. Five individual panels are installed in series for this facility. Shown on the left side of the collectors is the supply piping that continues behind the solar collectors and the return piping is shown in the fore ground. Specific requirements from the site called for the use of ProPress copper fittings. Traditional sweat fittings were only allowed under special situations.

Mounted to the solar collector header on the left is a pyranometer that measures available solar indices continuously (Figure 22). The pyranometer is installed at the same angle as the collectors (35 degrees). The output measurement from this device is monitored by the DAS.

The natural gas measurement devices are shown in Figure 23. A Romet (Model RM3000-DCID)

Figure 19: Solar Collector Framing

Figure 20: Close up of Framing Detail

Figure 21: West-Facing Solar Collectors

rotary meter (shown in the upper right corner) measures the natural gas supply to the existing boilers. Upstream of that measurement location is a branch line the feeds natural gas to the tankless water heaters (shown in the bottom center) with an Itron (Model 400A) positive displacement meter.

Figure 22. Solar Pyranometer

Figure 23. Natural Gas Measurement Devices

CHAPTER 4: Demonstration

The test protocol used at Courtside Cellars was to allow the Equinox Heating System to operate as required by the winery to meet the hot water demand profile of the facility. The GTI DAS enabled remote monitoring of the system performance including supply and output water flows and temperatures. The approach provided real-life operational loads on the system and allowed not only performance analysis, but also insight in to how the system could be adjusted for improved performance to meet the needs of the end user. Data was uploaded to the GTI server on a weekly basis and analyzed using a GTI developed performance analysis spreadsheet tailored to commercial systems utilizing the atmospheric storage tanks and associated hardware. Preliminary data was collected once the system was commissioned in August 2012. The exterior piping was insulated in October 2012 and full data monitoring was initiated.

Figure 24 shows the Equinox Heating System monthly natural gas-only efficiencies, compared to the monthly Available Solar Radiation, and variable Load. Figure 25 to Figure 35 show the daily Fuel Efficiencies compared to Available Solar Radiation, and Load. During the winter months, December 2012 to March 2013, the natural gas-only efficiencies exhibit a decline, and there were three reasons for this decline in efficiency: 1) Lower available solar radiation, 2) Lower ambient temperature, and 3) Large number of days the facility was closed. When the facility was closed, there was no hot water load, and therefore the fuel efficiency was essentially zero. December has the lowest reported fuel efficiency, and that was primarily because the facility was closed for nearly a week and a half during the winter holidays. The Equinox Heating System is located in an unconditioned space, so when there are lower ambient temperatures, there are higher standby losses from the tank and lower fuel efficiencies.

Figure 24: Monthly Natural Gas-Only Efficiencies

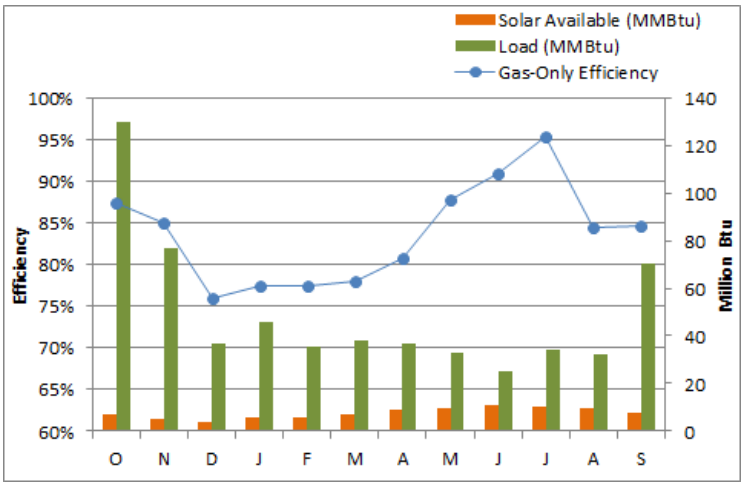


Figure 25: October Daily Fuel Efficiencies

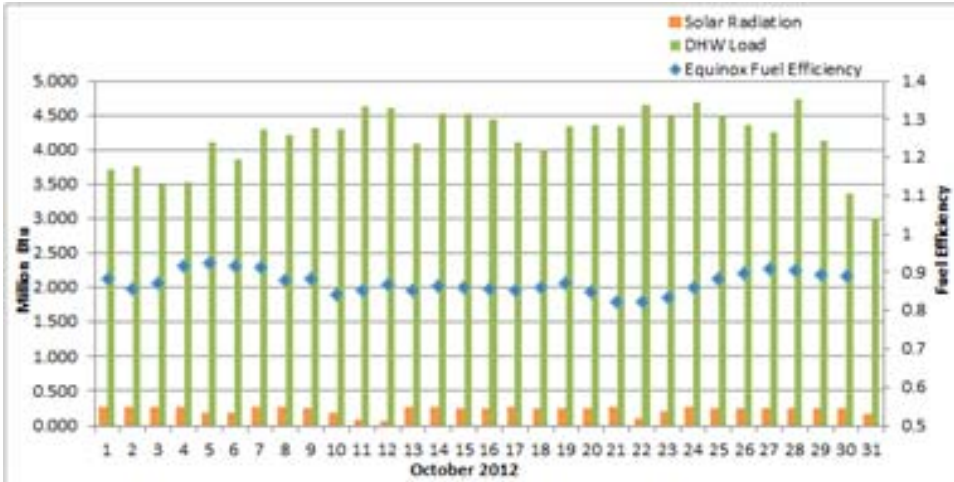


Figure 26: November Daily Fuel Efficiencies

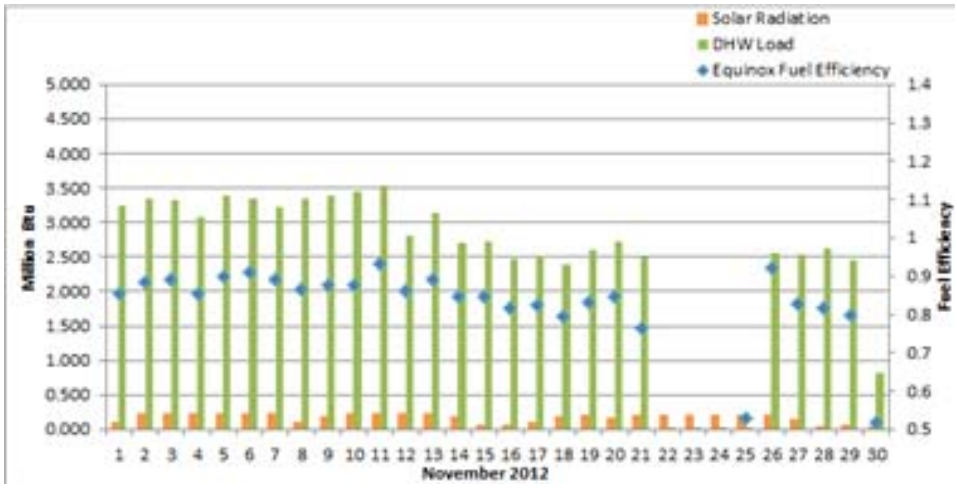


Figure 27: December Daily Fuel Efficiencies

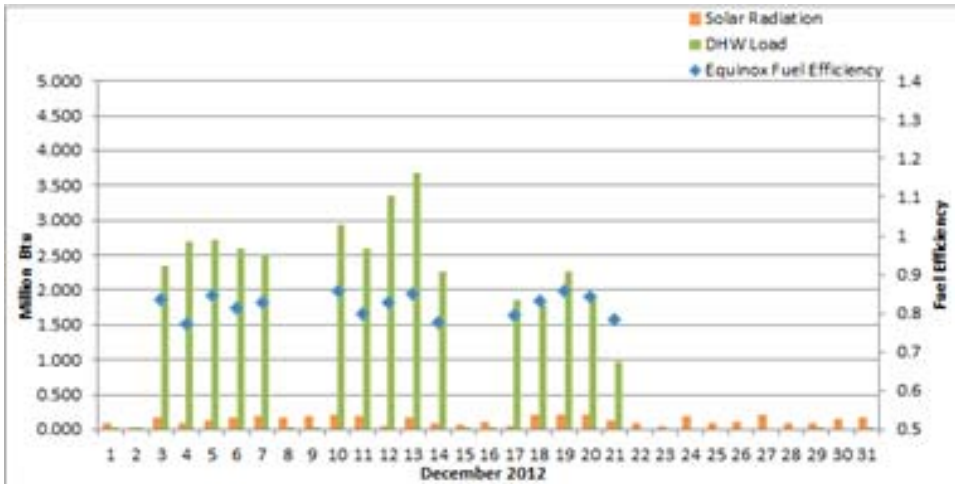


Figure 28: January Daily Fuel Efficiencies

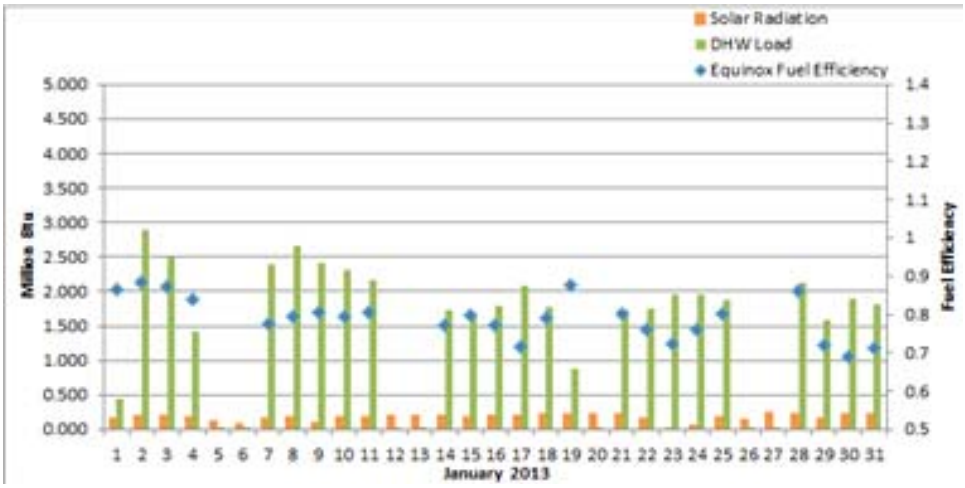


Figure 29: February Daily Fuel Efficiencies

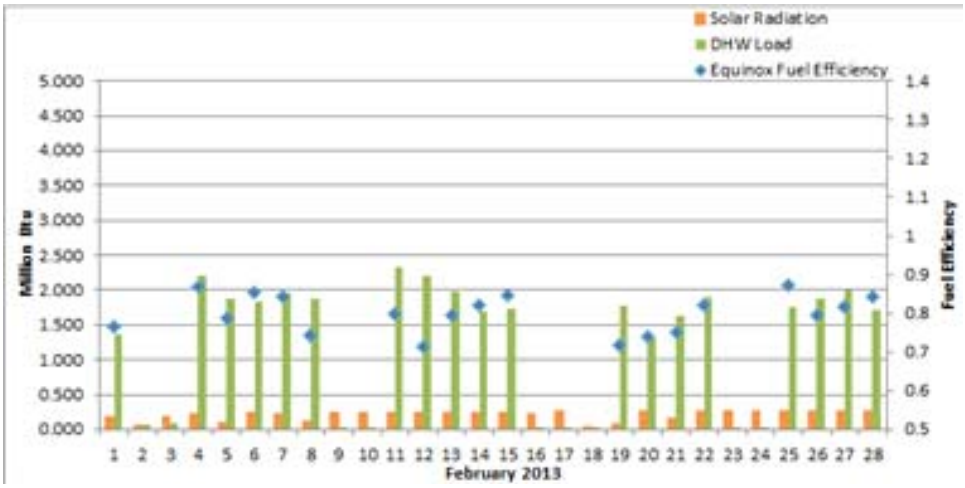


Figure 30: March Daily Fuel Efficiencies

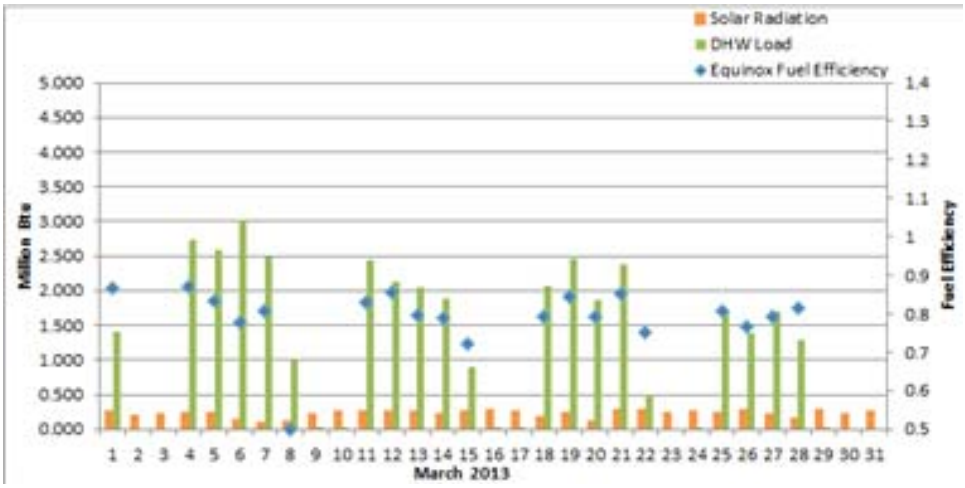


Figure 31: April Daily Fuel Efficiencies

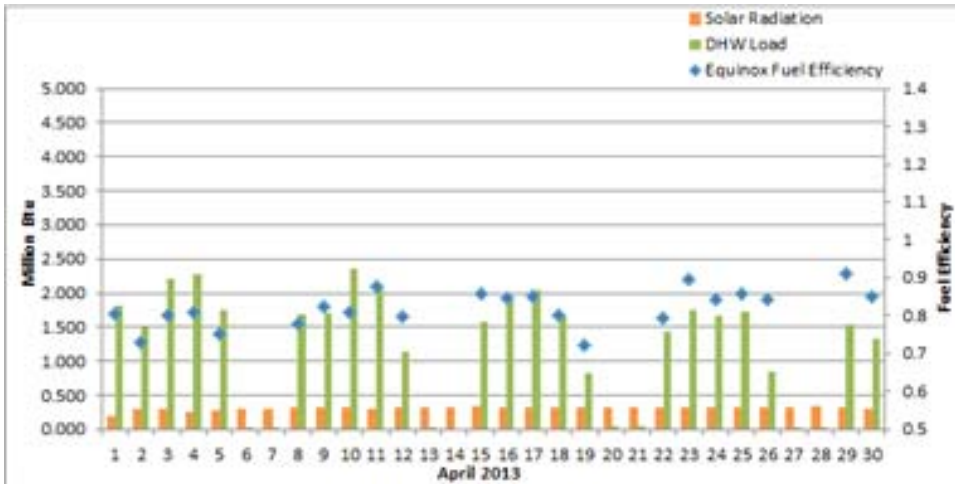


Figure 32: May Daily Fuel Efficiencies

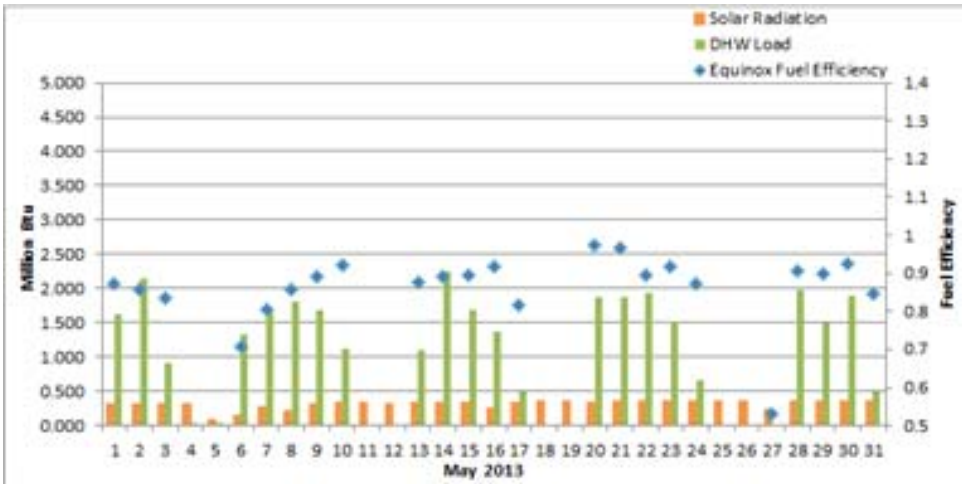


Figure 33: June Daily Fuel Efficiencies

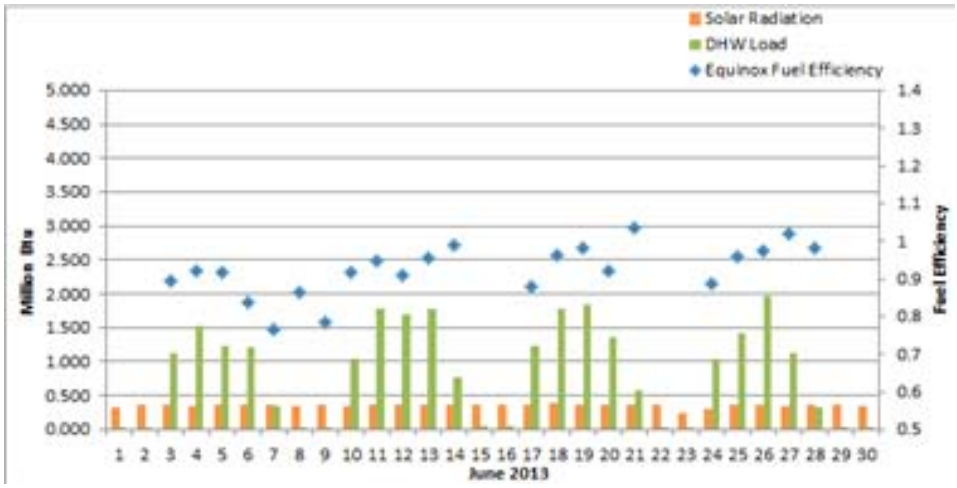


Figure 34: July Daily Fuel Efficiencies

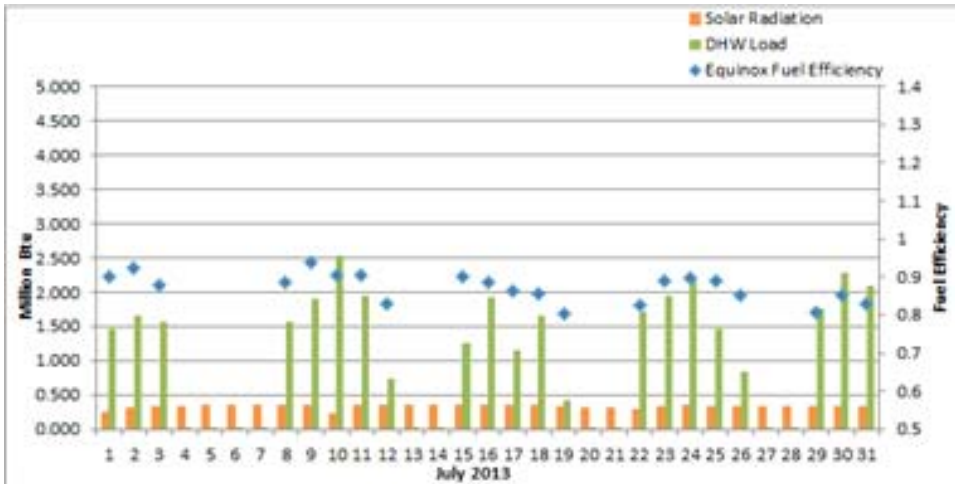


Figure 35: August Daily Fuel Efficiencies

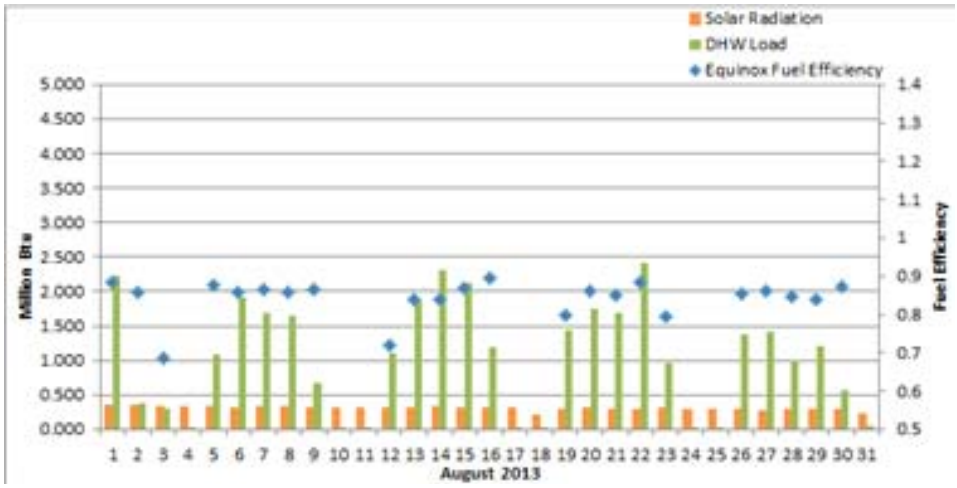
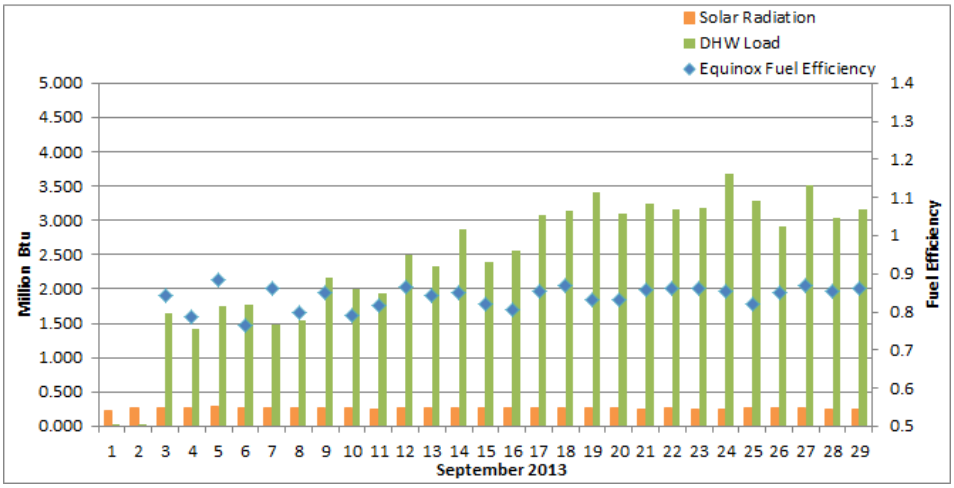


Figure 36: September Daily Fuel Efficiencies



To gain an understanding if available solar radiation, ambient temperature, or hot water load had a greater effect on the daily fuel efficiency, these factors were compared against the daily fuel efficiency. The correlation coefficients are shown in Table 3 and illustrated in Figure 37 thru Figure 40. When using all data points, the hot water load had the greatest correlation to fuel efficiency; however, this was because when the facility was closed, there was no heat delivered, consequently the fuel efficiency was zero. When data was filtered for only days the facility was open, the available solar radiation had the greatest effect on fuel efficiency, followed by the ambient temperature.

Table 3: Correlation Coefficient between Fuel Efficiency, Solar Radiation, Ambient Temperature, and Load

All Days		Only Days Facility was Open	
Factor	Correlation Coefficient (R^2)	Factor	Correlation Coefficient (R^2)
Available Solar Radiation	0.02	Available Solar Radiation	0.22
Ambient Temperature	0.02	Ambient Temperature	0.19
Hot Water Load	0.43	Hot Water Load	0.03

Figure 37: Daily Solar Radiation Available to Fuel Efficiency

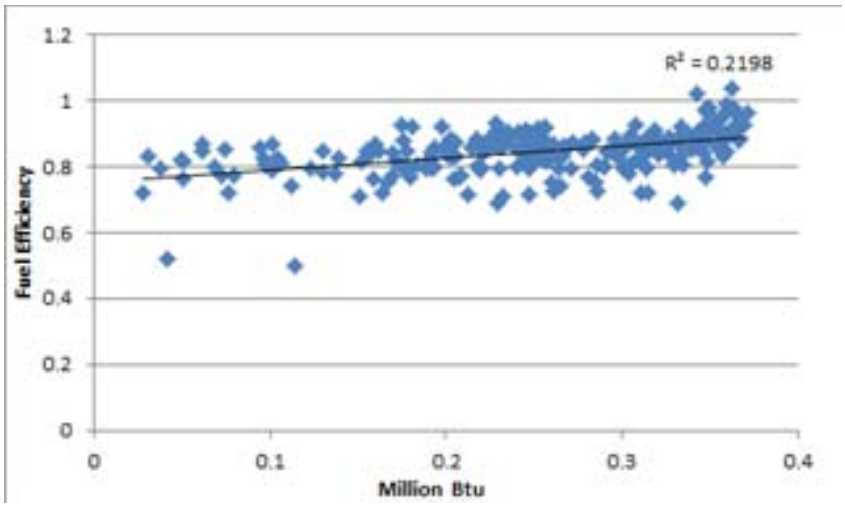


Figure 38: Average Ambient Temperature to Fuel Efficiency

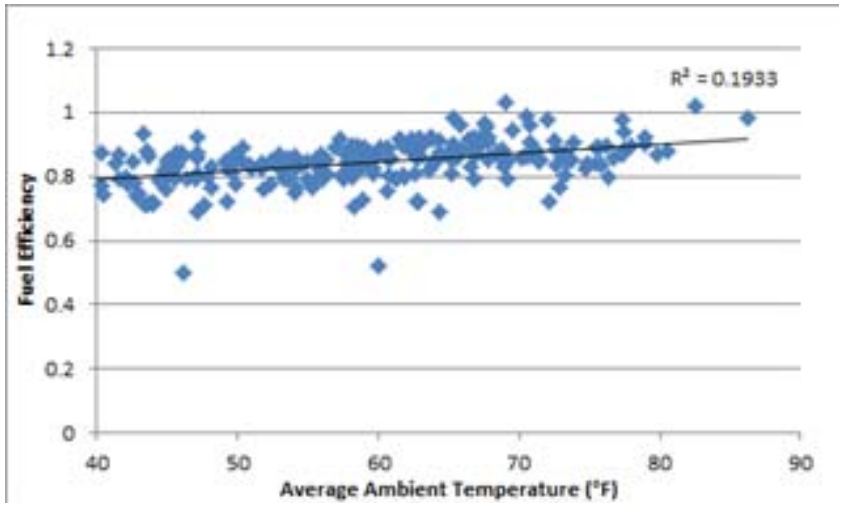


Figure 39: Daily Commercial Hot Water Load to Fuel Efficiency

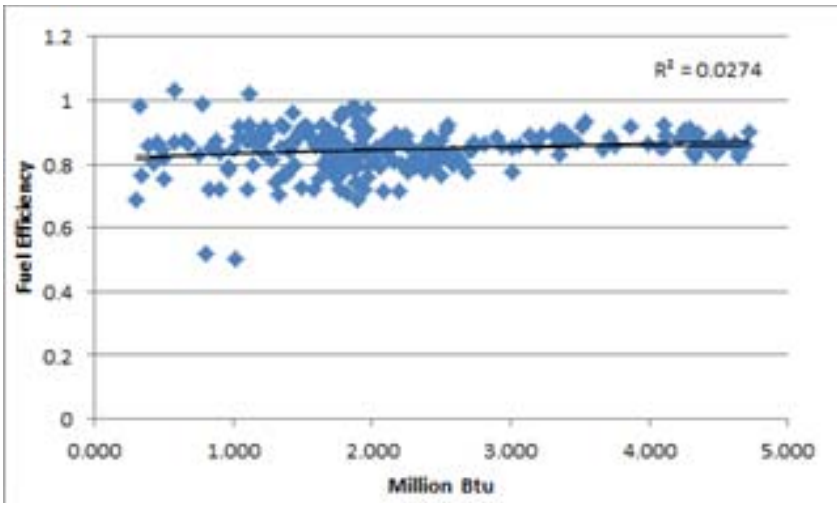
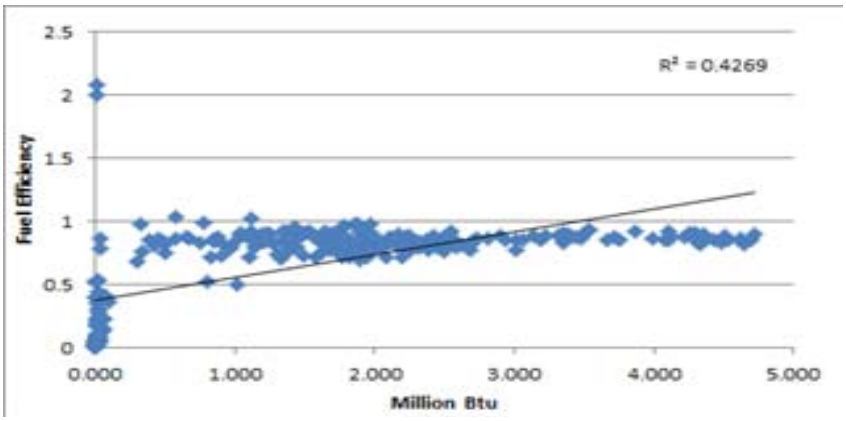
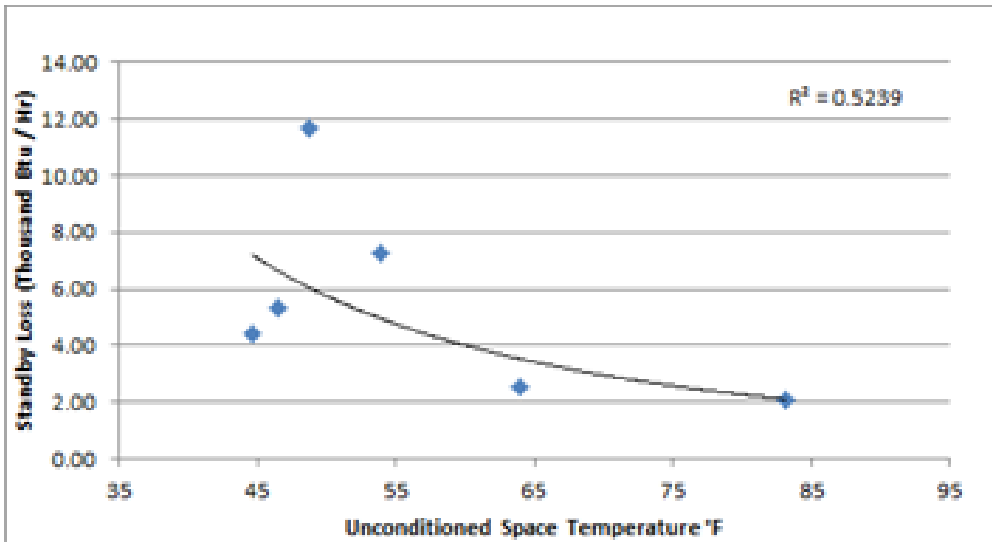


Figure 40: Unfiltered Daily Commercial Hot Water Load to Fuel Efficiency



The atmospheric storage tanks and tankless water heaters were located in an unconditioned space; therefore, as ambient temperature decreases during the winter months, the tanks have higher tank standby losses, and lower fuel efficiencies. A DAS measurement point located within the data logger enclosure represents essentially the ambient temperature of the boiler room. This temperature was compared against the standby loss of the storage tanks. Standby loss periods were selected when there was no hot water draw, no heat input, and the upper tank temperature started at 170.9 °F. The R2 value is 0.52, confirming that as the unconditioned room temperature decreases, there is higher a standby heat loss from the storage tanks (Figure 41).

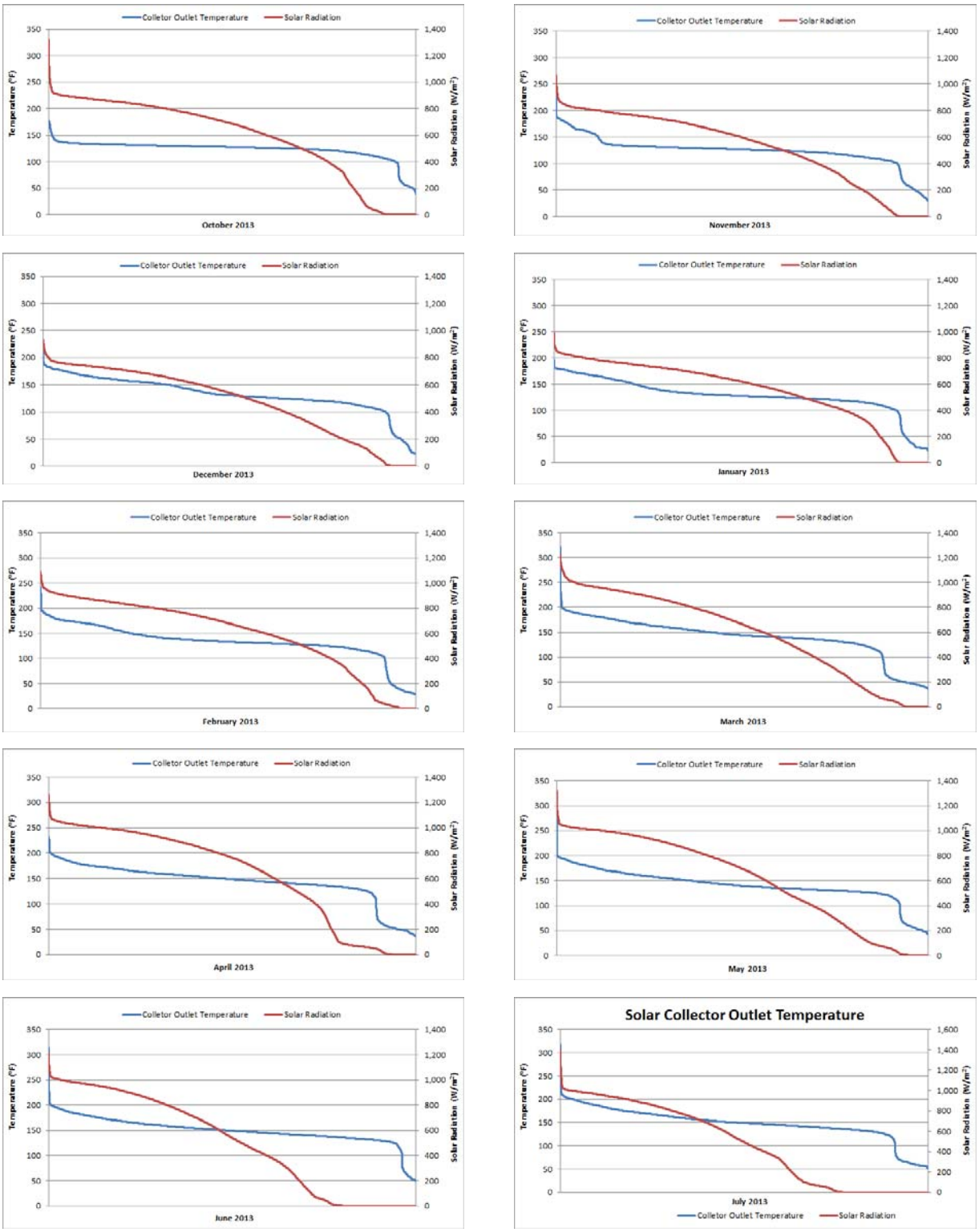
Figure 41: Atmospheric Storage Tank Standby Loss

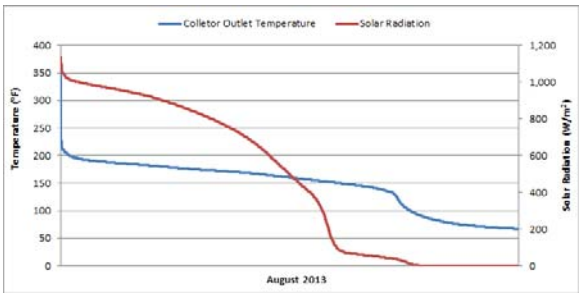


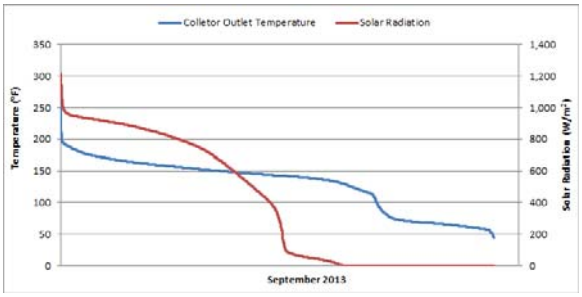
4.1 Collector Outlet Temperature

The available solar radiation to the collector outlet temperature on a monthly basis, filtered during only times when solar pumps are active was compared on Figure 42. The majority of temperatures range between 125 °F and 175 °F. During the winter months with the lowest radiation (October – February), the solar array outlet temperatures were lowest, with the majority at 150 °F or lower, and obviously during the months with the highest solar radiation (June – August), the solar outlet temperatures were the highest with temperatures great than 150 °F about half of the time.

Figure 42: Monthly Solar Collector Outlet Temperature and Available Solar Radiation







4.2 Solar Thermal Storage

Each Collector has a peak output of 6,632 Btu/h; or 33,160 Btu/h for all five collectors. Assuming eight hours of peak solar collection, this equates to a maximum solar collection of 265,280 Btu/day. However, thermal storage availability in the atmospheric storage tanks and maximum solar collector temperature can limit this capacity.

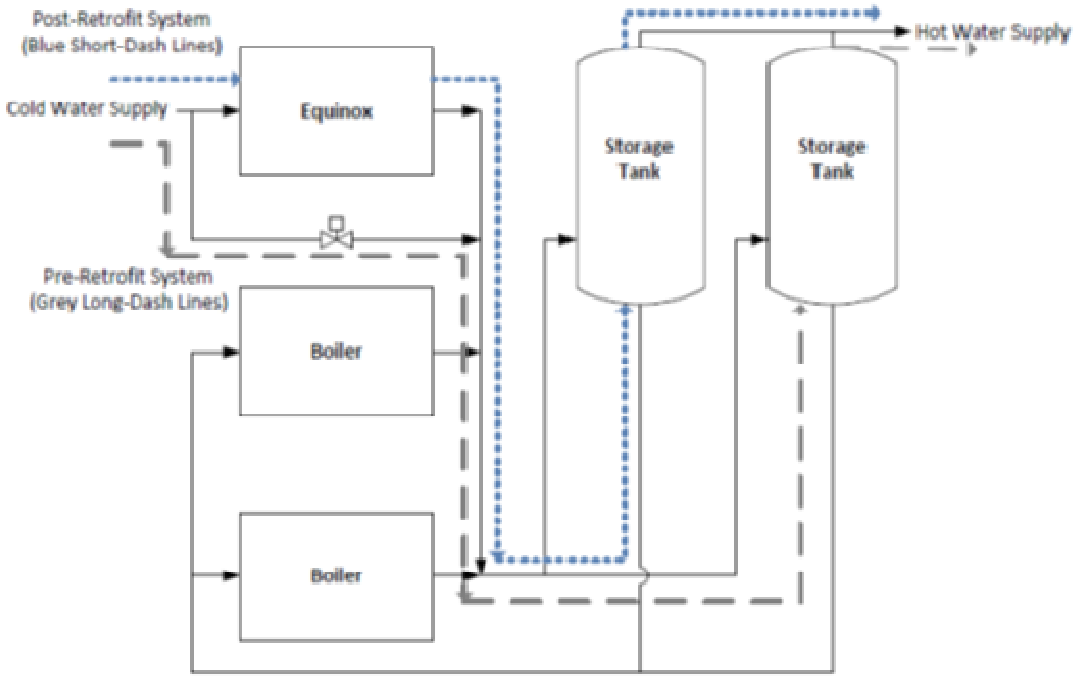
When the solar collector is greater than 250 °F, as an effort to protect the pumps, the system will go into "lockout" mode, and cease to collect solar energy until the temperature again falls below 250 °F. From October 2012 – August 2013, the system experienced no lockout events.

At standard conditions, the thermal storage of water is 8.33 Btu/gal °F (ASHRAE 2012 Handbook, Chapter 13, Equation 9). Each tank is 132 gal, which equates to a thermal storage capacity of 2,200 Btu/°F. Assuming an ambient temperature of 70 °F, and the maximum storage tank temperature of 180 °F, at steady state conditions, this equates to a total thermal storage capacity of 240,000 Btu. However, the system is designed to maintain a tank temperature of at least 130 °F, which leaves a temperature differential of 50 °F, or 107,800 Btu of available solar thermal energy storage capacity. Additionally, for the solar collector pump to engage, there must be a 30 °F temperature differential between the solar collectors and the storage tanks, therefore the collector temperature is required to be at least 160 °F before solar thermal collection can begin. Lowering the tank temperature setpoint would increase the available solar thermal energy storage capacity, and allow thermal collection to begin at lower temperatures.

4.3 Overall System Performance

In the pre-retrofit system, when a water draw occurred, the storage tanks were refilled with cold water. When the temperature of the tanks fell below 140 °F, then they are recharged by the existing boilers. In Figure 43 the pre-retrofit system flow is characterized by the grey long-dash lines. In the post-retrofit system, when a water draw occurred, the storage tanks were refilled with water from the Equinox Heating System. In Figure 43 this flow is shown by the blue short-dash lines.

Figure 43: Pre-Retrofit (Grey Long-Dash Lines) and Post-Retrofit (Blue Short-Dash Lines) Flow Diagram



The Monthly Energy Balance at Courtside Cellars is detailed in Table 4. Lines 1 – 9 are the energy balance for only the Equinox Heating System. The Natural Gas Only Efficiencies in Line 8 correspond to the efficiencies in Figure 24. Lines 10 – 13 look at the entire system at Courtside Cellars, including the boiler energy input and the entire system output. Lines 14 – 23 compare the pre-retrofit system efficiencies to the post-retrofit system efficiencies, which ultimately provide the energy savings. The annual savings equates to $878. Line 26 calculates the savings if the Equinox Heating System was processing the full load at the facility, which would be $2,623.

Table 4: Energy Balance for Courtside Cellars

		Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Total
Line	**Equinox Input**													
1	Solar Available, million Btu	6.9	5.3	3.9	5.5	5.9	7.2	9.0	9.9	10.7	10.3	9.4	7.6	91.5
2	Solar Collected, million Btu	4.2	2.9	2.0	3.1	3.2	3.7	4.7	4.7	4.9	4.9	4.7	4.4	47.3
3	Natural Gas Input to Tankless Water Heaters, million Btu	148.0	90.3	48.1	59.2	45.4	48.8	45.9	37.7	28.0	35.8	38.5	82.9	708.7
4	Heat Delivered to Storage Tank, million Btu	133.0	85.7	44.9	54.5	42.4	44.9	42.2	36.0	27.1	34.7	33.9	74	652.8
5	Tankless Efficiency, %	89.9	94.9	93.4	92.0	93.5	92.0	91.9	95.4	96.9	96.9	87.9	88.8	92.1
6	Electricity Input, %	0.6	0.4	0.3	0.3	0.3	0.3	0.4	0.3	0.4	0.5	0.7	0.7	5.2
	Equinox Output													
7	Heat Delivered, million Btu	129.5	76.7	36.6	45.8	35.2	38.0	37.1	33.1	25.4	34.1	32.5	70.2	594.3
8	Natural Gas-Only Efficiency, %	87.5	85.0	76.0	77.4	77.5	78.0	80.7	87.8	90.8	95.4	84.5	84.7	83.9
9	Fuel Efficiency, %	87.1	84.6	75.6	77.0	77.0	77.5	80.1	87.0	89.6	94.2	83.0	84.0	83.3
	System Energy Input													
10	Natural Gas Input (boilers), million Btu	318.9	293.5	202.5	292.6	214.6	161.2	130.4	110.7	101.8	114.5	91.2	217.0	2,249.1
	System Energy Output													
11	System Output, million Btu	292.0	231.4	109.6	172.0	117.9	111.5	98.7	90.7	81.3	99.8	76.5	189.3	1,670.7
12	Standby Loss*, million Btu	113.7	104.2	107.6	131.8	108.3	72.7	58.1	43.4	36.5	36.3	39.3	71.8	923.8
13	Fuel Efficiency, %	62.4	60.2	43.7	48.8	45.3	53.0	55.9	60.9	62.5	66.2	58.7	62.9	56.4

	Economic Analysis													
14	Natural Gas Commercial Price EIA ($/1000 cf)	6.90	7.53	8.14	7.41	6.99	7.41	7.65	7.85	8.43	7.59**	7.59**	7.59**	7.59

		Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Total
Line	**Equinox Input**													
15	Pre-Retrofit Heat Delivered, million Btu	196.5	173.4	81.4	135.4	90.3	83.6	71.6	64.6	61.7	74.8	55.1	141.0	1,299.5
16	Pre-Retrofit Natural Gas Efficiency, %	61.6	59.1	40.2	46.3	42.1	51.9	54.9	58.4	60.6	65.4	60.4	65.0	54.3
17	Pre-Retrofit Total Natural Gas Consumption, million Btu	473.9	391.7	272.8	371.5	280.1	214.9	179.9	155.4	134.2	152.7	126.6	291.0	3,045
18	Pre-Retrofit Natural Gas Costs, $	3,184	2,872	2,162	2,680	1,907	1,551	1,340	1,188	1,102	1,129	936	2,153	22,202
19	Post-Retrofit Heat Delivered, million Btu	95.5	58.0	28.2	36.5	27.6	27.9	27.2	26.0	19.7	25.0	21.4	48.3	441.2
20	Post-Retrofit Natural Gas Efficiency, %	64.5	64.2	58.7	61.7	60.7	57.2	59.1	69.1	70.3	69.9	55.5	59.2	62.3
21	Post-Retrofit Total Natural Gas Consumption, million Btu	467.0	383.9	250.6	351.8	260.0	209.9	176.3	148.4	129.7	150.3	129.8	299.9	2,958
22	Post-Retrofit Natural Gas Costs, $	3,137	2,814	1,986	2,539	1,770	1,515	1,314	1,135	1,065	1,111	959	2,217	19,344
23	Natural Gas Saved, million Btu	6.9	7.8	22.2	19.7	20.1	5.0	3.5	6.9	4.5	2.4	-3.1	-8.6	87.3
24	Actual Savings, $	46	57	176	142	137	36	26	53	37	18	-23	-64	641
25	Full-Retrofit Natural Gas Consumed, million Btu	452.8	360.4	186.7	278.9	194.1	195.0	167.0	131.2	115.7	142.9	137.8	325.2	2,688
26	Full-Retrofit Savings, $	142	229	683	668	586	144	96	184	152	72	-83	-251	2,623

* Assumes Boiler Efficiency of 84%
** Average of previous months
Energy Information Agency (EIA)

4.4 Equinox Heating System Sizing

At the onset of this project, the Courtside Cellars load was unknown; however, a year of monitoring has revealed the average daily load as 1.6 million Btu. The Equinox Heating System daily load ranged between 0.5 million Btu and 5.0 million Btu. If the average load was known at the beginning of the project, the corresponding collector area could be calculated. Equation 6 recommends collector area for the corresponding load at 128 m^2, or 45 collectors. Budgetary restraints of this project did limit the system to five collectors, or a load size of 0.178 million Btu.

Equation 6: NREL Solar Thermal Technology & Applications Solar Water Heating System Sizing

$$\text{Area(collector)} = \frac{L}{\eta_{\text{solar}} \text{ x } I_{max}}$$

where

Area(collector) Recommended collector area

L Average daily load

ηsolar Efficiency of solar system (0.5)

Imax Maximum daily solar radiation (0.025 million Btu/m2/day)

As the load increases, the solar energy contributes less of a percentage to the overall heat delivered, and the system efficiency tends to asymptote towards a standard commercial 80 percent efficient water heater. The large load and the budget limitation to five collectors did have an adverse effect on the equinox system efficiencies.

4.5 Emissions Saved

Compared to the standard baseline efficiency gas appliances, the system saved approximately 1190therms of natural gas during the year of monitoring. This energy savings corresponds to a potential reduction of 17,500 lbs of greenhouse gas emission per year. The state of California has over 1100 wineries; assuming a 10 percent market penetration, the savings would be 130,000 therms for all sites and a reduction of 1.9 million lbs, or 875 metric tons, of greenhouse gas emissions per year (equivalent to 175 passenger vehicles per year).[1]

[1] The reduction in GHG emissions was calculated using GTI's Source Energy and Emissions Analysis Tool which includes a source-energy and carbon emission calculation methodology that accounts for primary energy consumption and related emissions for the full-fuel-cycle of extraction, processing, transportation, conversion, distribution, and consumption of energy. This tool, available to the public at www.cmictools.com, was developed based on government data sources. Source Energy and Emissions Analysis Tool features and methodology are further described in a peer-reviewed ASHRAE technical paper available at http://www.techstreet.com/cgi-bin/detail?product_id=1714568.
US EPA Estimates an average passenger vehicle has tailpipe emissions of 5.1 metric tons: http://www.epa.gov/oms/climate/documents/420f11041.pdf

4.6 Economic Analysis

The actual installation costs for the system are outlined in (Table 5). The final cost for installation, equipment, permitting and engineering totaled $76,048. An alternative system would be a new boiler, which EIA Technology Forecast estimates at $17,000. The cost differential between the two is the incremental cost of the solar system, or $59,048. GTI conducted an analysis for state and local grants and incentives, which would be discounted from the installation costs. Assuming the system met all of the incentive requirements, the final incremental cost after grants and incentives reduced the solar system to a very competitive $6,452. Since the system was not performing optimally in August and September 2013, a full year was of savings was projected from the October 2012 –July 2013 data. With an annual savings of $878, the simple payback for this system is 7.3 years. Another comparison between the baseline system (boilers) and the solar system is the 15 year lifecycle costs, as shown in Table 6. The baseline boiler has a lifecycle cost of $350,034, while the solar system incremental price with incentives has a nearly $20,000 lower cost of $329,866.

Table 5: Installation Costs

Description	Vendor	Amount
Permitting & Engineering	Wallace Group	$ 8,216
Installation Contractor	Knechts Plumbing & Heating	$ 40,472
Electrical Contractor	Thoma Electric	$ 5,099
Solar Equipment	Solar Usage Now	$ 22,261
SubTotal		**$ 76,048**
Baseline Boiler System[2]	Total Installed Cost	$ 17,000
Incremental Cost		**$ 59,048**
State / Local Incentives		
California Solar Initiative - Solar Thermal Program	$14.53 per estimated therm displaced. Maximum incentive is $500,000.[1]	$ 10,770
Federal Incentives		
Corporate Tax Credit	30% Tax Credit For Solar	$ 22,814
USDA - Rural Energy for America Program (REAP) Grants[2]	25% of project cost	$ 19,012
Final Incremental Cost After Incentives		***$ 6,452***

[1]This amount was calculated using the California Solar Initiative Incentive Calculator and is different than actual therm savings. With this calculator, the "base case" when compared against tankless SDHW systems, will be a tankless water heater.

[2] The Baseline System is a 1 million Btu input boiler (80% efficient). The price was obtained from the EIA - Technology Forecast Updates (2011) - Residential and Commercial Building Technologies http://www.eia.gov/analysis/studies/buildings/equipcosts/pdf/appendix-a.pdf

Table 6: Fifteen Year Lifecycle Costs

	Capital Costs	Annual Energy Operating Costs	15 Year Energy Operating Cost	Simplified 15 Year Lifecycle Cost
Natural Gas Boiler (baseline)	$17,000	$22,202	$333,034	$350,034
Solar Thermal/Natural Gas incremental cost without incentives	$59,048	$21,561	$323,415	$382,463
Solar Thermal/Natural Gas incremental cost with incentives	$6,452	$21,561	$323,415	$329,866

4.7 Recommendations for System Performance Enhancements

In order to improve the Equinox Heating System fuel and gas-only efficiencies, GTI recommends having the atmospheric storage tank serve as storage for solar thermal energy only, to preheat the water before it is sent to the tankless water heater, as illustrated in Figure 44. There are four reasons this would lead to higher efficiencies:

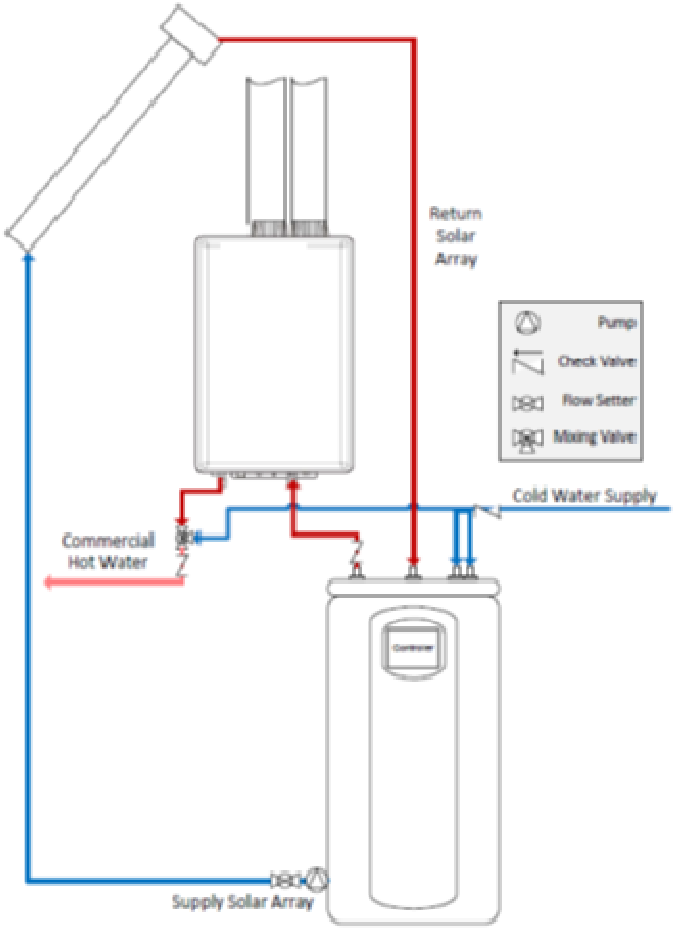
1. The Equinox could store more solar energy. Analysis in the section 4.2 Solar Thermal Storage, determined that at steady state conditions the tanks have a heat storage capacity of 240,000 Btu. However, maintaining a minimum tank temperature of 130 °F leaves only 107,800 Btu for solar thermal energy storage. If a minimum tank temperature was not maintained, the full heat storage capacity could be utilized for solar thermal storage.

2. The Equinox could collect additional solar energy. A 30 °F temperature differential between the storage tank and the solar collector was required before the system can initiate solar collection. The tank was required to maintain a minimum temperature of 130 °F, so generally the collectors must be at least 160°F before solar collection can initiate. If the storage tank temperature was lower, then the system could begin to collect solar energy at lower temperatures.

3. All standby losses from the storage tanks would be from solar energy only. At a very minimum, the Equinox system would have the efficiency of the tankless water heaters.

4. On days when there is no hot water load, the facility would use no natural gas. If the storage tanks were not able to maintain a set temperature, then the tankless water heaters would boost the temperature only when there was a load.

Figure 44: Atmospheric Storage Tank as Preheat Tank



CHAPTER 5:
Technology Transfer

5.1 Equipment

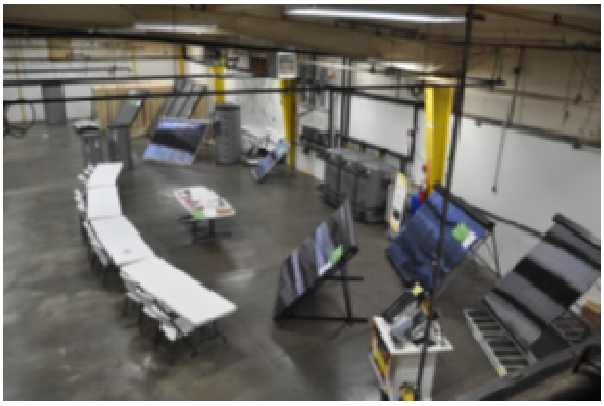
The Equinox Heating System design requires only a limited amount of standard equipment for assembly. This limits capital investment while allowing redundancy that minimizes potential for production interruptions resulting from any fabrication equipment breakdowns.

Figure 45: Solar Usage Now Warehouse

5.2 Facilities

Solar Usage Now's facility in Hamilton, Indiana includes a warehouse housing a large inventory of equipment and a training facility (Figure 46) for distributors and installer. The training is mandatory for larger commercial installations to assure safe, trouble-free, cost effective and efficient installation and operation of the Equinox Heating System in the field.

Figure 46: Solar Usage Now Training Facilities



5.3 Personnel Resources

Key management personnel are well qualified and include Thomas Blake Sr., President and CEO, Thomas Blake Jr., who provides design and other technical guidance and Donald Renner, who heads up production. Other dedicated team members focus on accounting, sales, purchasing, logistics and coordination, operations, and production. The twelve senior team members fill key full-time functional positions and can support any potential production demands. Additional resources are brought on board on an as needed basis to meet production needs.

5.4 Support Systems

Solar Usage Now is the sole importer atmospheric storage tanks manufactured by Rotex and of KU solar products in the US and has agreements in place supporting procurement of other key components to facilitate production of the Equinox Heating System to meet customer needs. The training facility located at the manufacturing site, is used to provide mandatory training to all distributors and installers regardless of their prior experience. Mechanical contractors are required to complete the training and assist in breaking down their Equinox Heating System, which eliminates the guesswork at the job site and allows for smoother installation. Solar Usage Now has in place a network of approximately 250 dealers across the U.S. and Canada that have multiple feet on the ground working with their existing customer base, visiting specifying engineers, and following up on solar leads.

CHAPTER 6: Conclusions

The Gas Technology Institute (GTI), along with its partner Solar Usage Now designed and developed a highly efficient prototype solar-assisted gas hot water heating system for commercial applications. The system, called the Equinox Heating System, was development to reduce the material, manufacturing, and installation cost of solar-assisted natural gas water heating systems for use in small commercial, industrial, and agricultural applications. The system was installed at the field demonstration site, Courtside Cellars, in San Miguel, California to verify performance of the technology in an applied environment. It has been operating continuously as required by the winery to meet the hot water demand profile of the facility. A data acquisition system collected data simultaneously to record the system variation and characterize performance.

The Equinox Heating System is a combination of an atmospheric storage tank, a highly efficient natural gas-fired tankless water heater, and a very efficient solar thermal collector. The result is a highly efficient hot water delivery system designed to meet the reliability and performance needs of hot water process found in small to mid-size wineries located throughout California. The modular design of the hot water storage tank makes them ideal to be linked together to replace boilers used for commercial applications such as hotels, schools, hospitals, etc. The design reduces and eliminates major components and associated costs, such as a second storage tank for solar, but affords maximum flexibility for installation and utility business considerations. The implementation of a high-efficient drainback solar collector expands the market for solar water heating, particularly to areas where freeze protection is required.

Under the context of the Energy Commission grant installing enough capacity to replace both existing boilers was estimated to be larger than what was economically possible. The path forward was determined to augment the existing boiler capacity with the Equinox Heating System. A year of monitoring has revealed the average daily load as 1.6 million Btu. The Equinox Heating System daily load ranged between 0.5 million Btu and 5.0 million Btu. An appropriately sized solar collector would be 128 m^2, or 45 collectors.

Overall, the Equinox Heating System performed extremely well; at peak conditions, at peak conditions the fuel efficiency was over 95 percent, generating more than 1,700 gallons of hot water daily. Compared to the standard baseline efficiency gas boiler, the system saved approximately 1190 therms of natural gas during the year of monitoring. This energy savings corresponds to a potential reduction of 17,500 lbs of greenhouse gas emission per year.

The estimated payback period for the Equinox Heating System was 7.3 years coupling with the present incentives provided by state and federal governments. Payback periods are dependent upon the solar fraction and the available incentives. Solar-assisted systems can currently provide a financially viable alternative over traditional water heating systems as documented in the 15 year lifecycle cost.

GLOSSARY

PIER-Public Interest Energy Research

RD&D-Research, Development, and Demonstration

GTI-Gas Technology Institute

FTA-Field Test Agreement

HP-Horsepower

P&ID-Piping and Instrumentation Diagram

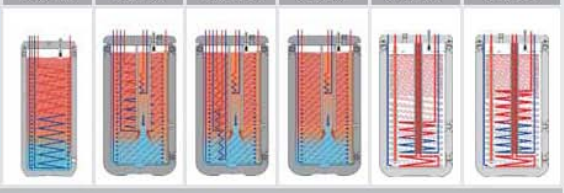
EF-Energy Factor

DAS-Data Acquisition Systems

EIA-Energy Information Agency

APPENDIX A:
Equinox Equipment Specifications

Atmospheric Storage Tank



Technical data Sanicube and Sanicube Solaris		Sanicube Solaris				HybridCube	
		SCS 328/14/0	SCS 538/16/0	SCS 538/16/16	SCS 538/0/0	HYC 544/19/0	HYC 544/32/0
Basic data							
Total storage capacity	Litres	300	500	500	500	500	500
Empty weight	kg	55	87	93	81	86	92
Total filled weight	kg	335	587	593	581	586	592
Dimensions (L x B x H)	cm	59,5x 61,5x 159	79 x 79 x 159	79 x 79 x 159	79 x 79 x 159	79 x 79 x 159	79 x 79 x 159
Max. permissible storage tank water temperature	°C	85	85	85	85	85	85
Readiness heat consumption at 60 °C	kWh/24h	1,3	1,4	1,4	1,4	1,4	1,4
Domestic hot water heating							
Domestic hot water capacity	Litres	19	24,5	24,5	24,5	28,4	28,4
Maximum operating pressure	bar	6	6	6	6	6	6
Domestic hot water heat exchanger material		stainless steel	stainless steel	stainless steel	stainless steel	stainless steel	stainless steel
Domestic hot water heat exchanger surface	m²	4,1	5,5	5,5	5,5	5,9	5,9
Average specific heat capacity	W/K	1 820	2 470	2 470	2 470	2 860	2 860
Storage tank primary loading heat exchanger (stainless steel)							
Water capacity heat exchanger	Litres	9,1	10,4	10,4	–	9,5	17,4
Surface area primary heat exchanger	m²	2,1	2,3	2,3	–	2,0	3,7
Average specific heat capacity	W/K	910	1 040	1 040	–	960	1 810
Storage tank secondary loading heat exchanger 2 (stainless steel)							
Water capacity heat exchanger	Litres	–	–	10,4	–	–	–
Surface area secondary heat exchanger	m²	–	–	2,3	–	–	–
Average specific heat capacity	W/K	–	–	1 040	–	–	–
Solar heating support (stainless steel)							
Water capacity heat exchanger	Litres	–	2	2	2	4,8	4,8
Heat exchanger surface area	m²	–	0,4	0,4	0,4	1,0	1,0
Average specific heat capacity	W/K	–	200	200	200	310	310
Thermal output data							
Output characteristic value N_L according to DIN 4708 [1]		2,2	2,3	2,5	2,3	–	–
Continuous rating Q_D according to DIN 4708	kW	27	35	45	35	–	–
Max. draw-off rate for a period of 10 min at 35 kW at (T_{KW} = 10 °C/T_{WW} = 40 °C/T_{SP} = 60 °C)	l/min	21	22	24	22	–	–
Hot water quantity without reheating up to 15 l/min tapping rate (T_{KW} = 10 °C/T_{WW} = 40 °C/T_{SP} = 60 °C)	Litres	200	220	220	220	–	–
Hot water volume with heating up at a power rating of 20 kW and 15 l/min draw-off rate (T_{KW} = 10 °C/T_{WW} = 40 °C/T_{SP} = 60 °C)	Litres	400	442	453	442	–	–
Kurzzeitwassermenge in 10 min	Litres	210	220	240	220	–	–
Thermal output data ROTEX HybridCube*							
Volume of hot water without reheating at 8 l/min / 12 l/min draw-off rate (TKW = 10 °C/TWW = 40 °C/TSP = 50 °C)	Litres	–	–	–	–	338 / 272	338 / 272
Volume of hot water without reheating at 8 l/min / 12 l/min draw-off rate (TKW = 10 °C/TWW = 40 °C/TSP = 60 °C)	Litres	–	–	–	–	527 / 468	527 / 468
Volume of hot water without reheating at 8 l/min / 12 l/min draw-off rate (TKW = 10 °C/TWW = 40 °C/TSP = 65 °C)	Litres	–	–	–	–	614 / 560	614 / 560
Min. reheating time	min	–	–	–	–	45	25
draw-off volume 140 l -> 5820 Wh (tapping one bathtub)		–	–	–	–	(HPSU 008)	(HPSU 016)
Min. reheating time	min	–	–	–	–	30	17
draw-off volume 90 l -> 3660 Wh (tapping one shower)		–	–	–	–	(HPSU 008)	(HPSU 016)
Pipe connections							
Cold and hot water	Inch	1" AG	1" AG	1" AG	1" AG	1" AG	1" AG
Heating flow and return flow	Inch	1" AG	1" AG	1" AG	1" AG	1" AG	1" AG

[1] at charging with 35 kW, 80 °C flow temperature, 65 °C storage tank temperature 45 °C hot water temperature and 10 °C cold water temperature

[6]

* **Definition**:
DHWV = The volume of hot water available without further heating and the volume of draw-off at a mixed water temperature of 40 °C and a cold water temperature of 10 °C.

Reheating time = The time required to reheat the hot water storage tank to a storage tank temperature of 50 °C after removing a specified volume of hot water.

Tankless Water Heater

NORITZ

Model NCC199 Series
Commercial Condensing Water Heater
Specification Sheet

Job Name _____
Location _____
Architect/Engineer _____
Wholesaler _____
Contractor _____
Model No. _____
Gas Type _____
No. of Units _____ Total BTU/hr Input _____
Flow Rate (GPH) _____
Notes

- **Standard Input** - gas consumption ranges from 11,000 BTUh to 199,900 BTUh
- **Compact Design** - ANSI Z21.10.3/CSA 4.3 certified design that can be wall-mounted indoors or installed outdoors with an -SV model using the optional Vent Cap
- **Durable Stainless Steel Casing**
- **Heat Exchanger** - manufactured with commercial grade copper, 25% thicker piping than standard models
- **Venting Options** - available in Standard (-SV) or Direct Vent (-DV) model that can use either Schedule 40 PVC/CPVC or Category III stainless steel pipe
- **Direct Electronic Ignition**
- **Multi-System Capability** - units can be linked together by using either the optional 2-unit Quick Connect or multi-unit System Controller for up to 24 units.
- **Fully Modulating** - BTU input can range from 11,000 to 4.8 million BTUh (for 24-unit Multi-System) with stable combustion provided by the industry's 1st Dual-Flame Burner
- **Thermal Efficiency** - fully condensing, 93% efficient for use with natural gas and propane
- **Temperature Controls** - includes remote thermostat that can precisely adjust the output temperature from 100°F to 180°F
- **Safety Devices** - Flame Sensor, Overheat Prevention Device, Lightning Protection Device, Freeze Protection, Neutralizer Overfill
- **Five Year Limited Heat Exchanger Warranty for Commercial Use**
- **Five Year Limited Parts Warranty**
- **Approvals** - CSA, UPC, NSF, Low NOx Approved By SCAQMD (Rule 1146.2)

SV Model *DV Model*

Model
NCC199 - _____
☐ *SV (Standard Vent)*
☐ *DV (Direct Vent)*

Accessories
☐ *PVC Adapter (#VP__-PVC-ADAPT)*
☐ *Birdscreen (#VP_-PVCS)*
☐ *Outdoor Vent Cap for Condensing -SV Model (#VC-4C)*
☐ *Isolator Valves (#IK-WV-7)*
☐ *Pipe Cover (#PC-3S-SUS)*
☐ *Quick Connect Cord (#QC-1)*
System Controller
☐ *6-unit (#SC-201-6M)*
☐ *12-unit (#SC-201-12M)*
☐ *24-unit (#SC-201-24M)*

NORITZ AMERICA CORPORATION
11160 Grace Avenue, Fountain Valley, CA 92708 Tel. 1-866-7NORITZ www.noritz.com

Solar Thermal Collector

Apricus AP-30 Solar Collector

Product Specifcations Sheet

Overview

Apricus solar collectors use high efficiency twin-glass evacuated tubes to absorb solar energy and convert it into usable heat. Freeze protected heat pipes transfer heat from within the evacuated tube up to an insulated copper header pipe through which a heat transfer liquid is circulated.

Suitable for domestic or commercial applications, Apricus solar collectors maintain strong efficiency levels even at high delta-t temperatures. For this reason Apricus collectors are ideal for cold regions and high temperature applications.

Physical Specifications

Overall Length	1980mm / 80"
Overall Height	156mm / 6.14"
Overall Width	2196mm / 86.4"
Absorber Area	2.4m^2 / 25.8ft^2
Aperture Area	2.82m^2 / 30.3ft^2
Gross Area	4.35m^2 / 46.8ft^2
Gross Dry Weight	95kg / 209lb
Fluid Capacity	710ml / 24fl oz
Max Operating Pressure	800kPa / 116psi
Stagnation Temperature	< 220 °C / 432°F

Performance Variables (aperture area)

Eta0 (y-intercept)	0.656
a1 [W/(m^{2}K)]	1.4*
a2 [W/(m^{2}K^2)]	0.007*
Heat Capacity [kJ/)(m^2/K)]	44.89
Peak Power Output	1850W / 6312Btu

Key Material Specifications

Evacuated Tubes	Borosilicate 3.3 Glass
Absorber	Al-N on Al on Glass
Heat Pipes	High Purity Copper
Heat Transfer Fins	Aluminum
Rubber Components	HTV Silicone Rubber
Mounting Frame	439 Stainless Steel
Manifold Casing	5005-H16 Aluminum

Installation Guidelines

Max Flow Rate	15L/min / 3.9gpm
Max Tubes in Series	150 tubes
Install Angle Range	20-70°

* Performance values internally verified

Internationally Certified Product

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Physical Specifications

Overall Length	1980mm / 80"
Overall Height	156mm / 6.14"
Overall Width	2196mm / 86.4"
Aperture Area	2.83m² / 30.45ft²
Gross Area	4.26m² / 45.83ft²
Gross Dry Weight	95kg / 209lb
Fluid Capacity	710ml / 24fl oz
Max Operating Pressure	800kPa / 116psi
Stagnation Temperature	< 220°C / 432°F

Key Material Specifications

Evacuated Tubes	Borosilicate 3.3 Glass
Absorber	Al-N on Al on Glass
Heat Pipes	High Purity Copper
Heat Transfer Fins	Aluminum
Rubber Components	HTV Silicone Rubber
Mounting Frame	439 Stainless Steel
Manifold Casing	5005-H16 Aluminum

Performance Variables (1)

Eta0 (y-intercept)	0.687
a1 [W/(m²K)]	1.505
a2 [W/(m²K²)]	0.011
Heat Capacity [kJ/)(m²/K)]	52.44
Peak Power Output (2)	1944W / 6632Btu

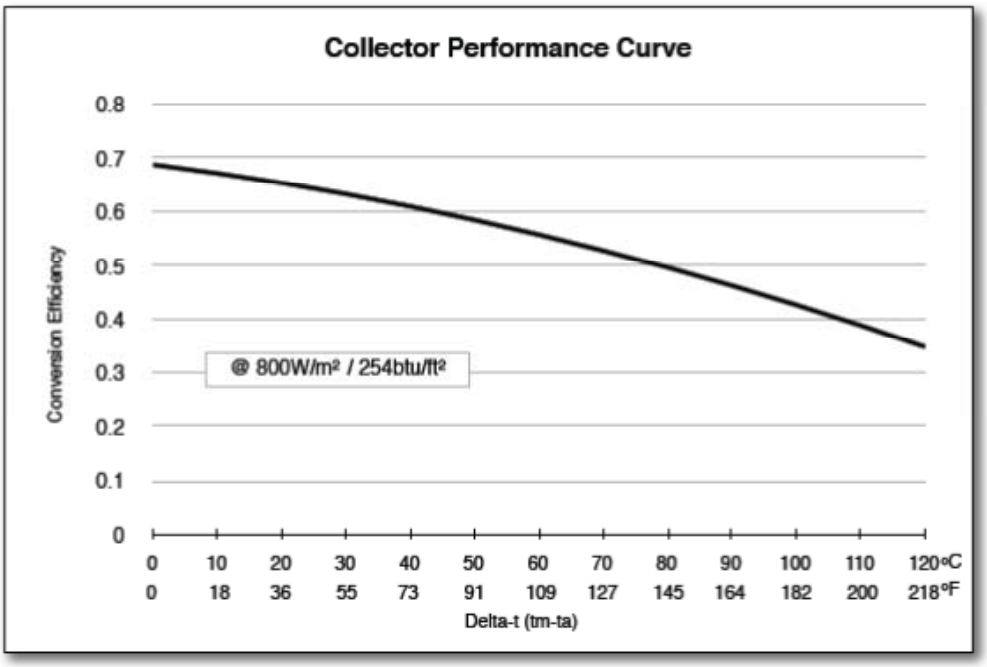
Incidence Angle Modifier (passive tracking):

Angle	0	20	40	50	60	70	90
Long	1.00	1.00	0.97	0.92	0.84	0.70	0.00
Trans	1.00	1.08	1.35	1.47	1.39	1.57	0.00

Installation Guidelines

Max Flow Rate	15L/min / 3.9 US gpm
Max Tubes in Series	150 tubes
Install Angle Range	20-80°
Maximum Pressure Drop(3)	10kPa / 3ft / 1.3psi

(1) Data from ITW test report 09COL805
(2) G=1000W/m², IAM angle = 0°
(3) @20°C/68°F & 15L/min / 4US gpm



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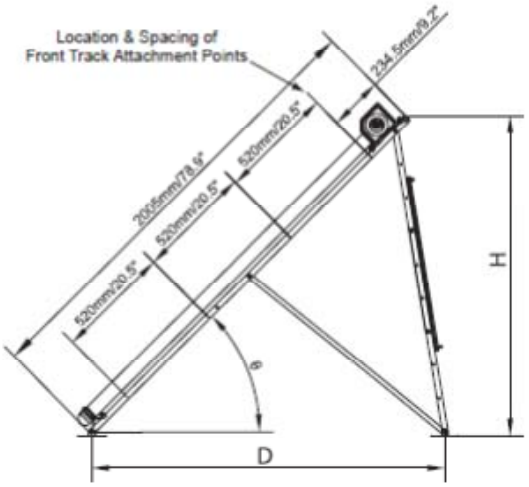
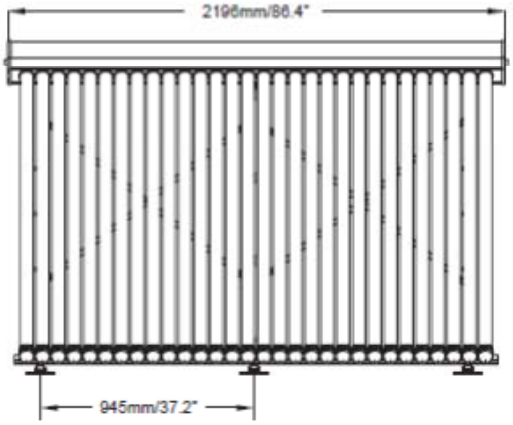
Mounting Frame Dimensions





Angle	Type	D	H
57°	High Angle (Round Feet)	1278mm / 50.3"	1674mm / 31.3"
51°		1427mm / 56.2"	1551mm / 61.1"
44°		1581mm / 62.2"	1393mm / 54.8"
38°		1709mm / 67.3"	1236mm / 48.7"
33°		1814mm / 71.4"	1078mm / 42.4"
51°	High Angle (Roof Track)	1900mm / 74.8"	1562mm / 61.5"
46°		1900mm / 74.8"	1448mm / 57.0"
41°		1900mm / 74.8"	1326mm / 52.2"
37°		1900mm / 74.8"	1196mm / 47.1"
32°		1900mm / 74.8"	1059mm / 41.7"
27°	Mid Angle (Round Feet)*	Variable	~ 918mm / 36.1"
27°	Mid Angle (Roof Track)*	1900mm / 74.8"	918mm / 36.1"
13°	Low Angle (Round Feet)*	Variable	~ 450mm / 17.7"
13°	Low Angle (Round Track)	1900mm / 74.8"	450mm / 17.7"

Certifications

North America: SRCC OG100 AP-30 Report # 100-2007033A
IAPMO USEC Report # S-5995
FSEC AP-30 Report # 00204N

Europe: Dincertco Solarkeymark # 011-7S161 R

Australia/NZ: Global Mark (AS/NZSAS2712) Client # 100633

ISO9001-2008: Global Mark Client # 100633

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SOLAR COLLECTOR CERTIFICATION AND RATING SRCC OG-100	**CERTIFIED SOLAR COLLECTOR**
	SUPPLIER: **Apricus Inc.** 965 West Main Street Branford,CT06405 USA
	MODEL: AP-30
	COLLECTOR TYPE: Tubular
	CERTIFICATION#: 2007033A

COLLECTOR THERMAL PERFORMANCE RATING

Megajoules Per Panel Per Day				Thousands of BTU Per Panel Per Day			
CATEGORY	CLEAR DAY	MILDLY CLOUDY	CLOUDY DAY	CATEGORY	CLEAR DAY	MILDLY CLOUDY	CLOUDY DAY
A (-5 °C)	48.7	36.7	24.8	A (-9 °F)	46.1	34.8	23.5
B (5 °C)	46.5	34.5	22.5	B (9 °F)	44.0	32.7	21.4
C (20 °C)	42.9	30.9	19.0	C (36 °F)	40.6	29.3	18.0
D (50 °C)	36.0	24.2	12.4	D (90 °F)	34.2	23.0	11.8
E (80 °C)	28.6	16.8	6.2	E (144 °F)	27.1	16.8	6.2

Original Certification Date: 24-AUG-09

COLLECTOR SPECIFICATIONS

Gross Area:	4.158 m^2	44.76 ft^2
Dry Weight:	96.2 kg	212. lb
Test Pressure:	1103. KPa	160. psig

Net Aperature Area:	2.99 m^2	32.21 ft^2
Fluid Capacity:	1 liter	0.3 gal

COLLECTOR MATERIALS

Frame:	Stainless Steel
Cover (Outer):	Glass Vacuum Tube
Cover (Inner):	None
Absorber Material:	Tube - Copper / Plate - Aluminum
Absorber Coating:	Aluminum Nitride
Insulation Side:	Vacuum
Insulation back:	Vacuum

Pressure Drop

Flow		ΔP	
ml/s	gpm	gpm	in H_2O
20.00	0.32	105.00	0.42
50.00	0.79	524.0	2.1
80.00	1.27	1257.00	5.05

TECHNICAL INFORMATION

Efficiency Equation [NOTE: Based on gross area and (P)=Ti-Taj]				Y INTERCEPT	SLOPE
S I UNITS:	η= 0.4560	-1.35090 (P)/I	-0.00381 $(P)^2/I$	0.5	-1.6 $W/m^2,°C$
I P UNITS:	η= 0.4560	-0.2380 (P)/I	-0.0004 $(P)^2/I$	0.5	-0.3 $Btu/hr.ft^2,°F$

Incident Angle Modifier [(S)=1/cosθ - 1, 0°<θ<=60°]				
Kα = 1	1.306 (S)	-1.034 $(S)^2$	**Model Tested:**	100-2007-033A
Kα = 1	0.23 (S)	Linear Fit	**Test Fluid:**	Water
			Test Flow Rate:	83 ml/s 1.32 gpm

REMARKS: Tested with long axis of tubes oriented north-south. IAM perpendicular to the tubes is listed above. IAM parallel to the tubes = 1.0 - 0.09(S)

September, 2009
Certification must be renewed annually, For current status contact:
SOLAR RATING & CERTIFICATION CORPORATION
c/o FSEC ♦ 1679 Clearlake Road ♦ Cocoa, FL 32922 ♦ (321) 638-1537 ♦ Fax (321) 638-1010

Circulation System

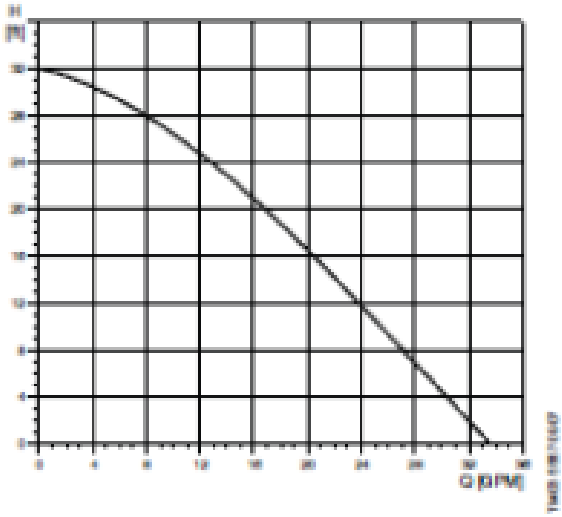
Controller

Watts P04161

Ambient temperature range for normal operation	32°F – 122°F
Electrical Protection **Installation Category** **Pollution Degree**	IP20 II 2
Fuse **Power supply** **Maximum Power Consumption** (with all outputs activated)	5A 120Vac (5x20mm) 120Vac +/- 10% 60Hz 4.2A (~504W)
Outputs: **P1** (Main pump with standard or PWM speed regulation): **P2** (Pump with standard or PWM speed regulation, Booster pump, valve): ***NOTE: Combined output of P1 and P2 not to exceed 3A.** **P3** (Extra, Additional heat, cooling…)	Triac 1.8A* 120VAC. Triac 1.8A* 120VAC Relay 2A 120VAC
Inputs: **T1** (Collector1): **T2** (Tank1): **T3** (Extra sensor): **T4** (Extra sensor, Tank2, Collector2): **T5** (Collector supply): **T6** (Flow meter): **GDS1** (Grundfos Flow meter): **GDS2** (Grundfos Pressure sensor):	PT 1000 type PT 1000 type PT 1000 type PT 1000 type PT 1000 type Impulse type (low voltage 5V) Analog type (Grundfos **VFS**) Analog type (Grundfos **VPS**)
Sensors delivered: **1 Collector sensor** **1 Tank** **1 Extra**	 PT1000 (1.5M 356°F) PT1000 (3M 221°F) PT1000 (3M 221°F)
Software version	Displayed during the start-up **Version xxxxxx**

Pump

Grundfos UP 26-99 F/BF



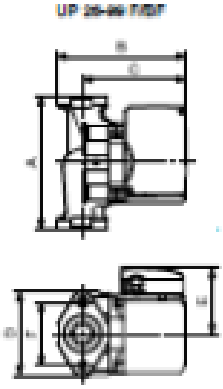
Flow range:	0-34 gpm
Head range:	0-32 feet
Motors:	2-pole, single-phase
Max. liquid temperature:	230 °F (110 °C)
Min. liquid temperature:	36 °F (2 °C)
Max. system pressure:	145 psi (10 bar)
Closed system (F) and Open system (BF)	

Model	Volts	Amps	Watts	Hp	Capacitor
UP 26-99 F/BF	115	2.15	245	1/6	10µF/150 V
	230	1.07	245	1/6	2.5µF/350 V

Approvals

UP 26-99 F/BF

UP 26-99 BF



Model type	Product number		Dimensions [inches]						Connection type and size	Shipping weight [lbs]
	115 V	230 V	A	B	C	D	E	F		
UP 26-99 F	52722355	52722351	6 1/2	6 3/8	5 1/16	4 1/8	3 1/2	3 5/32	GF 15/25 flange (2) 1/2" dia. bolt holes	12 1/2
UP 26-99 BF	52722347	52722346	6 1/2	6 3/8	5 1/16	4 1/8	3 1/2	3 5/32	GF 15/25 flange (2) 1/2" dia. bolt holes	12 1/2

Note: Dimensions in inches unless otherwise noted.

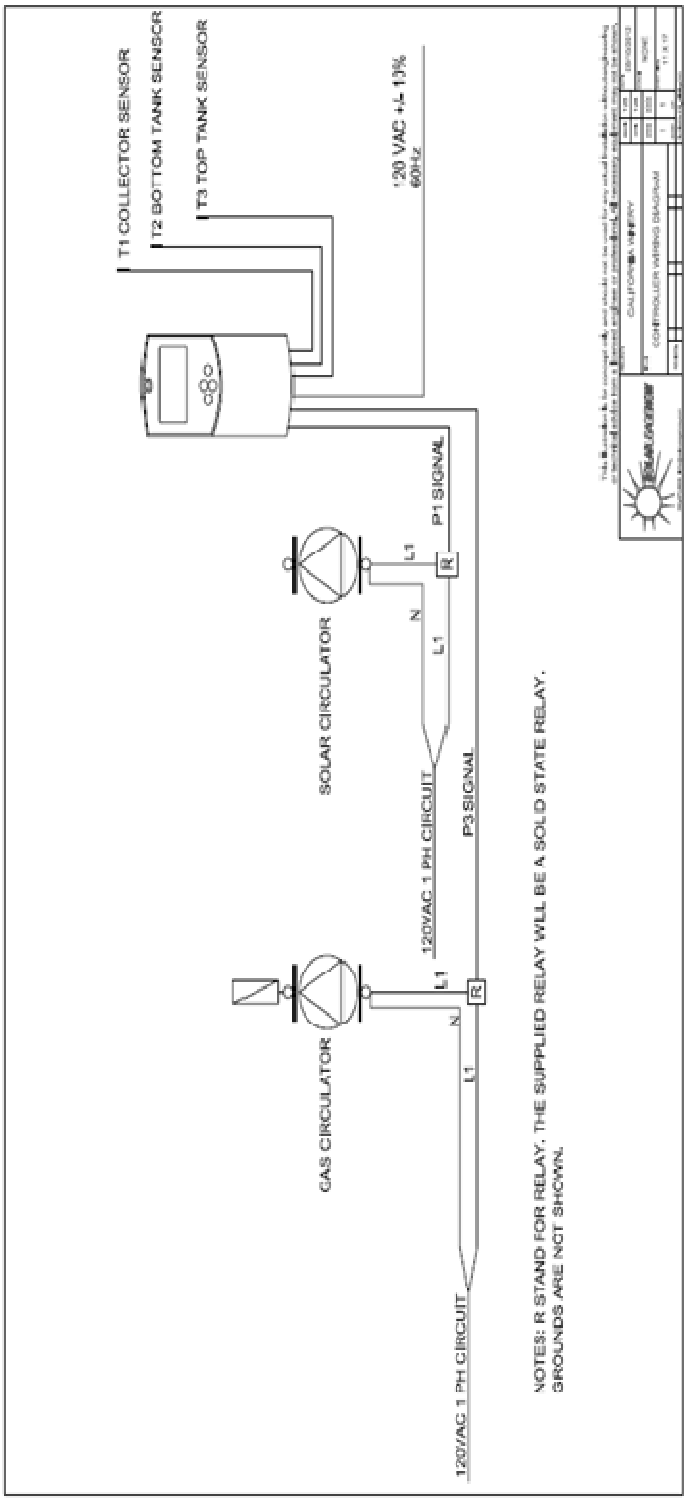



Figure 47: Pump Wiring Diagram