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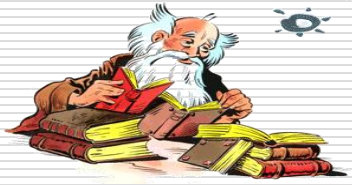
FEASIBILITY STUDY FOR GEOTHERMAL HVAC SYSTEM OF 465 kW_{TH} COOLING CAPACITY AT "ZENON CHRYSANTHOY HOTELS" HOTEL + SPA (COOLING)

Ayii Anargyri Natural Healing Spa Resort



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Study Conduction Time	June 2009
Energy Analysis Time	September 2010

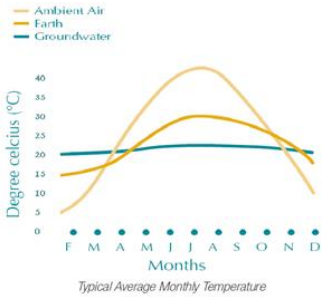
The selection of installing a geothermal system, based on the principles and rules laid down in directive 2002/91/EC OF THE EUROPEAN PARLIAMENT (16 December 2002) for the energy performance of buildings led to the following significant results:

- Optimization and stabilization of services and options of the Republic of Cyprus for the promotion of Renewable Energy Sources.
- Increase the efficiency of conversion and usage of energy.
- Reduction of total greenhouse gas emissions (primarily CO_2) causing the Greenhouse effect and meeting targets set by the Kyoto Protocol.
- Significant financial savings, reduction of fuel import needs, and increase of the competitiveness of manufacturing.

Installation Description – General Information

A Geothermal HVAC system of **total maximum capacity 465 kW-th**, was installed to meet the needs of air conditioning (cooling & heating) .
The chosen system led to a significant reduction in energy consumption compared with the corresponding conventional options (Oil Boilers , air-cooled/heated Heat Pump , etc) and a reduction of locally produced air pollutants caused by plant operations .
The operating principle of Geothermal air conditioning systems based on the exploitation of underground energy. The subsoil of each place has constant temperatures throughout the year, with minor variations , while theoretically has infinite heat capacity . This means that we can absorb or emmit very large amounts of heat in the subsurface (the cooling or heating loads of buildings in our case) , without changing its conditions .
Regarding the Paphos area climate, the annual average temperature of the subsoil to a depth > 3m, is of the order of 21 - 22 °C. Accordingly , air temperature during summer can reach 40 - 43 °C, while in winter 3 - 5 °C.
This temperature difference between the outside ambient air and subsoil is exploited using a geothermal system to heat or cool the building and reduce the installed electrical power to save energy .

Technical Specifications

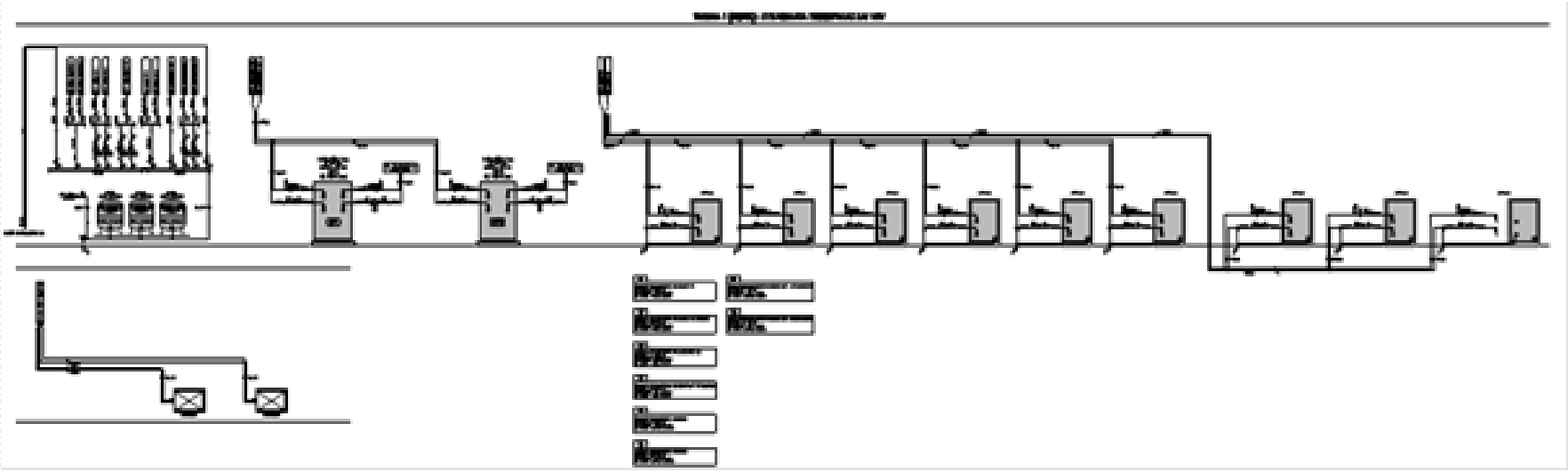


The application of the system was implemented using Vertical Earth (Geothermal) Heat Exchangers (VEHE) which settled in the surroundings of the buildings. The energy is pumped or rejected into the subsurface and is driven through central piping to individual plant rooms where the thermal gradient is changed through water-cooled VRV heat pumps and finally is circulated for indoor usage.

The pumping or discharge of heat into the subsurface is achieved by the construction of one hundred and forty (140) Vertical Earth Heat Exchangers . The average depth of each well is 100m from the final surface of excavation.

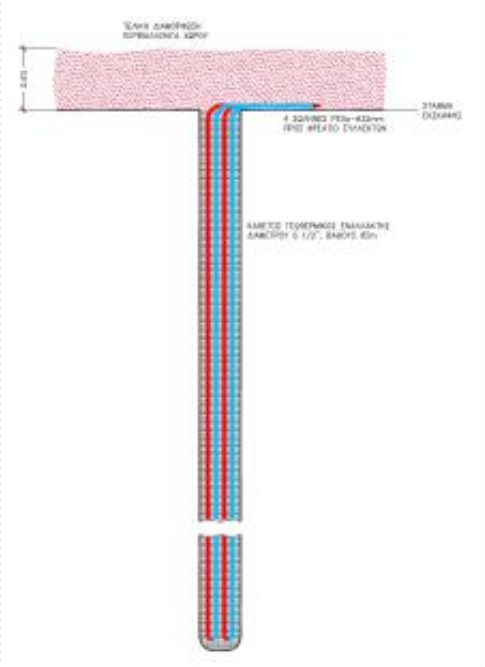
The Geothermal networks are constructed from PEXa 32x2.9mm - SDR11 tubes. The horizontal networks are constructed in groups of 10 circuits in brass manifolds 1 ½" - 10 of Raugeo 32x2.9mm type.

Installation diagram & pictures



Energy behaviour of the system

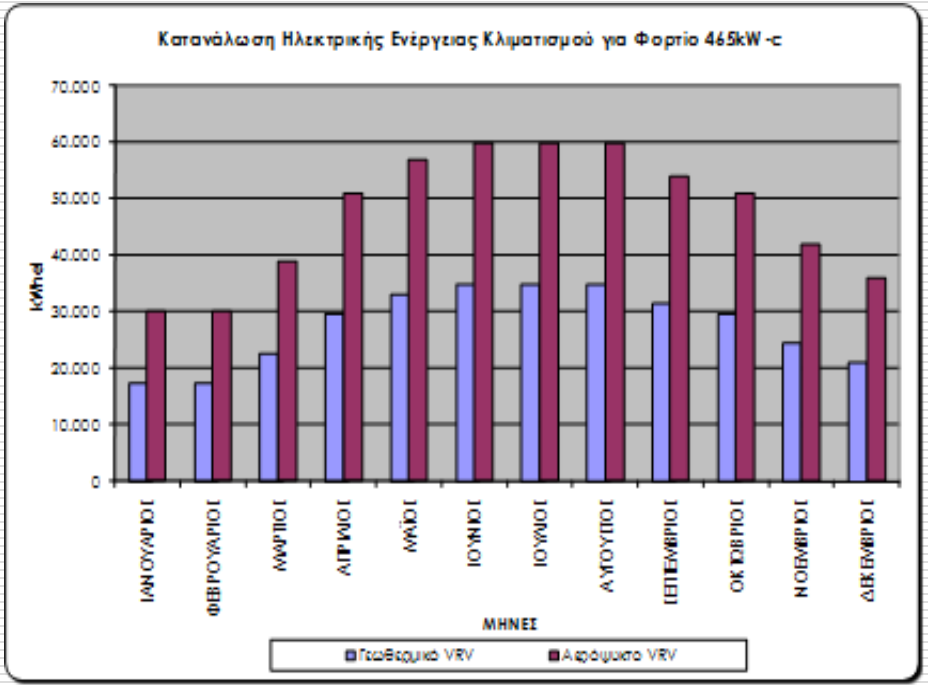
Nominal Setup Capacity	**465**	**kW-th/c**
Load delay	65%	
Functioning Load	302.25	kW-th/c
COP (seer) cooling (BMS readings)	5.89	
COP heating (estimate)	4.5	



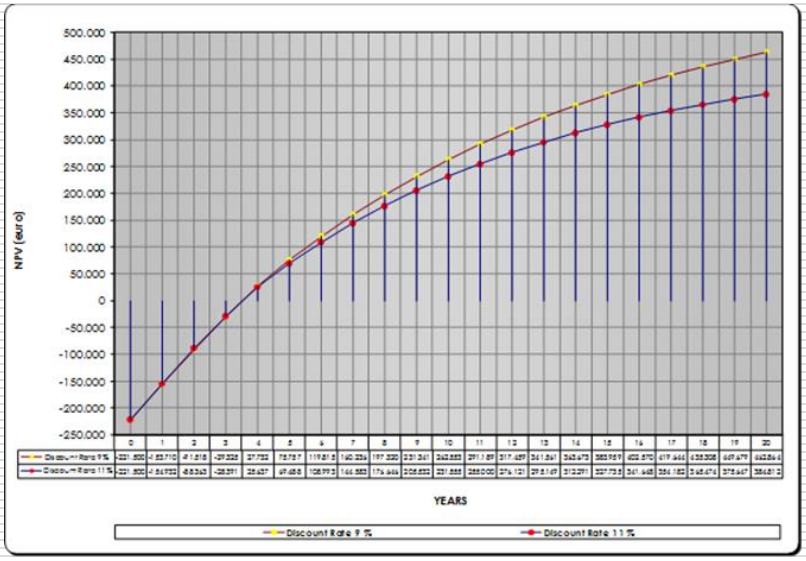
Intended use and function of facilities

HVAC System				
Nominal Heating Capacity			465	kWth
Geothermal System Average Annual COP			4,8	
Average annual air-cooled VRV COP			2,8	
Month	Occupancy	Working Hours	Electric Energy Consumption for HVAC	
			Geothermal VRV	Air-Cooled VRV
JANUARY	50%	180	17.438	29.893
FEBRUARY	50%	180	17.438	29.893
MARCH	65%	234	22.669	38.861
APRIL	85%	306	29.644	50.818
MAY	95%	342	33.131	56.796
JUNE	100%	360	34.875	59.786
JULY	100%	360	34.875	59.786
AUGUST	100%	360	34.875	59.786
SEPTEMBER	90%	324	31.388	53.807
OCTOBER	85%	306	29.644	50.818
NOVEMBER	70%	252	24.413	41.850
DECEMBER	60%	216	20.925	35.871
Total		3.420 h	331.313 kWhel	567.964 kWhel
Electric Energy reduction (kWh/year)				-236.652
Energy Savings Percentage				42%

Intended operating and energy loads- consumption
Repayment Period Charts – Operation Benefits



Month	Electric Energy consumption for Cooling (kWh-c)	Electric Energy consumption for Heating (kWh-th)
12 Month Total	180,820	130,862



Month	Cooling Operation Hours	Heating Operation Hour	Cooling Energy Consumption (kWh-c)	Heating Energy Consumption (kWh-th)
12 Month Total	3,524	1,948	1,065,032	588,880

Results – Conclusions

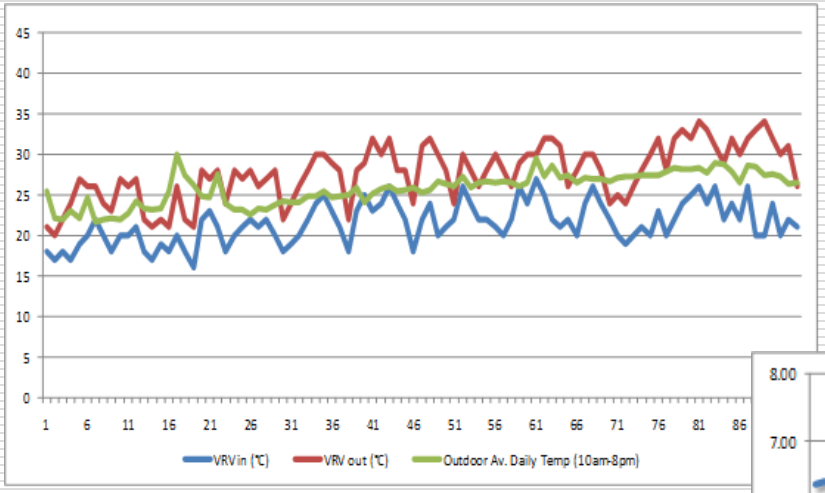
The following are based on measurements made on the installation during its operation from 01 June 2010 to 31 August 2010 and are referred to the Cooling system of the Group.
The comparison for assessing the percentage of energy saving is made between the installed system with water-cooled VRV (covering heating needs as well) and an installation of a corresponding thermal and cooling capacity air-cooled Heat Pump to meet their respective needs for Cooling and Heating spaces

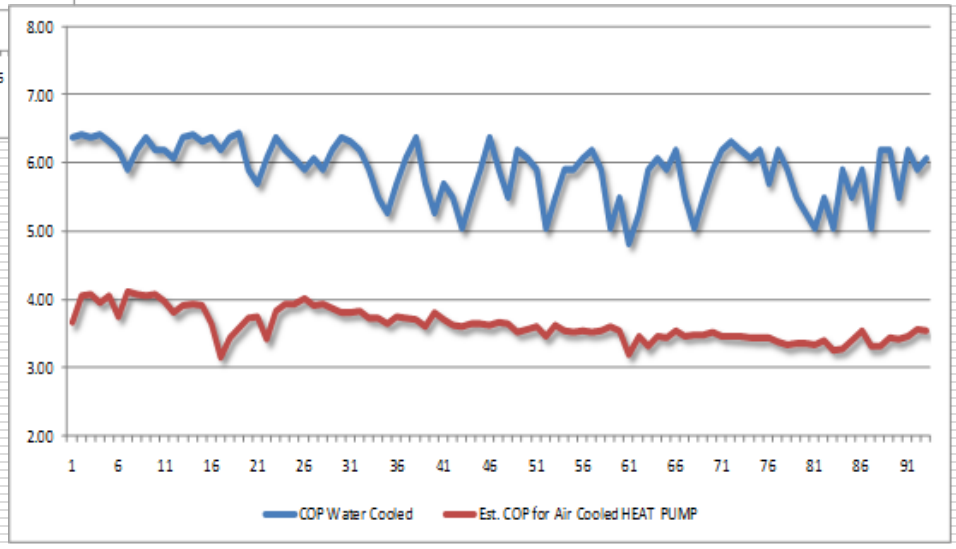
The results of the following analysis are summarized in the following :

- The average EER of the facility for the period **of operation 01/07/2010 - 31/08/2010 was 5.89**.
- The corresponding average EER of a facility that would use air-cooled Heat Pump to meet the respective needs of Refrigeration, was calculated at 3.62 .
- **The percentage of energy savings** for cooling is, **according to the measurement results, 38.6 %**
- For the period of heating the average COP of the installation is estimated to range between 4.2 to 4.8.
- For the period of heating the average COP of a facility that would use air-cooled Heat Pump to meet their respective needs for Heating , was estimated to range between 2.6 to 3.0.
- The percentage of energy savings for the heating season are expected to rise to a range between 35-42% depending on the conditions of outside air and cold seasons that will occur during the upcoming winter .
- **The reduction of installed capacity amounts to 65 kVA**.
- **The reduction of electricity consumption amounted for the period 01/07/2010 - 31/08/2010 is ~ 36000kWh-el.**
- **The average yield** of geothermal heat for the period 01/07/2010 - 31/08/2010 **ranged between 3,15 - 4,05 kWth/100m**. (average yield 36,5 W / m depth)

Measurements

Inlet and outlet temperatures of the water from the VRV and daily average outside air temperature for the period from 01/07/2010 to 31/08/2010

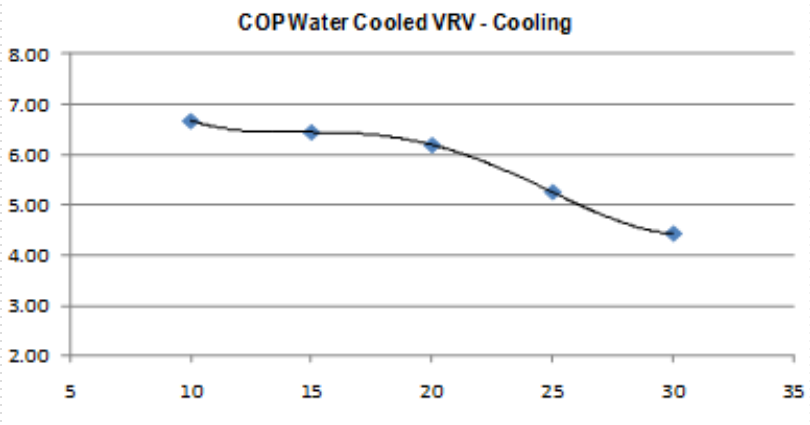


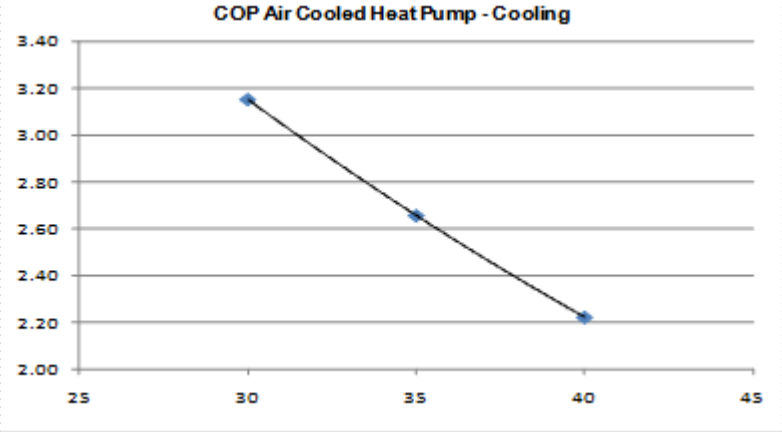


Inlet and outlet temperatures of the water from the VRV and daily average outside air temperature for the period from 01/07/2010 to 31/08/2010

Measured Size Values

WATER COOLED VRV PERFORMANCE - COOLING				
Tin	Tout	kWc	kWel	EER
10	14.6	26.7	4	6.68
15	19.6	26.7	4.14	6.45
20	24.6	26.7	4.31	6.19
25	29.7	26.7	5.08	5.26
30	34.9	26.7	6.03	4.43



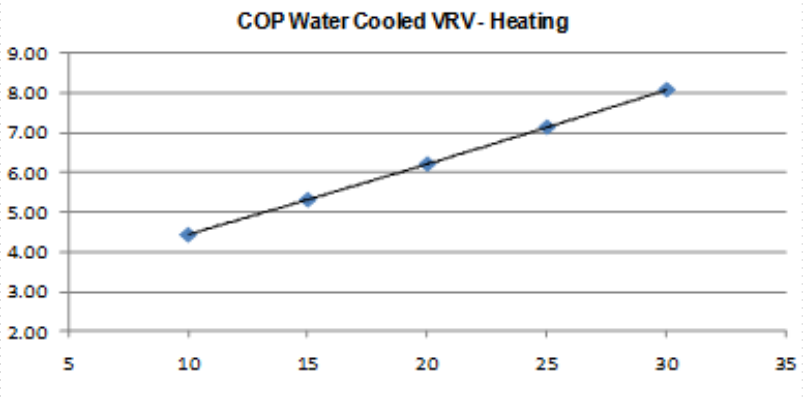


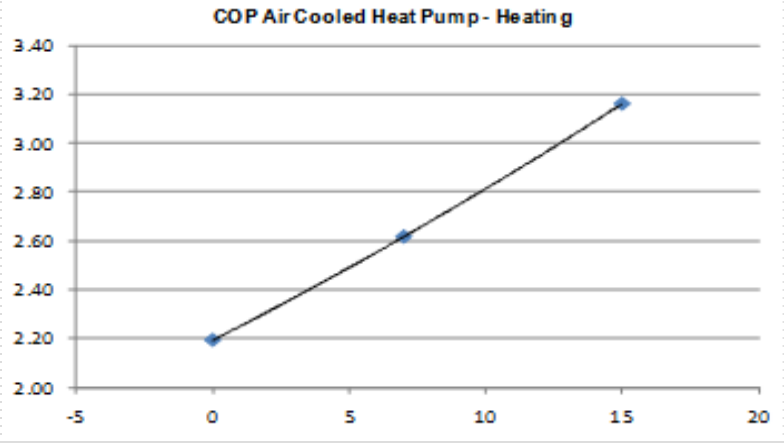
AIR COOLED HEAT PUMP PERFORMANCE - COOLING				
OT (°C)	T-indoor	kWc	kWel	COP
30	26	27.1	8.6	3.15
35	26	25.5	9.6	2.66
40	26	24	10.8	2.22

Function approximation for the winter season.

Function approximation of water-cooled Heat pump for the winter season.

WATER COOLED VRV PERFORMANCE - HEATING				
Tin	Tout	kWth	kWel	COP
10	7.45	22.1	4.98	4.44
15	12.3	22.1	4.16	5.31
20	17.2	22.1	3.56	6.21
25	22.2	22.1	3.1	7.13
30	27.1	22.1	2.74	8.07





AIR COOLED HEAT PUMP PERFORMANCE - HEATING				
OT (°C)	T-indoor	kWc	kWel	COP
0	20	21.7	9.9	2.19
7	20	25.9	9.9	2.62
15	20	31.3	9.9	3.16

Function approximation of air-cooled Heat pump for the winter season.

According to this approach, summarized as follows:

• The option to apply a geothermal system is a very a important initiative to upgrade the operation, energy security and competitiveness of the building .

• The economic benefit is particularly important for the function of the building , and the total investment raises both the project itself and the options of the Republic of Cyprus in the Promotion of Renewable Energy.

• Energy savings obtained during the summer period are 36.000kWhe (for the period from 01/07/2010 to 31/08/2010 - two months)

• Because of the subsoil the performance of the heat exchangers was measured at 36,5W/m depth . Which are Reduced by 20% over the expected returns in central Europe.

• **Improved SEER stands at 62.7%**

• **The expected improvement in SCOP stands at 60.7%**

• The excessive growth of performance during the summer period arises from the fact that some of the waste heat to the Earth is used to heat the spa so the installation works with waste heat recovery system (ie Cogeneration)

• **Reduction of installed capacity in 65kVA, or a percentage of 37.8 %**

Thank you for your attention!