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Designing a Snow Melting System for 5MWe Sabalan Geothermal Pilot Power Plant Project

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ABSTRACT

The Sabalan geothermal field is a high-temperature area under development. Geothermal exploration was started in 1975 by the Ministry of Energy of Iran. After revolution in 1979 in Iran, it was stopped, and it was started again in 1998 by SUNA – the Renewable Energy Organization of Iran. Three deep exploration wells and two shallow reinjection wells were drilled in 2002-2004 in three sites A, B and C, by SUNA beside the preparation of two sites D and E for new drilling. This area is about 16 km southeast of the town of Meshkinshahr. There is an overall potential for the generation of about 200 MWe over the greater prospect area. SKM (main consultants 1998-2006) assesses that commercial geothermal power generation can be achieved at Sabalan at a levelised cost of electricity of less than 5 USc/kWh. SUNA is planning to drill thirteen new wells, and build a 50 MWe power plant, when these wells will be drilled. As the first part of project, SUNA will build a pilot power plant in order to confirm, that a geothermal power plant can be operated in Iran. Moshanir was the consultant for civil work 1998-2006 and since 2006 the consortium of Moshanir, EDC and Lahmeyer was selected as main consultant for geothermal field that the new drilling was started since of 2008 till 2011. In this stage 5 deep wells were drilled and one of the previous well was be deeper.

Well NWS-6D is the sixth drilled well in the second stage of exploration and third to be discharged. This well was flow tested in the time period of 7th September to 31th may in 2011

In this paper we discuss the designing of a hydronic snow melting system in above mentioned project. The snow melting system designing is presented based on criteria established by ASHRAE and supposed to be designed only for main access road from the administration building to the power house in the site of this geothermal pilot power plant, Geothermal energy is supplied to system through a heat exchanger so It is a closed cycle type and the fluid which is required for this system is supplied from a heat exchanger. The heating water which will be used in heat exchanger will be supplied from the silencer and separator drain. For designing the snow melting system we need to know about the location and the climatic condition of the power plant site which designing depends on such as the rate of snow fall, air temperature, relative humidity and wind velocity. Piping materials are cross linked polyethylene (PEX) tubing and applicable fittings due to corrosion Problems.

1. INTRODUCTION

Snow melting using geothermal hot water and steam has been demonstrated in several countries, including Argentina, Japan and the United States. Snow melting in industrial applications is used where safe, clean and easy access is critical. These installations include sidewalks, roadways and bridges. Most commonly it is done with a glycol solution, hot water or steam being circulated in pipes within or below the area, using either heat pipes or geothermal fluids, however, in one instances hot water has been sprinkled directly onto it. In this paper we discuss the designing of the snow melting system in the Sabalan Geothermal Power Plant project.

Figure 1.Snow Melting Implementation in Iceland

2. DESIGN CRITERIA

Designing factors for snow melting systems depend on four atmospheric factors: (1) rate of snow fall, (2) air temperature, (3) relative humidity, and (4) wind velocity (ASHRAE Handbook, 1995). The snow melting system must first melt the snow and then evaporate the resulting water film. The rate of snowfall identifies the heat required to warm the snow to 32°F and to melt it. The evaporation rate of the melted snow from the road is affected by the wind speed and by the difference in vapor pressure between the air and the melted snow. Since the vapor pressure is established by the relative humidity and temperature of the air, and as the road surface temperature is usually fixed, the resulting evaporation rate varies with changes in air temperature, and wind speed. Convection and radiation loss from the melted snow depends on the film coefficient and the difference in temperature between the surface and air. The film coefficient is just a function of wind speed, and since the road temperature is fixed, convection and radiation losses vary with changes in air temperature and wind speed (ASHRAE Handbook, 1995). Chapman (1952) derives and explains equations for the heating requirement of a snow-melting system. Chapmanand Katunich (1956) derive the general equation for the required road heat output (q_o) in Btu/h.ft^2:

$$q_o = q_s + q_m + A_r (q_e + q_h) \tag{1}$$

where q_s, q_m, A_r, q_e, q_h are sensible heat transferred to the snow ($\frac{Btu}{h.ft^2}$.), heat of fusion (latent heat flux) ($\frac{Btu}{h.ft^2}$.), ratio of snow-free area to total area (dimensionless), heat of evaporation ($\frac{Btu}{h.ft^2}$.), and heat transfer by convection and radiation(from snow-free surface) ($\frac{Btu}{h.ft^2}$.), respectively.

The sensible heat q_s to bring the snow to 32 °F is:

$$q_s = s\, c_p\, \rho\, (32 - t_a) / c_1 \tag{2}$$

where s, c_p, ρ, t_a, c_1 are rate of snowfall (inches of water equivalent per hour), specific heat of snow (0.5 $\frac{Btu}{lb.°F}$), density of water equivalent of snow (62.4 lbs/ft^3), air temperature (°F) and conversion factor (12 in/ft), respectively.

For hot water (hydronic) systems, the above reduces to:

$$q_s = 2.6\, s\, (32 - t_a) \tag{3}$$

The heat of fusion q_m to melt the snow is:

$$q_m = s h_f\, \rho / c_1 \tag{4}$$

Where h_f is enthalpy of fusion for water (143.5 Btu/lb).

For hot water (hydronic) systems, the above reduces to:

$$q_m = 746\, s \tag{5}$$

The heat of evaporation q_e (mass transfer) is (for hydronic):

$$q_e = h_{fg}\, (0.0201\, V + 0.055)\, (0.188 - p_{av}) \tag{6}$$

where h_{fg}, V, p_{av} are heat of evaporation at the film temperature (Btu/lb), wind speed (mph), and vapor pressure of moist air (inches of mercury), respectively.

The heat transfer q_h (convection and radiation) is (for hydronic):

$$q_h = 11.4\, (0.0201\, V + 0.055)\, (t_f - t_a) \tag{7}$$

where t_f is water film temperature (°F), usually taken as 33°F.

The solution of the general equation for q_o for the required road heat output, requires the simultaneous consideration of all four climatic factors: wind speed, air temperature, relative humidity, and rate of snowfall (ASHRAE HANDBOOK, 2011 and John W. L,2000).

Annual averages or maximums for the climatic factors should not be used because they are most likely not to occur simultaneously. It is thus necessary to investigate the various combinations that might occur at a site, based on several year's worth of data, to determine the critical combination that is most likely to be experienced (ASHRAE Handbook, 1995).

Design climatic conditions and required weather data are collected as follows:

3. CLIMATIC CONDITIONS

The climate in the area is relatively dry, especially during the summer months.

The site is exposed to severe winter weather, including very high wind speeds of up to 180 km/h. Winter temperature has been measured as low as -30°C. The barometric pressure is 0.75 bar in site E. Table 1 shows some climate data on well site.

Table 1: Summary of weather data

	Temperatur e (°C)	Relative Humidity(%	Precipitatio n	Wind velocity(km
Annual Average	3.6	52	306	-
Annual average	29	-	-	50
Annual average	-30	-	-	-

3.1 Temperature

The temperature fluctuations in the project area are large oscillating from -30°C in January to +35°C in June and July. The average monthly temperature in the project area is shown in Figure 20.

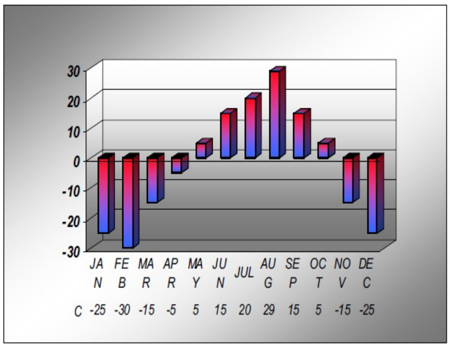


Figure 2.Temperature variation in the project area

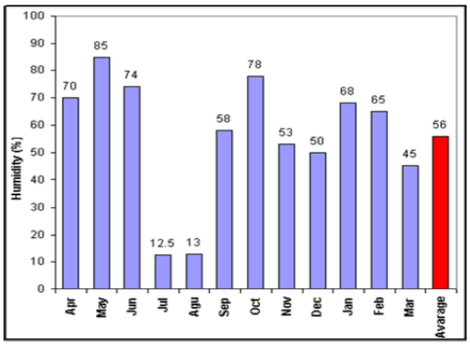


Figure 3.Monthly average relative humidity in the project area

3.2 Humidity

The humidity in the area is not very high due to high elevation and cold climate. The annual mean relative humidity in the study area is 59.5%. The monthly average relative humidity in the project area is shown in 03.

4. DESIGNING THE SNOW MELTING SYSTEM

On the power plant plan (figure 4) the layout of the plant is shown. The area which is supposed to be designed for snow melting system is hatched.

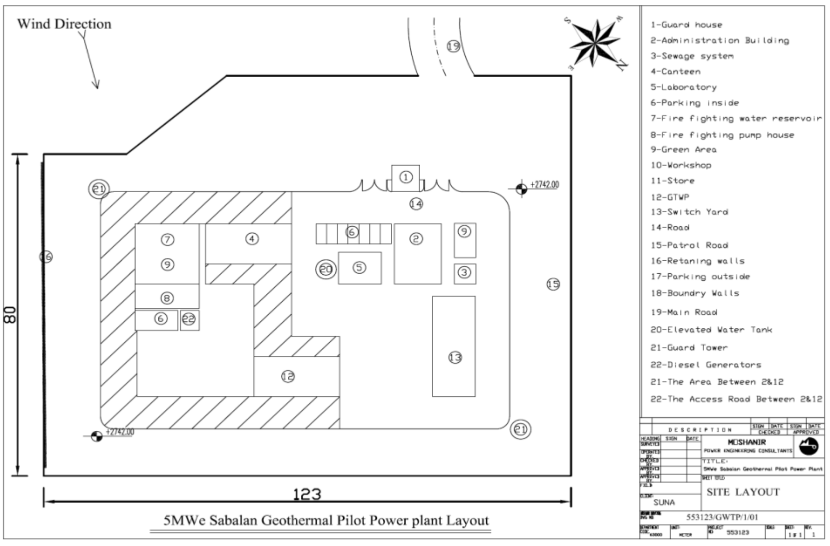


Figure 4: Power Plant Layout

Hydronic system design includes selection of the following components: (1) heat transfer fluid, (2) piping, (3) fluid heater, (4) pump(s) to circulate the fluid, and (5) controls. With concrete slabs, thermal stress is also a design consideration.

The Advanced Snow Melt Control is typically used in medium to large size residential, commercial and industrial areas, building entrances, parking ramps and lots, emergency entrances. Use this control when accurate ice and snow detection is required. Ensures energy savings of up to 80% compared to thermostatically controlled systems

In the first step of the designing our system we should choose the level of the system. We should consider the customer's intention and expectation of the snow melting system to select the correct design criteria level. There are 3 levels:

Level 1 Residential

• Designed to keep the surface completely free of snow 95% of the time

• Occasional snow or ice buildup may occur

• Typically 5/8" Pextron tubing with 9" spacing (1/2" for small areas)

Common applications:

• Residential applications

• Driveways

• Sidewalks

• Hot tub areas

Level 2 Residential/Commercial

• Designed to keep the surface completely free of snow 98% of the time

• Typical level selection for most cases

• Typically 5/8" Pextron tubing with 6" or 9" spacing (3/4"for large areas)

Common applications:

• Commercial and light commercial applications • Public access areas to buildings

• Handicapped ramps

• Commercial stairways

Level 3 Industrial/Critical

• Designed to keep the surface completely free of snow 99% of the time

• Advanced Snow Melt Control for sensitivity

• System must melt snow with no accumulation

• Typically 5/8" Pextron tubing with 6" spacing (3/4" for large areas)

• System idling often needed for quick response

Common applications:

• Critical applications

• Hospital emergency ramps

• Helipads

• Access areas for emergency vehicles (fire stations, etc.)

• Areas deemed critical for public safety

In summary Chapman (1957) classifies snow melting installation according to type as Class I, II or III. These types are described as follows:

Class I (minimum): residential walks or driveways, interplant ways or paths

Class II (moderate): commercial sidewalks and driveways; steps of hospitals

Class III (maximum): toll plazas of highways and ridges; aprons and loading area of airports; hospital emergency entrances.

Considering the Client's expectation our system will be assumed as level 3(Class III).

In the second step of the designing we should calculate the Snow melting load.

5. CALCULATING THE SNOW MELTING LOAD

We use the equation which is mentioned in DESIGN CRITERIA section. Our data for this project due to the plans and climatic conditions are s= 0.24, C_p= 0.5, ρ= 62.4, t_a= - 23.8, c_1= 12

So from (2) we have:

$$q_s = 0.24 \times 0.5 \times 62.4 \times (32-(-23.8))/12$$

$$q_s = 34.81$$

Or for hydronic (hot water) (equation (3)) we have:

$$q_s = 2.6 \times 0.24 \times (32-(-23.8))$$

$$q_s = 34.81$$

Then we have h_f= 143.5 therefore from (4) we have :

$$q_m = 0.24 \times 143.5 \times 62.4/12$$

$$q_m = 179.08$$

or for hydronic (hot water) (equation (5)) we have:

$$q_m = 746 \times 0.24$$

$$q_m = 179.04$$

Also we have values of V and H_{fg} which are V=111.84, H_{fg}= 1075.8 Btu/Ibm and for p_{av} we know that

$$Ø = p_v/p_g$$

We have Ø=59.5% and p_g=0.0062 psia at t=-22°F from the thermodynamic tables therefore we have (1psi=2.036 in Hg):

$$P_{av} = p_v = 0.595 \times 0.0062 \times 2.036$$

$$P_{av} = 0.0075 \text{ in Hg}$$

Therefore from (6) we have:

$$q_e = 1075.8 \times (0.201 \times 111.84 + 0.055) \times (0.188 - P_{av})$$

$$q_e = 4375.85$$

And we have t_f= 33 so from equation (7):

$$q_h = 11.4(0.0201 \times 111.84 + 0.055 \times (33-(-23.8))$$

$$q_h = 61.24$$

We assume that don't have any snow-free area therefore A_r = 0 so finally from (1) we have:

$$q_o = 34.81 + 179.04$$

$$q_o = 213.85 \text{ Btu/h.ft2}$$

q_o is our the heat output requirement . These values do not include back and edge heat losses; they must be added to get final heat output requirement

6. BACK AND EDGE HEAT LOSS

Back and edge heat loss is the percentage of heat lost through the back and edge of the snow melt area. Back and edge heat losses may add up to 40% to the snow melting load, depending on:

1- Construction, 2- Insulation, 3- Exposure, 4- Operating temperature, 5- Ground temperature

By Multiplying the snow melting load (q_o) by the adjusting multiplier we can calculate the actual snow melting load. Most of designer companies suggest a multiplier with a value of 1.05 for projects Full Below but No Edge Insulation which is our case. Therefore the actual snow melting load will be:

$$q_{o\ actual} = 213.85$$

In the third step of the designing we should calculate the Tube Spacing.

7. TUBE SPACING

Decreasing the tube spacing will allow the snow melting system to operate at lower fluid temperatures while meeting the heat output requirements. We choose the following values for spacing:

Circuit spacing	9 "
Circuit offset from the wall	3"
Circuit entry spacing	5"

8. HEAT TRANSFER FLUID

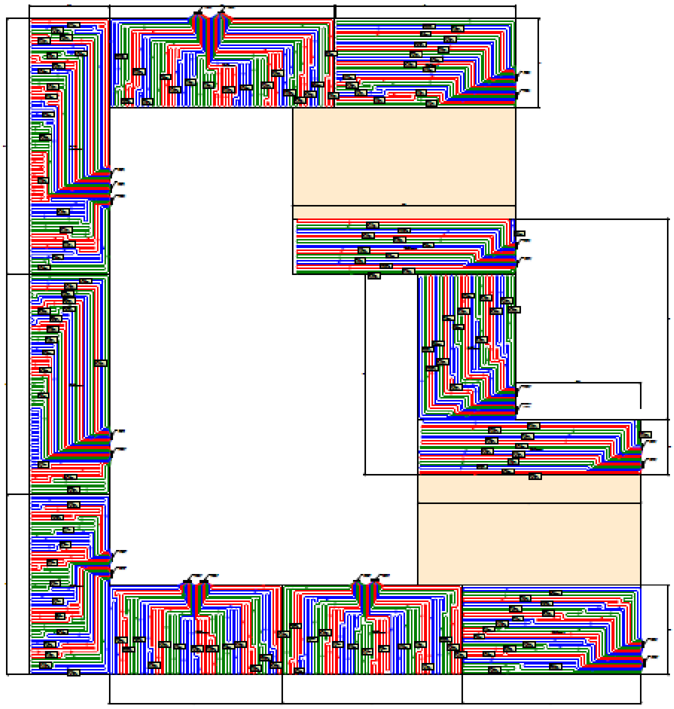
Not only because Glycols (ethylene glycol and propylene glycol) are the most popular in snow-melting systems but also because of their moderate cost, high specific heat, and low viscosity; ease of corrosion control we choose them as our Heat Transfer Fluid Automotive glycols containing silicates are not recommended because they can cause fouling, pump seal wear, fluid gelation, and reduced heat transfer. The piping should be designed for periodic addition of an inhibitor. Glycols should be tested annually to determine any change in reserve alkalinity and freeze protection. Only inhibitors obtained from the manufacturer of the glycol should be added. Heat exchanger surfaces should be kept below 140°C, which corresponds to about 280 kPa (gage) steam. Temperatures above 150°C accelerate deterioration of the inhibitors (ASHRAE Handbook,2009). We used the 50% Glycol Fluid type due to it’s freezing point (about Freezing Point (°F) and our climatic conditions.

Figure 5.Snow Melting Implementation in Iceland

9. DESIGNING THE SNOW MELTING SYSTEM WITH LOOP CAD 2013

We will use the **Loop cad 2013 with** to design snow melting system and to draw in needed drawings. **Loop cad** is an industry standard software for the creation of professional circuit layout drawings. The Professional Edition includes Residential Heat Loss Calculations (ASHRAE and CSA options), Hydronic Calculations (temperatures, flows, head losses), Snow Melt Design and Load Calculations, 3D CAD Views and OEM Software Add-ons for fully integrated design and quotations features.

Here are the results of the designing with aforementioned software. The remaining of the results are in the appendix due to the longsome of the results.



Project Number: 553123
Project Name: 5MWe Sabalan Geothermal Pilot Power Plant
Location: Sabalan,Ardebil
Date: Tuesday, March 16, 2014
Prepared By:

Floor Plan: Snow Melt
Circuit Information:

Total Length: 22,478 ft - ViegaPEX Barrier 1/2" (Coil)

Circuit	Length	Manifold	Tube Type
A-0	138	Manifold 19	1/2
A-1	144	Manifold 2	1/2
A-2	140	Manifold 2	1/2
A-3	137	Manifold 2	1/2
A-4	135	Manifold 2	1/2
A-5	132	Manifold 2	1/2
A-6	131	Manifold 2	1/2
A-7	131	Manifold 2	1/2
A-8	131	Manifold 2	1/2
A-9	131	Manifold 2	1/2
A-10	145	Manifold 5	1/2
A-11	145	Manifold 3	1/2
A-12	146	Manifold 3	1/2
A-13	143	Manifold 3	1/2
A-14	143	Manifold 3	1/2
A-15	141	Manifold 3	1/2
A-16	138	Manifold 3	1/2
A-17	146	Manifold 3	1/2
A-18	144	Manifold 3	1/2
A-19	147	Manifold 3	1/2
A-20	142	Manifold 4	1/2
A-21	149	Manifold 5	1/2
A-22	146	Manifold 5	1/2
A-23	142	Manifold 5	1/2

LoopCAD 2013

Note: Details of the tubing bend radius have been simplified for clarity. Consult tubing manufacturer for specific bend radius recommendations.
Created using LoopCAD 2013 4.0.0098

Project Number: 553123
Floorplan: Snow Melt (Fit To Page)
Monday, December 07, 2013

LoopCAD® 2013

Snow Melt System Design Report

Project #:553123
December 7, 2013

Project Information

Project #: 553123
Name: 5MWe Sabalan Geothermal Pilot Power Plant
Location: Sabalan,Ardebil

Notes:

Design Conditions and Summary

Load Calculation Method:	Manual	Total Tubing Lengths:		Total Snow Melt Load:	3,383,550 Btu/hr
Fluid Type:	50% Propylene Glycol	ViegaPEX Barrier 1/2" (Coil)	22,478 ft		
Total Flowrate:	254.7 USGPM				
Max. Head Loss:	243.0 ft water				
Design Temp. Drop:	30.0 °F	Total Circuits:	161		
Total Area:	15,098 ft²	Total Manifolds:	23		
		Total Tubing Volume:	206.92 USG		
		Glycol Volume (50%):	103.46 USG		

Snow Melt System Design

Snow Melt

Total Area:	1,380 ft²	Tubing:	ViegaPEX Barrier 1/2" (Coil)	Design Load:	295,249 Btu/hr
Heated Area:	1,380 ft²			Downward Loss:	14,762 Btu/hr
Construction:	Snow Melt - Concrete	Total Circuits:	14	Total Heat Load:	310,011 Btu/hr
Slab Depth:	3.9 in	Avg. Circuit Length:	145 ft	(User Specified Load)	
		Total Length:	1,905 ft		
		Avg. Tube Spacing:	9 in		
		Min Supply Temp:	118 °F		

See end of report for important Notes and Disclaimers.

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CONCLUSION

As it is shown in the results for each case, the required flow rate and source temperature to be supplied is calculated and based on our brine it is possible to provide the needed temperature and flow rate for the system. It should be mentioned that the equipment for implementation limit our design. For example the maximum temperature that can be used in pex al pex tubes is 150 °F (or 160) or the maximum flow rate of a manifold which can be used is 18 US GPM(or according to some manufacturer 22). Also total length of tubes should be lower than 150 ft. These recommendations are suggested by some of the snow melting equipment manufacturers and it is tried that the design complied with these suggestions.

ACKNOWLEDGEMENTS

We would like to thank Mr. I. Ghaderi and Dr. S. Porkhial one for their assistance most sincerely.

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ASHRAE Handbook, Fundamentals (2009)

ASHRAE HANDBOOK, HVAC Applications (2011)

APPENDIX

Name:5MWe Sabalan Geothermal Pilot Power Plant
Project #:553123

Snow Melt System Design Report
December 7, 2013

Snow Melt

Total Area:	1,378 ft^2	Tubing:	ViegaPEX Barrier 1/2" (Coil)	Design Load:	294,754 Btu/hr
Heated Area:	1,378 ft^2	Total Circuits:	16	Downward Loss:	14,738 Btu/hr
Construction:	Snow Melt - Concrete	Avg. Circuit Length:	133 ft	Total Heat Load:	309,492 Btu/hr
Slab Depth:	3.9 in	Total Length:	1,972 ft	(User Specified Load)	
		Avg. Tube Spacing:	8 in		
		Min Supply Temp:	117 °F		

Snow Melt

Total Area:	1,220 ft^2	Tubing:	ViegaPEX Barrier 1/2" (Coil)	Design Load:	260,863 Btu/hr
Heated Area:	1,220 ft^2	Total Circuits:	14	Downward Loss:	13,043 Btu/hr
Construction:	Snow Melt - Concrete	Avg. Circuit Length:	133 ft	Total Heat Load:	273,906 Btu/hr
Slab Depth:	3.9 in	Total Length:	1,742 ft	(User Specified Load)	
		Avg. Tube Spacing:	8 in		
		Min Supply Temp:	117 °F		

Snow Melt

Total Area:	1,075 ft^2	Tubing:	ViegaPEX Barrier 1/2" (Coil)	Design Load:	228,946 Btu/hr
Heated Area:	1,070 ft^2	Total Circuits:	12	Downward Loss:	11,447 Btu/hr
Construction:	Snow Melt - Concrete	Avg. Circuit Length:	135 ft	Total Heat Load:	240,394 Btu/hr
Slab Depth:	3.9 in	Total Length:	1,518 ft	(User Specified Load)	
		Avg. Tube Spacing:	8 in		
		Min Supply Temp:	118 °F		

Snow Melt

Total Area:	1,075 ft^2	Tubing:	ViegaPEX Barrier 1/2" (Coil)	Design Load:	229,896 Btu/hr
Heated Area:	1,075 ft^2	Total Circuits:	12	Downward Loss:	11,495 Btu/hr
Construction:	Snow Melt - Concrete	Avg. Circuit Length:	134 ft	Total Heat Load:	241,391 Btu/hr
Slab Depth:	3.9 in	Total Length:	1,500 ft	(User Specified Load)	
		Avg. Tube Spacing:	9 in		
		Min Supply Temp:	119 °F		

See end of report for important Notes and Disclaimers.

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Name:5MWe Sabalan Geothermal Pilot Power Plant
Project #:553123

Snow Melt System Design Report
December 7, 2013

Snow Melt

Total Area:	1,511 ft²	Tubing:	ViegaPEX Barrier 1/2" (Coil)	Design Load:	323,256 Btu/hr
Heated Area:	1,511 ft²	Total Circuits:	16	Downward Loss:	16,163 Btu/hr
Construction:	Snow Melt - Concrete	Avg. Circuit Length:	142 ft	Total Heat Load:	339,419 Btu/hr
Slab Depth:	3.9 in	Total Length:	2,115 ft	(User Specified Load)	
		Avg. Tube Spacing:	9 in		
		Min Supply Temp:	119 °F		

Snow Melt

Total Area:	1,729 ft²	Tubing:	ViegaPEX Barrier 1/2" (Coil)	Design Load:	369,833 Btu/hr
Heated Area:	1,729 ft²	Total Circuits:	18	Downward Loss:	18,492 Btu/hr
Construction:	Snow Melt - Concrete	Avg. Circuit Length:	143 ft	Total Heat Load:	388,325 Btu/hr
Slab Depth:	3.9 in	Total Length:	2,377 ft	(User Specified Load)	
		Avg. Tube Spacing:	9 in		
		Min Supply Temp:	118 °F		

Snow Melt

Total Area:	1,742 ft²	Tubing:	ViegaPEX Barrier 1/2" (Coil)	Design Load:	372,574 Btu/hr
Heated Area:	1,742 ft²	Total Circuits:	18	Downward Loss:	18,629 Btu/hr
Construction:	Snow Melt - Concrete	Avg. Circuit Length:	144 ft	Total Heat Load:	391,202 Btu/hr
Slab Depth:	3.9 in	Total Length:	2,438 ft	(User Specified Load)	
		Avg. Tube Spacing:	9 in		
		Min Supply Temp:	118 °F		

Snow Melt

Total Area:	1,337 ft²	Tubing:	ViegaPEX Barrier 1/2" (Coil)	Design Load:	285,891 Btu/hr
Heated Area:	1,337 ft²	Total Circuits:	14	Downward Loss:	14,295 Btu/hr
Construction:	Snow Melt - Concrete	Avg. Circuit Length:	141 ft	Total Heat Load:	300,185 Btu/hr
Slab Depth:	3.9 in	Total Length:	1,836 ft	(User Specified Load)	
		Avg. Tube Spacing:	9 in		
		Min Supply Temp:	118 °F		

See end of report for important Notes and Disclaimers.

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Name:5MWe Sabalan Geothermal Pilot Power Plant
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Snow Melt System Design Report
December 7, 2013

Snow Melt

Total Area:	1,391 ft²	Tubing:	ViegaPEX Barrier 1/2" (Coil)	Design Load:	297,588 Btu/hr
Heated Area:	1,391 ft²	Total Circuits:	14	Downward Loss:	14,879 Btu/hr
Construction:	Snow Melt - Concrete	Avg. Circuit Length:	145 ft	Total Heat Load:	312,468 Btu/hr
Slab Depth:	3.9 in	Total Length:	1,882 ft	(User Specified Load)	
		Avg. Tube Spacing:	9 in		
		Min Supply Temp:	119 °F		

Snow Melt

Total Area:	1,232 ft²	Tubing:	ViegaPEX Barrier 1/2" (Coil)	Design Load:	263,578 Btu/hr
Heated Area:	1,232 ft²	Total Circuits:	13	Downward Loss:	13,179 Btu/hr
Construction:	Snow Melt - Concrete	Avg. Circuit Length:	138 ft	Total Heat Load:	276,757 Btu/hr
Slab Depth:	3.9 in	Total Length:	1,667 ft	(User Specified Load)	
		Avg. Tube Spacing:	9 in		
		Min Supply Temp:	119 °F		

Name:5MWe Sabalan Geothermal Pilot Power Plant
Project #:553123

Snow Melt System Design Report
December 7, 2013

Manifold Summary

Manifold Name	# Circuits	Flowrate	Head Loss	Required Temp.	Supplied Temp.	Max Temp. Drop	Manifold Type
Manifold 1	7	10.02	19.2	117	119	31	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 2	9	13.27	20.9	116	119	31	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 3	9	14.69	24.3	118	119	30	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 4	9	14.54	24.7	118	119	30	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 5	6	9.69	24.8	117	119	31	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 6	6	9.65	24.2	118	119	31	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 7	6	10.10	26.4	118	119	31	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 8	8	12.65	22.5	117	119	31	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 9	6	8.61	25.8	119	119	30	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 10	8	12.90	23.5	119	119	31	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 11	6	9.56	23.2	118	119	30	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 12	7	10.04	19.5	117	119	31	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 13	7	10.58	23.4	117	119	31	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 14	6	8.54	25.3	118	119	31	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 15	6	9.55	23.3	117	119	31	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 16	7	11.65	25.6	118	119	30	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 17	7	11.68	25.6	118	119	30	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 18	7	11.43	24.7	118	119	30	Stainless Steel - Shut Off/Balancing, 1-1/4"

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Manifold 19	7	11.16	23.3	118	119	30	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 20	7	11.56	24.7	119	119	30	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 21	7	11.96	26.6	119	119	30	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 22	7	11.24	22.5	119	119	30	Stainless Steel - Shut Off/Balancing, 1-1/4"
Manifold 23	6	9.59	22.3	119	119	30	Stainless Steel - Shut Off/Balancing, 1-1/4"
Total	161	254.67	26.6	119	-	-	-

Tubing Circuit Details

Manifold 1

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-120	Snow Melt	127	9	82	ViegaPEX Barrier 1/2" (Coil)	1.39	13.8	30 (31)	18,428
A-121	Snow Melt	136	9	90	ViegaPEX Barrier 1/2" (Coil)	1.51	17.1	30 (31)	20,109
A-122	Snow Melt	124	9	82	ViegaPEX Barrier 1/2" (Coil)	1.39	13.4	30 (31)	18,428
A-123	Snow Melt	128	9	85	ViegaPEX Barrier 1/2" (Coil)	1.43	14.6	30 (31)	19,015
A-124	Snow Melt	126	9	83	ViegaPEX Barrier 1/2" (Coil)	1.40	13.8	30 (31)	18,574
A-125	Snow Melt	136	9	89	ViegaPEX Barrier 1/2" (Coil)	1.50	16.8	30 (31)	19,892
A-126	Snow Melt	131	9	83	ViegaPEX Barrier 1/2" (Coil)	1.41	14.5	30 (31)	18,725
Total	-	908		593	-	10.02	17.1		133,171

** Head loss for circuit tubing only

See end of report for important Notes and Disclaimers.

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Manifold 2

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-1	Snow Melt	144	9	91	ViegaPEX Barrier 1/2" (Coil)	1.54	18.8	30 (31)	20,522
A-2	Snow Melt	140	9	90	ViegaPEX Barrier 1/2" (Coil)	1.53	18.0	30 (31)	20,289
A-3	Snow Melt	137	9	89	ViegaPEX Barrier 1/2" (Coil)	1.51	17.2	30 (31)	20,057
A-4	Snow Melt	135	9	88	ViegaPEX Barrier 1/2" (Coil)	1.49	16.5	30 (31)	19,824
A-5	Snow Melt	132	9	87	ViegaPEX Barrier 1/2" (Coil)	1.47	15.9	30 (31)	19,591
A-6	Snow Melt	131	9	86	ViegaPEX Barrier 1/2" (Coil)	1.46	15.5	30 (31)	19,359
A-7	Snow Melt	131	9	85	ViegaPEX Barrier 1/2" (Coil)	1.44	15.1	30 (31)	19,126
A-8	Snow Melt	131	9	84	ViegaPEX Barrier 1/2" (Coil)	1.42	14.8	30 (31)	18,893
A-9	Snow Melt	131	9	83	ViegaPEX Barrier 1/2" (Coil)	1.40	14.5	30 (31)	18,661
Total	-	1,212		785	-	13.27	18.8		176,321

** Head loss for circuit tubing only

Manifold 3

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-11	Snow Melt	145	9	95	ViegaPEX Barrier 1/2" (Coil)	1.61	20.3	30 (30)	21,392
A-12	Snow Melt	146	9	98	ViegaPEX Barrier 1/2" (Coil)	1.65	21.5	30 (30)	21,959
A-13	Snow Melt	143	9	96	ViegaPEX Barrier 1/2" (Coil)	1.63	20.4	30 (30)	21,602
A-14	Snow Melt	143	9	97	ViegaPEX Barrier 1/2" (Coil)	1.63	20.5	30 (30)	21,689
A-15	Snow Melt	141	9	96	ViegaPEX Barrier 1/2" (Coil)	1.62	20.0	30 (30)	21,469
A-16	Snow Melt	138	9	94	ViegaPEX Barrier 1/2" (Coil)	1.59	19.0	30 (30)	21,097
A-17	Snow Melt	146	9	98	ViegaPEX Barrier 1/2" (Coil)	1.66	21.6	30 (30)	22,109
A-18	Snow Melt	144	9	97	ViegaPEX Barrier 1/2" (Coil)	1.64	20.7	30 (30)	21,734
A-19	Snow Melt	147	9	99	ViegaPEX Barrier 1/2" (Coil)	1.67	22.0	30 (30)	22,142
Total	-	1,293		869	-	14.69	22.0		195,192

** Head loss for circuit tubing only

Manifold 4

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-20	Snow Melt	142	9	95	ViegaPEX Barrier 1/2" (Coil)	1.60	19.8	30 (30)	21,278
A-127	Snow Melt	143	9	95	ViegaPEX Barrier 1/2" (Coil)	1.61	20.0	30 (30)	21,372
A-128	Snow Melt	144	9	98	ViegaPEX Barrier 1/2" (Coil)	1.65	21.1	30 (30)	21,919
A-129	Snow Melt	140	9	94	ViegaPEX Barrier 1/2" (Coil)	1.59	19.2	30 (30)	21,175
A-130	Snow Melt	142	9	96	ViegaPEX Barrier 1/2" (Coil)	1.62	20.1	30 (30)	21,542
A-131	Snow Melt	147	9	99	ViegaPEX Barrier 1/2" (Coil)	1.68	22.3	30 (30)	22,344
A-132	Snow Melt	139	9	92	ViegaPEX Barrier 1/2" (Coil)	1.56	18.5	30 (30)	20,766
A-133	Snow Melt	147	9	98	ViegaPEX Barrier 1/2" (Coil)	1.65	21.6	30 (30)	21,933
A-149	Snow Melt	141	9	93	ViegaPEX Barrier 1/2" (Coil)	1.57	18.9	30 (30)	20,804
Total	-	1,285		860	-	14.54	22.3		193,133

** Head loss for circuit tubing only

Manifold 5

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-10	Snow Melt	145	9	95	ViegaPEX Barrier 1/2" (Coil)	1.61	20.3	30 (31)	21,340
A-21	Snow Melt	149	9	99	ViegaPEX Barrier 1/2" (Coil)	1.67	22.4	30 (31)	22,237
A-22	Snow Melt	146	9	98	ViegaPEX Barrier 1/2" (Coil)	1.65	21.5	30 (31)	21,966
A-23	Snow Melt	142	9	95	ViegaPEX Barrier 1/2" (Coil)	1.61	19.9	30 (31)	21,396
A-24	Snow Melt	139	9	93	ViegaPEX Barrier 1/2" (Coil)	1.58	18.9	30 (31)	20,958
A-26	Snow Melt	140	9	93	ViegaPEX Barrier 1/2" (Coil)	1.57	18.8	30 (31)	20,898
Total	-	861		573	-	9.69	22.4		128,795

** Head loss for circuit tubing only

Manifold 6

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-25	Snow Melt	140	9	93	ViegaPEX Barrier 1/2" (Coil)	1.56	18.7	30 (31)	20,793
A-27	Snow Melt	137	9	91	ViegaPEX Barrier 1/2" (Coil)	1.53	17.6	30 (31)	20,346
A-28	Snow Melt	147	9	99	ViegaPEX Barrier 1/2" (Coil)	1.67	21.9	30 (31)	22,152
A-29	Snow Melt	141	9	96	ViegaPEX Barrier 1/2" (Coil)	1.62	20.1	30 (31)	21,555
A-30	Snow Melt	143	9	97	ViegaPEX Barrier 1/2" (Coil)	1.64	20.6	30 (30)	21,752
A-31	Snow Melt	143	9	96	ViegaPEX Barrier 1/2" (Coil)	1.63	20.4	30 (30)	21,663
Total	-	850		571	-	9.65	21.9		128,261

** Head loss for circuit tubing only

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Manifold 7

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-32	Snow Melt	149	9	103	ViegaPEX Barrier 1/2" (Coil)	1.74	23.9	30 (30)	23,082
A-33	Snow Melt	149	9	100	ViegaPEX Barrier 1/2" (Coil)	1.69	22.8	30 (31)	22,490
A-34	Snow Melt	149	9	101	ViegaPEX Barrier 1/2" (Coil)	1.71	23.1	30 (31)	22,663
A-36	Snow Melt	149	9	101	ViegaPEX Barrier 1/2" (Coil)	1.71	23.2	30 (31)	22,666
A-48	Snow Melt	143	9	95	ViegaPEX Barrier 1/2" (Coil)	1.60	19.9	30 (31)	21,321
A-49	Snow Melt	148	9	98	ViegaPEX Barrier 1/2" (Coil)	1.65	21.7	30 (31)	21,924
Total	-	887		597	-	10.10	23.9		134,147

** Head loss for circuit tubing only

Manifold 8

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-35	Snow Melt	146	9	95	ViegaPEX Barrier 1/2" (Coil)	1.60	20.3	30 (31)	21,286
A-37	Snow Melt	143	9	94	ViegaPEX Barrier 1/2" (Coil)	1.58	19.5	30 (31)	21,049
A-38	Snow Melt	140	9	93	ViegaPEX Barrier 1/2" (Coil)	1.57	18.7	30 (31)	20,813
A-39	Snow Melt	141	9	95	ViegaPEX Barrier 1/2" (Coil)	1.60	19.7	30 (31)	21,316
A-40	Snow Melt	138	9	93	ViegaPEX Barrier 1/2" (Coil)	1.57	18.5	30 (31)	20,813
A-41	Snow Melt	138	9	92	ViegaPEX Barrier 1/2" (Coil)	1.55	18.1	30 (31)	20,577
A-42	Snow Melt	142	9	94	ViegaPEX Barrier 1/2" (Coil)	1.59	19.4	30 (31)	21,092
A-43	Snow Melt	143	9	94	ViegaPEX Barrier 1/2" (Coil)	1.59	19.6	30 (31)	21,112
Total	-	1,130		748	-	12.65	20.3		168,058

** Head loss for circuit tubing only

Manifold 9

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-72	Snow Melt	23	9	11	ViegaPEX Barrier 1/2" (Coil)	0.18	0.2	30 (30)	2,418
A-73	Snow Melt	149	9	101	ViegaPEX Barrier 1/2" (Coil)	1.71	23.3	30 (30)	22,776
A-75	Snow Melt	148	9	101	ViegaPEX Barrier 1/2" (Coil)	1.71	23.0	30 (30)	22,674
A-76	Snow Melt	148	9	100	ViegaPEX Barrier 1/2" (Coil)	1.69	22.6	30 (30)	22,434
A-134	Snow Melt	148	9	99	ViegaPEX Barrier 1/2" (Coil)	1.67	22.1	30 (30)	22,194
A-135	Snow Melt	148	9	98	ViegaPEX Barrier 1/2" (Coil)	1.65	21.7	30 (30)	21,954
Total	-	763		510	-	8.61	23.3		114,450

** Head loss for circuit tubing only

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Manifold 10

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-44	Snow Melt	144	9	95	ViegaPEX Barrier 1/2" (Coil)	1.60	20.0	30 (31)	21,282
A-45	Snow Melt	140	9	93	ViegaPEX Barrier 1/2" (Coil)	1.57	18.8	30 (31)	20,879
A-46	Snow Melt	145	9	97	ViegaPEX Barrier 1/2" (Coil)	1.65	21.1	30 (31)	21,890
A-47	Snow Melt	141	9	96	ViegaPEX Barrier 1/2" (Coil)	1.62	20.0	30 (31)	21,483
A-50	Snow Melt	137	9	93	ViegaPEX Barrier 1/2" (Coil)	1.57	18.5	30 (30)	20,905
A-51	Snow Melt	140	9	97	ViegaPEX Barrier 1/2" (Coil)	1.64	20.2	30 (30)	21,767
A-52	Snow Melt	146	9	96	ViegaPEX Barrier 1/2" (Coil)	1.63	20.9	30 (31)	21,658
A-53	Snow Melt	147	9	96	ViegaPEX Barrier 1/2" (Coil)	1.62	20.8	30 (31)	21,498
Total	-	1,140		763	-	12.90	21.1		171,361

** Head loss for circuit tubing only

Manifold 11

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-136	Snow Melt	145	9	97	ViegaPEX Barrier 1/2" (Coil)	1.63	20.9	30 (30)	21,715
A-137	Snow Melt	142	9	96	ViegaPEX Barrier 1/2" (Coil)	1.62	20.1	30 (30)	21,475
A-144	Snow Melt	139	9	95	ViegaPEX Barrier 1/2" (Coil)	1.60	19.3	30 (30)	21,235
A-145	Snow Melt	138	9	93	ViegaPEX Barrier 1/2" (Coil)	1.58	18.8	30 (30)	20,995
A-146	Snow Melt	138	9	92	ViegaPEX Barrier 1/2" (Coil)	1.56	18.4	30 (30)	20,756
A-147	Snow Melt	140	9	93	ViegaPEX Barrier 1/2" (Coil)	1.57	18.8	30 (30)	20,874
Total	-	842		566	-	9.56	20.9		127,050

** Head loss for circuit tubing only

Manifold 12

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-58	Snow Melt	116	9	74	ViegaPEX Barrier 1/2" (Coil)	1.25	10.5	30 (31)	16,594
A-59	Snow Melt	129	9	85	ViegaPEX Barrier 1/2" (Coil)	1.43	14.9	30 (31)	19,048
A-60	Snow Melt	136	9	90	ViegaPEX Barrier 1/2" (Coil)	1.52	17.3	30 (31)	20,249
A-61	Snow Melt	130	9	87	ViegaPEX Barrier 1/2" (Coil)	1.47	15.7	30 (31)	19,543
A-62	Snow Melt	131	9	87	ViegaPEX Barrier 1/2" (Coil)	1.46	15.6	30 (31)	19,443
A-63	Snow Melt	132	9	86	ViegaPEX Barrier 1/2" (Coil)	1.45	15.5	30 (31)	19,322
A-64	Snow Melt	132	9	85	ViegaPEX Barrier 1/2" (Coil)	1.44	15.4	30 (31)	19,189
Total	-	907		594	-	10.04	17.3		133,387

** Head loss for circuit tubing only

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Manifold 13

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-65	Snow Melt	137	9	89	ViegaPEX Barrier 1/2" (Coil)	1.50	17.0	30 (31)	19,895
A-66	Snow Melt	132	9	86	ViegaPEX Barrier 1/2" (Coil)	1.45	15.5	30 (31)	19,314
A-67	Snow Melt	129	9	84	ViegaPEX Barrier 1/2" (Coil)	1.42	14.6	30 (31)	18,898
A-68	Snow Melt	132	9	87	ViegaPEX Barrier 1/2" (Coil)	1.47	16.0	30 (31)	19,594
A-69	Snow Melt	137	9	90	ViegaPEX Barrier 1/2" (Coil)	1.53	17.6	30 (31)	20,291
A-70	Snow Melt	143	9	93	ViegaPEX Barrier 1/2" (Coil)	1.58	19.5	30 (31)	20,988
A-71	Snow Melt	149	9	96	ViegaPEX Barrier 1/2" (Coil)	1.62	21.2	30 (31)	21,538
Total	-	959		626	-	10.58	21.2		140,519

** Head loss for circuit tubing only

Manifold 14

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-148	Snow Melt	23	9	11	ViegaPEX Barrier 1/2" (Coil)	0.19	0.2	30 (30)	2,468
A-150	Snow Melt	149	9	100	ViegaPEX Barrier 1/2" (Coil)	1.69	22.9	30 (31)	22,504
A-151	Snow Melt	149	9	100	ViegaPEX Barrier 1/2" (Coil)	1.69	22.9	30 (31)	22,477
A-152	Snow Melt	149	9	99	ViegaPEX Barrier 1/2" (Coil)	1.67	22.5	30 (31)	22,241
A-153	Snow Melt	149	9	98	ViegaPEX Barrier 1/2" (Coil)	1.66	22.0	30 (31)	22,006
A-154	Snow Melt	149	9	97	ViegaPEX Barrier 1/2" (Coil)	1.64	21.6	30 (31)	21,770
Total	-	769		505	-	8.54	22.9		113,466

** Head loss for circuit tubing only

Manifold 15

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-155	Snow Melt	146	9	96	ViegaPEX Barrier 1/2" (Coil)	1.63	21.0	30 (31)	21,668
A-156	Snow Melt	144	9	96	ViegaPEX Barrier 1/2" (Coil)	1.62	20.4	30 (31)	21,478
A-157	Snow Melt	141	9	95	ViegaPEX Barrier 1/2" (Coil)	1.60	19.6	30 (31)	21,243
A-158	Snow Melt	140	9	94	ViegaPEX Barrier 1/2" (Coil)	1.58	19.1	30 (31)	21,007
A-159	Snow Melt	140	9	93	ViegaPEX Barrier 1/2" (Coil)	1.56	18.7	30 (31)	20,771
A-160	Snow Melt	141	9	92	ViegaPEX Barrier 1/2" (Coil)	1.56	18.8	30 (31)	20,708
Total	-	853		565	-	9.55	21.0		126,875

** Head loss for circuit tubing only

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Manifold 16

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-84	Snow Melt	140	9	94	ViegaPEX Barrier 1/2" (Coil)	1.59	19.2	30 (30)	21,101
A-85	Snow Melt	146	9	100	ViegaPEX Barrier 1/2" (Coil)	1.68	22.1	30 (30)	22,347
A-87	Snow Melt	144	9	98	ViegaPEX Barrier 1/2" (Coil)	1.67	21.4	30 (30)	22,123
A-138	Snow Melt	143	9	98	ViegaPEX Barrier 1/2" (Coil)	1.65	21.0	30 (30)	21,956
A-139	Snow Melt	146	9	99	ViegaPEX Barrier 1/2" (Coil)	1.68	22.0	30 (30)	22,293
A-140	Snow Melt	149	9	101	ViegaPEX Barrier 1/2" (Coil)	1.71	23.2	30 (30)	22,665
A-141	Snow Melt	149	9	100	ViegaPEX Barrier 1/2" (Coil)	1.68	22.6	30 (30)	22,351
Total	-	1,016		689	-	11.65	23.2		154,836

** Head loss for circuit tubing only

Manifold 17

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-77	Snow Melt	143	9	96	ViegaPEX Barrier 1/2" (Coil)	1.62	20.4	30 (30)	21,545
A-78	Snow Melt	145	9	99	ViegaPEX Barrier 1/2" (Coil)	1.67	21.6	30 (30)	22,147
A-79	Snow Melt	144	9	99	ViegaPEX Barrier 1/2" (Coil)	1.67	21.4	30 (30)	22,148
A-80	Snow Melt	144	9	99	ViegaPEX Barrier 1/2" (Coil)	1.67	21.4	30 (30)	22,148
A-81	Snow Melt	145	9	99	ViegaPEX Barrier 1/2" (Coil)	1.67	21.6	30 (30)	22,148
A-82	Snow Melt	149	9	101	ViegaPEX Barrier 1/2" (Coil)	1.71	23.2	30 (30)	22,683
A-83	Snow Melt	149	9	100	ViegaPEX Barrier 1/2" (Coil)	1.68	22.5	30 (30)	22,354
Total	-	1,018		691	-	11.68	23.2		155,175

** Head loss for circuit tubing only

Manifold 18

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-86	Snow Melt	148	9	99	ViegaPEX Barrier 1/2" (Coil)	1.67	22.0	30 (30)	22,124
A-88	Snow Melt	135	9	91	ViegaPEX Barrier 1/2" (Coil)	1.54	17.5	30 (30)	20,406
A-89	Snow Melt	147	9	100	ViegaPEX Barrier 1/2" (Coil)	1.69	22.3	30 (30)	22,399
A-90	Snow Melt	142	9	97	ViegaPEX Barrier 1/2" (Coil)	1.64	20.6	30 (30)	21,799
A-91	Snow Melt	141	9	96	ViegaPEX Barrier 1/2" (Coil)	1.62	20.0	30 (30)	21,554
A-92	Snow Melt	144	9	98	ViegaPEX Barrier 1/2" (Coil)	1.65	21.1	30 (30)	21,951
A-93	Snow Melt	143	9	97	ViegaPEX Barrier 1/2" (Coil)	1.63	20.5	30 (30)	21,676
Total	-	999		676	-	11.43	22.3		151,907

** Head loss for circuit tubing only

See end of report for important Notes and Disclaimers.

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Name:5MWe Sabalan Geothermal Pilot Power Plant
Project #:553123

Snow Melt System Design Report
December 7, 2013

Manifold 19

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-0	Snow Melt	138	9	94	ViegaPEX Barrier 1/2" (Coil)	1.59	19.0	30 (30)	21,112
A-94	Snow Melt	143	9	97	ViegaPEX Barrier 1/2" (Coil)	1.63	20.6	30 (30)	21,692
A-95	Snow Melt	139	9	94	ViegaPEX Barrier 1/2" (Coil)	1.60	19.2	30 (30)	21,222
A-114	Snow Melt	143	9	98	ViegaPEX Barrier 1/2" (Coil)	1.65	20.9	30 (30)	21,941
A-115	Snow Melt	136	9	93	ViegaPEX Barrier 1/2" (Coil)	1.57	18.3	30 (30)	20,835
A-116	Snow Melt	140	9	94	ViegaPEX Barrier 1/2" (Coil)	1.60	19.3	30 (30)	21,208
A-117	Snow Melt	136	9	90	ViegaPEX Barrier 1/2" (Coil)	1.53	17.4	30 (30)	20,268
Total	-	975		660	-	11.16	20.9		148,278

** Head loss for circuit tubing only

Manifold 20

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-96	Snow Melt	140	9	95	ViegaPEX Barrier 1/2" (Coil)	1.60	19.5	30 (30)	21,269
A-97	Snow Melt	139	9	95	ViegaPEX Barrier 1/2" (Coil)	1.61	19.4	30 (30)	21,383
A-98	Snow Melt	145	9	101	ViegaPEX Barrier 1/2" (Coil)	1.70	22.3	30 (30)	22,605
A-99	Snow Melt	143	9	99	ViegaPEX Barrier 1/2" (Coil)	1.68	21.6	30 (30)	22,321
A-100	Snow Melt	140	9	97	ViegaPEX Barrier 1/2" (Coil)	1.65	20.5	30 (30)	21,878
A-101	Snow Melt	143	9	98	ViegaPEX Barrier 1/2" (Coil)	1.66	21.2	30 (30)	22,097
A-102	Snow Melt	143	9	98	ViegaPEX Barrier 1/2" (Coil)	1.66	21.1	30 (30)	22,000
Total	-	993		684	-	11.56	22.3		153,552

** Head loss for circuit tubing only

Manifold 21

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-103	Snow Melt	144	9	98	ViegaPEX Barrier 1/2" (Coil)	1.66	21.2	30 (30)	22,026
A-104	Snow Melt	149	9	102	ViegaPEX Barrier 1/2" (Coil)	1.73	23.6	30 (30)	22,939
A-105	Snow Melt	148	9	102	ViegaPEX Barrier 1/2" (Coil)	1.73	23.4	30 (30)	22,933
A-118	Snow Melt	146	9	101	ViegaPEX Barrier 1/2" (Coil)	1.71	22.7	30 (30)	22,688
A-119	Snow Melt	149	9	103	ViegaPEX Barrier 1/2" (Coil)	1.74	24.1	30 (30)	23,171
A-142	Snow Melt	146	9	101	ViegaPEX Barrier 1/2" (Coil)	1.70	22.6	30 (30)	22,627
A-143	Snow Melt	148	9	100	ViegaPEX Barrier 1/2" (Coil)	1.70	22.7	30 (30)	22,532
Total	-	1,030		708	-	11.96	24.1		158,915

** Head loss for circuit tubing only

See end of report for important Notes and Disclaimers.

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Name:5MWe Sabalan Geothermal Pilot Power Plant
Project #:553123

Snow Melt System Design Report
December 7, 2013

Manifold 22

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-54	Snow Melt	138	9	93	ViegaPEX Barrier 1/2" (Coil)	1.58	18.7	30 (30)	20,994
A-55	Snow Melt	141	9	97	ViegaPEX Barrier 1/2" (Coil)	1.63	20.2	30 (30)	21,709
A-56	Snow Melt	137	9	95	ViegaPEX Barrier 1/2" (Coil)	1.61	19.3	30 (30)	21,420
A-57	Snow Melt	138	9	96	ViegaPEX Barrier 1/2" (Coil)	1.62	19.6	30 (30)	21,568
A-74	Snow Melt	135	9	94	ViegaPEX Barrier 1/2" (Coil)	1.58	18.3	30 (30)	21,052
A-106	Snow Melt	139	9	96	ViegaPEX Barrier 1/2" (Coil)	1.62	19.8	30 (30)	21,589
A-107	Snow Melt	137	9	94	ViegaPEX Barrier 1/2" (Coil)	1.58	18.7	30 (30)	21,007
Total	-	964		665	-	11.24	20.2		149,338

** Head loss for circuit tubing only

Manifold 23

Circuit	Areas Served	Total Length	Tube Spacing	Area Covered	Tubing	Flowrate	Head Loss**	Temp Drop	Load
A-108	Snow Melt	140	9	96	ViegaPEX Barrier 1/2" (Coil)	1.63	20.0	30 (30)	21,654
A-109	Snow Melt	136	9	95	ViegaPEX Barrier 1/2" (Coil)	1.60	18.9	30 (30)	21,240
A-110	Snow Melt	136	9	94	ViegaPEX Barrier 1/2" (Coil)	1.59	18.6	30 (30)	21,132
A-111	Snow Melt	136	9	94	ViegaPEX Barrier 1/2" (Coil)	1.59	18.8	30 (30)	21,189
A-112	Snow Melt	137	9	94	ViegaPEX Barrier 1/2" (Coil)	1.59	18.9	30 (30)	21,189
A-113	Snow Melt	138	9	94	ViegaPEX Barrier 1/2" (Coil)	1.58	18.8	30 (30)	21,015
Total	-	824		567	-	9.59	20.0		127,419

** Head loss for circuit tubing only

See end of report for important Notes and Disclaimers.

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LoopCAD® 2013

Snow Melt Panel Schedule

Project #:553123
December 7, 2013

Project Information

Project #:	553123	Notes:
Name:	5MWe Sabalan Geothermal Pilot Power Plant	
Location:	Sabalan,Ardebil	

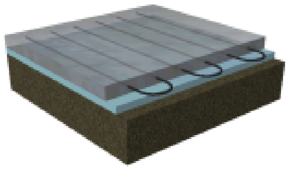
Design Conditions and Summary

Load Calculation Method:	Manual	Total Snow Melt Load:	3,383,550 Btu/hr
Fluid Type:	50% Propylene Glycol		
Total Flowrate:	254.7 USGPM		
Max. Head Loss:	243.0 ft water		
Design Temp. Drop:	30.0 °F		
Total Area:	15,098 ft²		

Radiant Panel Details

Panel Type #1 - Snow Melt - Concrete

Embedded Layer Thickness:	3.9 in
Tube Depth (Embedded Layer):	1.7 in
Embedded Layer R per inch:	0.14 °F·ft²·hr/Btu·in
Insulation Rv:	10.0 hr·ft²·°F/btu
Spacing:	9 in
Fastener:	Plastic Zip Ties
Floorplans:	
Snow Melt	15,033 ft²



Note: Tube depth is measured from top of embedded layer to the centerline of the tubing.

See end of report for important Notes and Disclaimers.

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