Exploiting Geothermal Energy as a Source of Heating System in Al-Shaydia Phosphate Mining: Overview and Case Study

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Abstract

Nowadays, energy is the primary input for all economic activities. It plays a significant role in raising the standard of living, which has become the ultimate goal of most communities. This natural energy can be produced from the earth's heat, used for heating, and cooling buildings, generating electricity, and providing warm/cold water for agricultural items in greenhouses. Jordan's NE and SE deserts have geothermal resources. Based on that, the researcher developed a project that uses hot water from the Shaydia mine to heat the buildings. Talking about If geothermal power is used, then the cost of the heat exchanger should be saved. Thermal loads and mass flow rates were calculated manually to determine the size of the system. The cost of the project has been calculated by ordering all parts and pipelines from many companies, comparing their prices, and testing with their average prices. This paper shows how to control mass flow rate for all apartments by varying convection heat transfer coefficient with outdoor and indoor temperatures. The heat load is 3828 kW, so 82.08 m^3/h of flow is needed to cover all residential structures and 0.33 L/h of chemical treatment before water enters the network. After calculating the costs of the current system and comparing them to the costs of the project to see if it is possible or not, it's found that it is possible and very available to the company, which will bring in about $300,000 per year

Keywords: Geothermal; Energy saving; Heating system; Heat pump; Power generation.

1. Introduction

Nowadays, a country's energy consumption represents a type of its development. About 24% of worldwide energy consumption is used for transportation, 40% for industry, 30% for residential and commercial applications, and 6% for other uses such as agriculture (Olabi et al., 2020). Jordan, as one of the developing countries in the Middle East, has persistent environmental and economic interests regarding energy resources(Al-Zyoud, 2019a; Gomaa et al., 2021; Gomaa et al., 2020). In recent years, total power usage has risen by 10%. About 2429 million JD was spent on 17,574 GWh of electricity in 2017 (Umam et al., 2019). In the future, Jordan will need an integrated geothermal plan, built in the Jordanian desert like Al-Shaydia can be used for various purposes (Al-Rawashdeh et al., 2019; Al-Zyoud, 2019a; Rezk et al., 2019). Renewable energy sources can provide a substantial portion of the world's energy needs without emitting greenhouse gases or causing pollution such as, solar (photovoltaic and thermal), wind, ocean, marine, hydropower, geothermal, and biomass. Globally, geothermal (ground-source) heat pumps represent for 71.6% of installed capacity and 59.2% of annual energy consumption (Lund et al., 2021). Future developments geothermal energy may include technological innovations to reduce drilling costs, the development of enhanced geothermal systems, and increased coproduction of geothermal energy from oil and gas reservoirs (Archer, 2020). Geothermal, a domestic source of sustainable and renewable energy, can replace fossil fuels and other energy sources. For many countries, geothermal energy decreases their dependence on imported fuels. For all countries, it eliminates pollutants such as carbon particles and greenhouse gases (Al-Rawashdeh et al., 2021; Lund et al., 2016). In recent years, oil companies have increased their efforts to exploit and utilize geothermal energy with advanced technologies for heat-tracing oil collection, transport, and central heating, etc (S. Wang et al., 2016). The relatively extensive use of district heating systems and advances in technology have paved the way for the establishment of a district cooling system to meet both the heat and cooling demands of the district system. However, these systems are relatively new, so they are not as prevalent as district heating systems (Rafferty, 2003). In addition, geothermal energy is not affected by weather and can provide heat and electricity continuously throughout the year. Although geothermal energy has some disadvantages, such as a high initial cost and a lengthy construction period, nevertheless it has several advantages that other renewable energy sources do not, such as working year-round, requiring less land, and being resistant to the elements (Anderson et al., 2019; Li et al., 2020; Y. Wang et al., 2020). These advantages make geothermal energy more suitable than other renewable energy sources (Noorollahi et al., 2019; Soltani et al., 2019). In Jordan, shallow geothermal systems are abundant, and the viability of geothermal energy applications for purposes such as power generation, heating and cooling has recently been evaluated (Al-Khasawneh et al., 2019; Al Dhoun, 2019). Jordan's geothermal gradient map reveals an average geothermal gradient of 3.3 ^{0}C/100m (Al-Zyoud, 2019b). In Jordan, ground source heat pump and heat exchanger applications have recently emerged as a promising environmental geothermal application (Al-Zyoud, 2019b). The geothermal production of heat and electricity is dependent on reservoir depth (Al-Douri et al., 2019). It has been determined that using geothermal heat exchangers for cooling and heating in central Jordan will reduce energy consumption by 15 to 30 percent (Raed et al., 2013). The primary benefit of a geothermal heat pump system is the reduction of the incoming primary energy (Kljajić et al., 2020). Geothermal energy resources can be divided into three categories based on water temperature:1- temperature geothermal resource of 90 ^{o}C, 2- moderate temperature geothermal resource of temperature between 90 ^{o}C and 150 ^{o}C, and 3- high temperature geothermal resource (greater than 150 ^{o}C). Typically, the high-temperature geothermal group is utilized for electricity generation (Ozgener et al., 2004). The most suitable applications of geothermal energy in deserts were anticipated to be ground-source heat pumps for heating and cooling purposes and crops drying. Despite the potential, political, technical, and financial obstacles, exploiting new geothermal resources in deserts will aid in resolving the socioeconomic and environmental issues dealing desert regions with limited resources (Al-Zyoud, 2019a). Significant differences exist between industrialized and developing countries energy consumption. Until recently, the majority of this demand was satisfied by conventional fossil fuels. Oil, coal, natural gas, and electricity are becoming increasingly rare and expensive. Innovative approaches to conventional and non-conventional energy sources, as well as energy conservation, are being developed to meet rising demand.

2. Energy resources

Like other natural resources, energy resources are also renewable as well as non-renewable.

2.1. Renewable and non-renewable energy resources

Renewable energy resources are mostly biomass-based and can be renewed in a short time. Renewable energy sources can be replaced and reused. Forest firewood, petrol plants, plant biomass, solar, wind, and geothermal energy are examples. These are self-replicating in nature and can be harvested continuously with proper planning and management. Nonrenewable energy is limited and develops slowly. Unlimited use will eventually deplete them. These include oil, coal, natural gas, and nuclear energy, Global fossil fuel, uranium, and thorium resources are finite and will eventually run out. Fossil fuel use also causes air pollution, global warming, acid rains, and oil spills. Thus, reducing fossil fuel use and replacing it with renewable resources has become critical.

In the mountains adjacent to the crater on the eastern side, there are more than 130 hot springs. In the highlands east of the Jordan Valley: Al-Himma, Deir Alia, Abu Dhableh Hisban, Ain Sweimah, Ain Zarqa, and others. In the Dead Sea highlands, the Zara (45 springs) and Zarqa Ma'in (more than 60 springs), Wadi Hammad (6 springs), Ghor al-Adha, and Wadi Karak springs. East of Wadi Araba, Afra and Brabita. Hot water found in more than 100 wells dug for groundwater exploration. Al-Hama, Northern Shouneh, Waqas, Abu Ziyad, and Al-Manshiya in the northern Jordan Valley and Kafrin (10 wells), in the Azraq basin (17 wells), Al-Lajjun, and Al-Jafr have had 250-1100 m water wells drilled. In the area south of Queen's Airport Alia, 40 wells are used for agriculture after being cooled in nearby ponds. 240-400 m (6 wells) in the Al-Shaydia mine in the Maan.

2.2. Application of geothermal energy

2.2.1 Geothermal power plants

Geothermal power plants use water (hydro) and heat (thermal). Hydrothermal resources (300-700°F) are required for geothermal plants. By drilling wells and piping steam or hot water to the surface, we can exploit these resources (Melikoglu et al., 2017) . Geothermal wells are 1-mile deep. As shown in Figure1, Geothermal plants come in three types: A) Dry steam plants; generating turbines are turned by geothermal steam. The first geothermal power plant was erected in 1904 in Tuscany, Italy. B) Flash steam plants; use high-pressure hot water from deep down to drive generator turbines. When the steam cools, it condenses into water and is injected back into the earth. Geothermal flash plants are common. C) Binary power plants; geothermal hot water heats another liquid (DiPippo, 2015). A generator turbine drives a generator by heating the second liquid to steam. The net average production data of the geothermal and solar power output for a typical spring day are shown in the Figure 2.

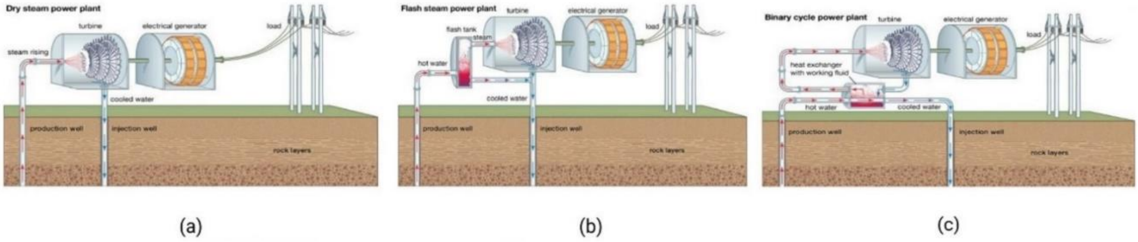

Figure 1 (a) Dry steam plants, (b) Flash steam plants, and (c) Binary power plants. (Lund, 2022)

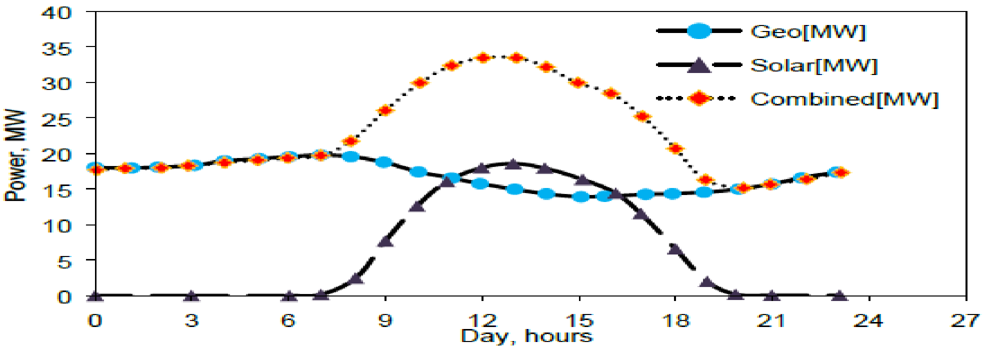

Figure 2 Geothermal and solar PV output net average production for a typical spring day (DiMarzio et al., 2015)

2.2.2 Geothermal heat pumps

Geothermal heat pump (GHP) systems use Earth's low-grade thermal energy to power a heat pump. Heinrich Zoelly's 1912 Swiss patent first mentions geothermal heat pump systems (Sanner, 2017). Geothermal heat pumps heat and cool buildings using the Earth's temperature. In winter, they transport heat from the earth (or water) into buildings. Geothermal heat pumps are the most energy-efficient, clean, and cost-effective temperature management technologies, according to the EPA. Geothermal heat pumps are becoming increasingly popular, while most households still use furnaces and air conditioners.

3. Experimental and procedure

3.1 Direct use geothermal energy (Heating buildings)

Direct utilization of geothermal energy refers to its thermal consumption, not its conversion to electrical energy. Geothermal energy can be used for any process or application that relies on heat, as long as the resource and load temperatures match (see Figure 3). 80 countries directly use geothermal energy for a thermal purpose, with spas and recreation being the most common at 50% of the total worldwide use, followed by space heating at 30%. Figure 4 illustrates a comparison of worldwide direct-use geothermal energy in TJ year $^{-1}$. The earliest geothermal district heating project in the U.S. began in 1892 on Warm Springs Avenue in Boise, Idaho, and heats 450 residences. In this research, thermal energy is extracted from the Shaydia mining well in Maan Governorate, used to wash phosphate after chilling.

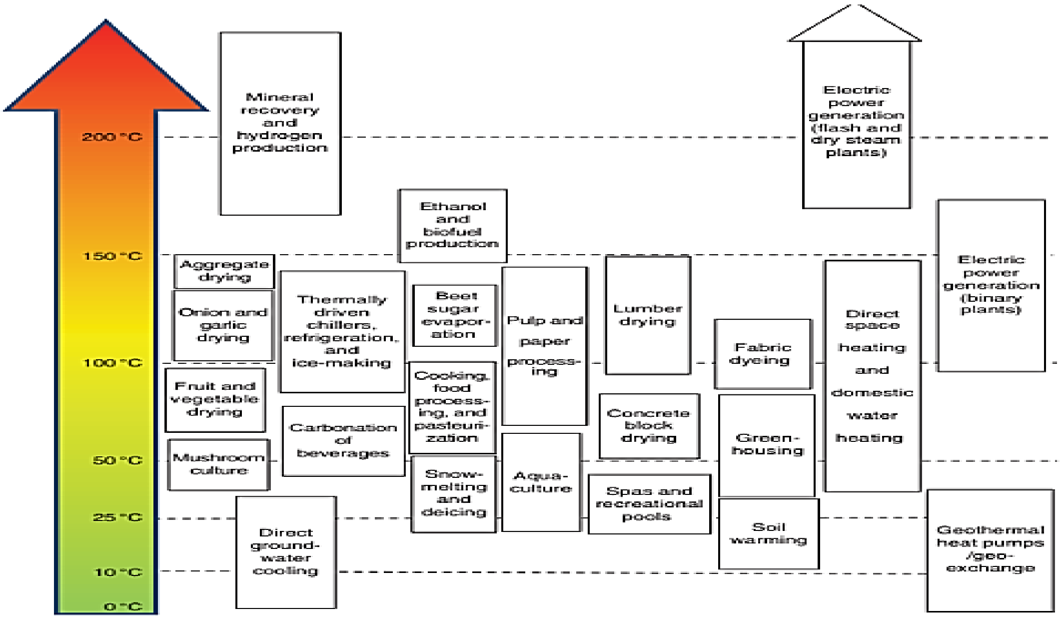

Figure 3 Worldwide past and present utilization of geothermal energy based on resource temperature.

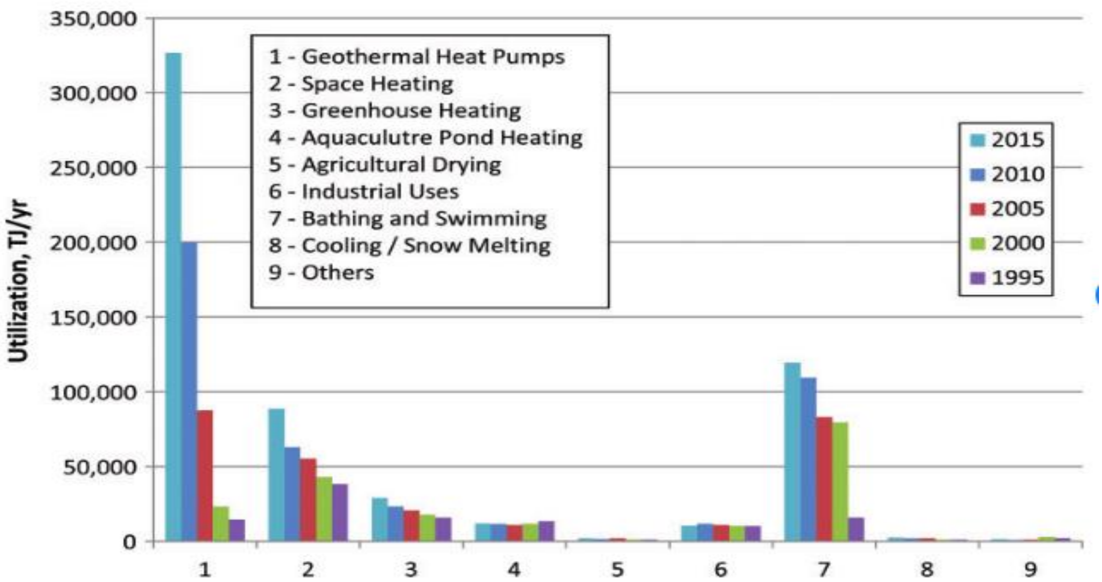

Figure 4 Comparison of worldwide direct-use geothermal energy in TJ year^{-1} from 1995,2000, 2005, 2010 and 2015 (Lund & Boyd, 2016)

3.1.1 Residential buildings in Al-Shaydiya and the current heating system

Because the mine is far from the nearest residential area, the workers are obliged to stay in the mine for long periods of time. In our project, we will focus on delivering warmth to these buildings and modifying the current quality of heating, which differs across residential and administrative buildings and costs the company annually. Residential buildings as shown in Figure 5 are: A3: It has 40 structures, each with 6 apartments (two rooms, a hall, kitchen, and bathroom), a diesel boiler heating system, and a supply tank. Apartments have 6 radiators. A2: 26 buildings, 6 units each (two rooms, a hall, kitchen and bathroom). Each apartment has 6 radiators, and 7 boilers cover 26 structures. Each structure comprises 6 apartments (two rooms, a hall, kitchen, and bathroom), a boiler, a supply tank, and 6 radiators. Each building has 9 apartments (two rooms, hall, kitchen, bathroom), a particular boiler, a supply tank, and each apartment has 6 radiators. Each B5 building has 3 stories, 5 rooms, a kitchen, and 3 bathrooms. Each building has a boiler, supply tank, and radiator. Our initiative focuses on heating residential structures about a kilometer from the last water distribution point, which now depends on expensive diesel heating. Some pictures of the buildings as shown in Figure 5.


Figure 5 pictures of the buildings

3.1.2. Current heating system

Using oil boilers in a traditional system, a heat exchanger warms cold water, where the heated water can be utilized in radiators, faucets, and showers to heat and hot water your home. The tank lacks an automatic shut-off valve, so a boiler fire could spread to it. Every apartment has a room thermostat, where boilers need a qualified maintenance engineer to inspect the condensate drain, clean the siphon, and clean the combustion chamber. The site's boilers range in capacity from 50 kW for one building to 400 kW for 8 buildings.

(a)

(b)

Figure 6 (a) Boiler with a capacity of 192 kW, (b) Some burners in different sizes

(a)

(b)

Figure 7 (a) Hot water tank, and (b) Radiators inside the rooms

Shaydiya has six sustainable hot water wells with temperatures ranging from 65-70°C. This water is cooled in chemical reactions that produce oxides and phosphates using 8-inch to 16-inch tubes and it is cooled in cooling towers to 20^0C. In the heating system using ground water heat, a portion of this heat will be exploited by extending a tube with certain specifications to the nearest point between residential buildings, where the water will enter the network with a temperature of up to 60 ° C for 24 hours, and when hot water passes into the current heating network to radiators, the rooms will be heated throughout the winter without additional cost. The water will then come out and return to the towers a Cooling until it is cooled enough and complete them its natural in the company without significant loss in these waters. In the new system, the extensions inside the structures won't be changed, merely maintained.

3.1.3 Prefer a direct heating system over a heat exchanger

Heat exchangers are commonly used to transfer the heat from the geothermal water to a secondary fluid. The heating of individual rooms and buildings is achieved by passing this heated secondary fluid through heat convectors (or emitters) located in each room. Cooling can occur with an absorption refrigeration system.

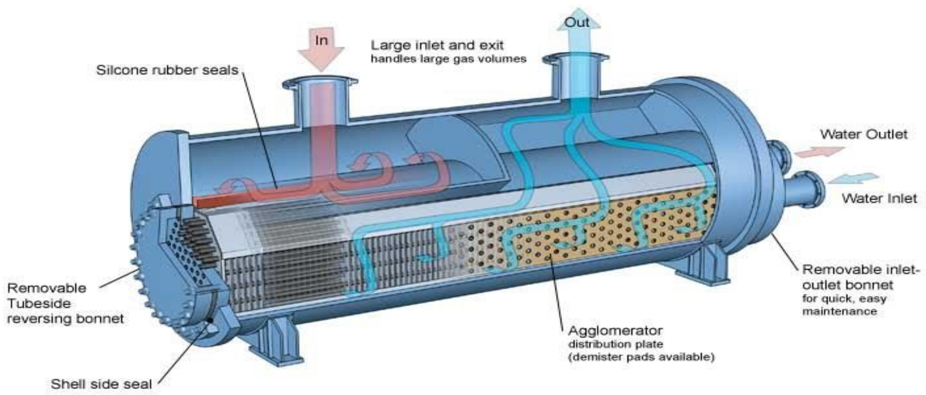

Figure 8 shell and tube heat exchanger

Geothermal water heat is transferred to a secondary fluid via heat exchangers. This heated secondary fluid is passed through heat convectors (or emitters) in each room to heat them. An absorption system can cool.

Our proposal decided to directly bring water to the network for numerous reasons, including the lack of a heat exchanger. Because the extracted water requires a simple and inexpensive treatment before it is fed into the network, it was compensated by performing water treatment.

3.2. Jordan Phosphate Mines Company

Phosphate Mines Company is a Jordanian public limited company founded in 1949 with 82.5 million dinars in capital to mine phosphate ores. In the past 60 years, the company has established a significant position among worldwide companies in the exploration and fertilizer industries, which are key to Jordan's economy and exports. Jordan Phosphate Mines Company's activities fall into two complimentary sectors: mining and phosphate fertilizer manufacture. By integrating the two, the company has demonstrated its worth in global markets. The business has also established a phosphate port in Aqaba to boost exports to overseas markets.

3.2.1. Al-Shaydiya Mine

The Shaydiya Mine is 50 km southeast of Ma'an, over a 315 km^2 area. The Phosphate Mines Company studied Shaydiya extensively since it is phosphate rich (1975-1979). During phosphate washing, water is taken from six wells near the mine (5 wells within the work and 1 reservoir 15 km away). Each well is 2000m deep. The water comes out of the wells at a flow rate of up to 1350 cubic meters/hour at a temperature of 70 degrees Celsius, therefore the company cools it before the cooling process. Water is injected with chemicals, chilled in two cooling towers, and then sent to mines for use in chemical processes that produce oxides and phosphates as shown in Figure 9.

(a) **(b)**

Figure 9 (a) chemical treatment unit and (b) Cooling towers

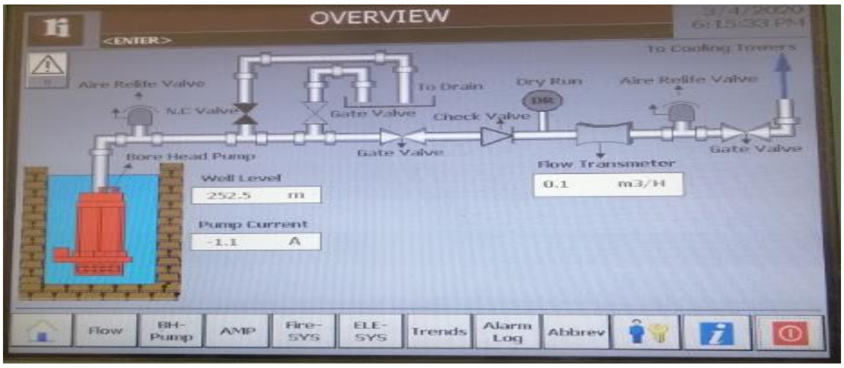

Figure 10 Picture of the pump control showing the extensions from the well to the cooling tower (PLC program)

3.3. Parts of the new system

To deliver water to the buildings, the new system uses a pipe whose dimensions have been calculated, then branches with lines to each building, raising hot water to apartment networks via the water pumps currently in use, and finally purifying the water before distributing it to the sub-lines for treatment, and a shut-off valve should be installed at the start of all branching during maintenance to ensure continued heating on the rest of the buildings. A gate valve should be installed at the main line before the branching to separate the entire network or run it and control the flow rate. Temperature and flow rate sensors should also be installed. Before and after constructions, there must be repetitions to prevent water from returning to the network and reaching the cooling towers.

3.4 Water treatment unit and water specifications before and after treatment

The Shaydiya mine owns a special unit responsible for treating water, so we will use the existing within our project. The reason for the treatment plant is the cooling tower, which needs certain water specifications to preserve it and ensure no calcifications occur inside it. We will use the same unit to treat water before entering the network to protect it from calcification. The existing treatment system CIP (Clean in place) is used for the cooling tower, but it can be used to cleanse water before entering iron pipes and radiators, and to protect pump fans, that is, to safeguard the network from mechanical difficulties. A product consisting of polymers of organic materials produced by Nalco Company and the product name is used 3D Trasar @ 3DT120. This treatment improves water's specifications and is done as follows: 7 ppm (7 mg/L) will be added the first week of operation to clean the old network and remove existing calcifications. And then get rid of this water and don't return it to the cooling tower to ensure it doesn't affect it. Conduct water tests after a certain period, and when making sure there are no calcifications, return to the normal position, add 4 ppm, and return the water after leaving the heating network to the cooling to sewer.

(a) (b) (c)

Figure 11 (a) control in treatment unit, and (b) and (c) Organic matter tank 3DT120

Water specifications before and after treatment.

Table 1 Water specification before treatment

Result	44.4	> 1.0	0.7	31.67	3.6	350	46.9	17.5	77.2	> 2.00	422	7.25
Unit	mg/l	mg/l	mg/l	mg/l	NTU	mg/l	mg/l	mg/l	mg/l	mg/l	µS/cm	--
Test	SO4	NO3	Iron	Silica	Turbidity	TDS	Ca	Mg	Chloride	TSS	Cond.	pH

Table 2 Water specification after treatment

Chemical analysis	pH	Total Hardness	Chloride	3DT120	ClO2	Turbidity	Iron	Silica	Sulfate	Conductivity
Unit	-	ppm	ppm	ppm	ppm	FAU	ppm	ppm	ppm	µS/Cm
feed water (before cooling tower)	7.1	180	80	4	NA	2	1.16	23	31	610

After consulting the engineer in charge of the treatment process, he explained that these results show the treatment system's effectiveness and applicability to the heating network, ensuring that the water does not affect the network. A comprehensive examination is performed every 6 months and periodic checks are performed every day. Flow needs and pipe distances are known when designing pipework. When the pipe length and diameter are known for a specified flow rate, the choosing the pipe determine a piping design that results in sufficient flow. 1"-12" line pipe is offered. Glass fiber Reinforced Epoxy (GRE) pipes are made using e-glass and epoxy resin cured with aliphatic amine curing agent for high pressure and temperature performance. Geothermal energy exploration corrosion control. Applications include low to high pressure flow lines, tubing, casing, cemented liners, and slotted production liners. GRE pipes are superior to steel and coated steel. Advantages include resistance to CO_2 and/or H_2S-gas and saline water. GRE also has a benefit over steel in terms of weight, handling, and installation. Although tubular can be used in many sectors and settings, GRE is increasingly used in some. These GRE applications have 30 years of field expertise. The product is utilized in geothermal energy exploration and oil and gas production. Unlike carbon steel, GRE is resistant to corrosion. GRE tubulars are corrosion-resistant against CO_2, H_2S, hydrocarbons, water, and natural gas (Hossein Arian, 1996), making them ideal for geothermal applications. Considering the temperature (maximum 200°F) and pressure (4,000 psi) constraints, GRE makes a good substitute for steel because it eliminates the requirement for plastic lining, catholic protection, and inhibitory systems. GRE also requires little or no maintenance.

Excellent GRE flow (and remain so due to the resistance against corrosion). Very low effective roughness (0.00006") gives GRE 30% superior flow properties than steel.

4. Methodology

4.1 Thermal load calculation

An engineer must calculate the thermal loads to build a heating system. According to the data supplied to the engineer, he must use the fastest and easiest way. So, due to the currently installed heating system, load is found by collecting the capacity of the currently installed boilers so that they appropriately cover the needs and create the required capacity. One residence will be used to demonstrate how to manually compute thermal loads.

$$\dot{Q} = U \times A \times \Delta T \qquad (1)$$

where $\dot{Q}$ is the Heat flow (W), U is the overall heat transfer coefficient (W/m^2 $.^0$C), A is the Area (m^2), and ΔT is the Temperature difference between inside and outside,(^{0}C).

The overall heat transfer coefficient can be calculated by using the following steps;

$$U = \frac{1}{AR_t} \qquad (2)$$

where R_t is the total thermal resistance (^{0}C/W)

The total thermal resistance can be founded by conduction and convection

$$R_t = R_{cond} + R_{conv} \qquad (3)$$

where R_{cond} *is the* thermal resistance by conduction (^{0}C/W) and R_{conv} *is the* thermal resistance by convection (^{0}C/W)

$$R_{cond} = \frac{L}{KA} \qquad (4)$$

where L is the thickness (m), K is the thermal conductivity (W/m $.^0$K)

$$R_{conV} = \frac{1}{hA} \qquad (5)$$

where h is the heat transfer coefficient by convection (W/m^2 $.^0$K)

The load will be calculated according to the apartment plan that was drawn using the AutoCAD program and the area of the apartment is approximately 70 m^2

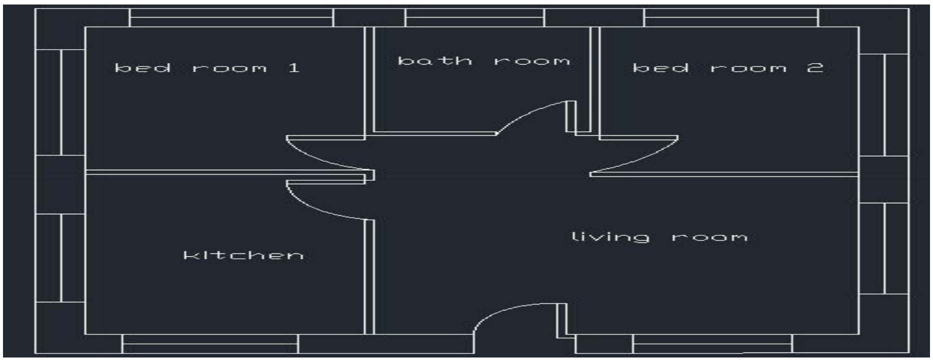

Figure 12 Apartment in AutoCAD.

The thermal load is calculated for the walls on which the heat difference occurs, so calculation was done for the exteriorly, but it is not calculated for the wall cutters (barriers) because the temperature difference on them is equal to zero.

The composite wall is shown in Fig 13.

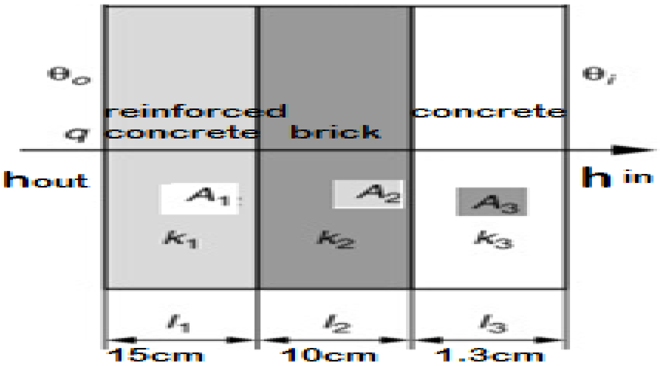

Figure 13 The composite wall

The thermal conductivity for reinforced concrete, brick wall and concrete wall are $K_{reinforced}$ =1.4 W/m .K, K_{brick} = 0.7 W/m. K, and $K_{concrete}$ =0.4 W/m. K, respectively (Cengel et al., 2003).

Due to the difference in air velocity and the difficulty of knowing the details of the air velocity most of the time. Usually when calculating the heating load, the value of heat transfer coefficient (h) is assumed. The convection heat transfer coefficient for inside and outside area are h_{in}=9.37 W/m^2. K and h_{out}=34 W/m^2. K at air speed 24 m/s (Cengel & Heat, 2003).

Table 3 Values of R, U, and $\dot{Q}$ to plane wall, windows and doors for each apartment at ΔT = 18 ºC.

	R (ºC/W)	U (W/m^2.ºC)	$\dot{Q}$ (W)
Plane wall 1	0.0216	2.39	834.14
Plane wall 2	0.0155	2.39	1160.9
Plane wall 3	0.0216	2.39	834.14

Plane wall 4	0.0210	2.39	877.14
Windows	0.019	6.73	968.81
Doors	0.129	2.59	139.85
			$\dot{Q}_{total}$ = 4815

The total thermal loads of the apartment equal to 4.815 kW, let it 7.2 kW to ensure that no excessive load on the network. The total number of apartments is 530 apartments, so the total thermal load for all appartements is 3828 kW.

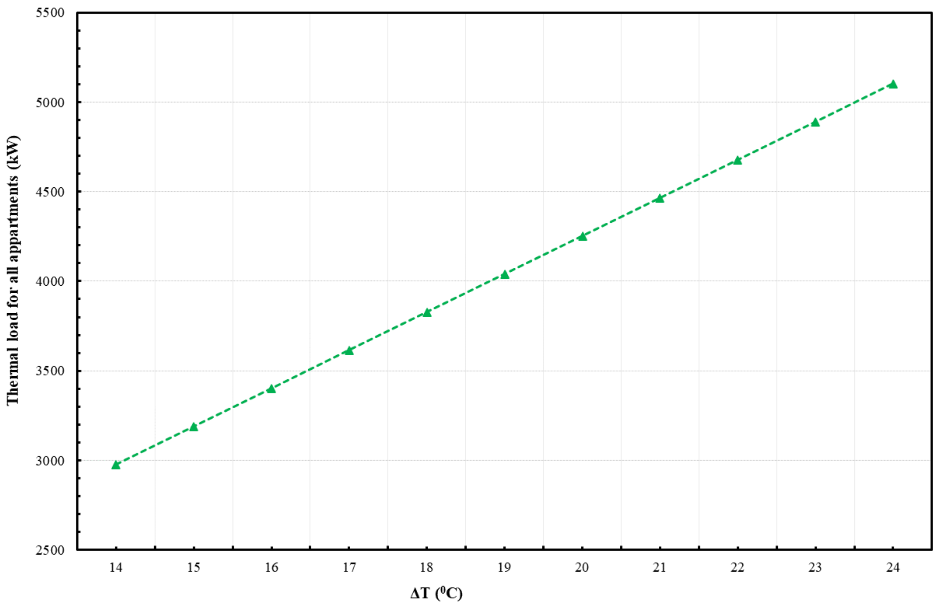

Figure 14 Temperature difference between inside and outside versus thermal load for all apartments

Figure 14 shows that the thermal load can be controlled by changing the temperature difference between the outside and inside surface.

5. Results and discussion

5.1 Flow rate and the amount of polymer organic materials added to the filter annually

The mass flow rate can be found by;

$$\dot{m} = \frac{\dot{Q}}{C_P * \Delta T} \quad (6)$$

where $\dot{m}$ is the mass flow rate (kg/s), $\dot{Q}$ is the Heat flow (W), C_P is the specific heat for water and is equal 4.2 kJ/kg, and ΔT is the temperature difference for the water between the inlet and exit of the system and equals 40 $^{\circ}$C.

$$\dot{m} = \frac{3828000}{4.2*40} = 22.8\,\frac{kg}{s} = 82.08\,\frac{m^3}{h}$$

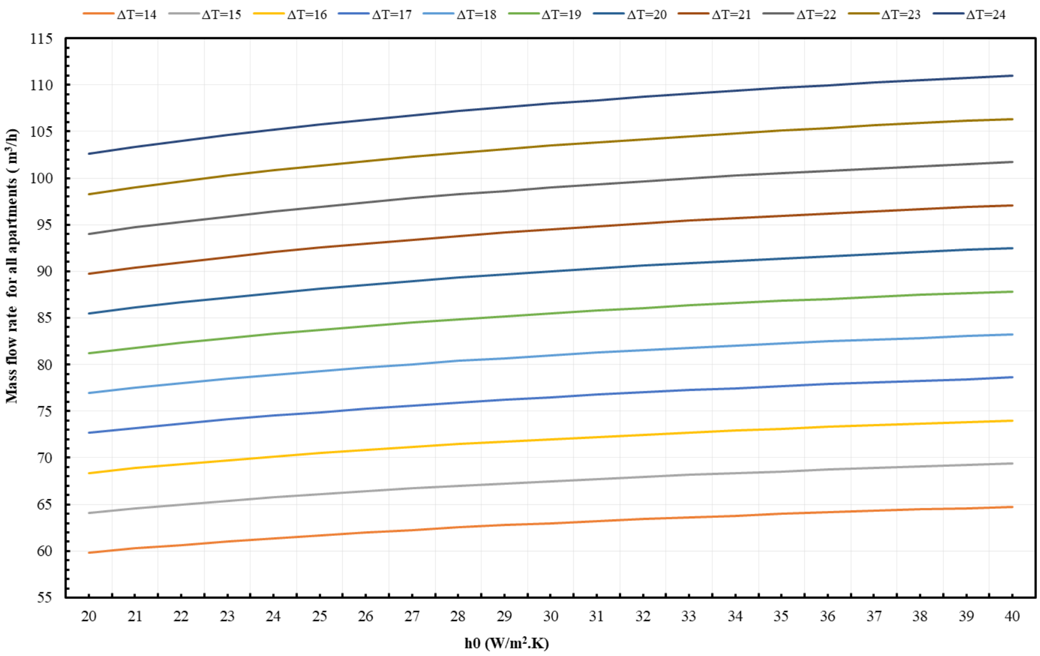

Figure 15 convection heat transfer coefficient versus mass flow rate for all apartments at difference temperature.

Figure 15 illustrates how to control the mass flow rate for all apartments by varying the convection heat transfer coefficient with a temperature difference between the outdoor and indoor. The appropriate flow selected is based on the change of the temperature difference between the outside and inside surface and the heat transfer coefficient, which is dependent on the value of the velocity of the wind. As shown in Figure 16, the required mass flow rate is approximately 109 m^3/h when the outdoor temperature is 10^0C and the temperature difference is 24 ^{0}C. However, this decreases to approximately 63.8 m^3/h when the outdoor temperature is 11 ^{0}C and the temperature difference is 14 ^{0}C.

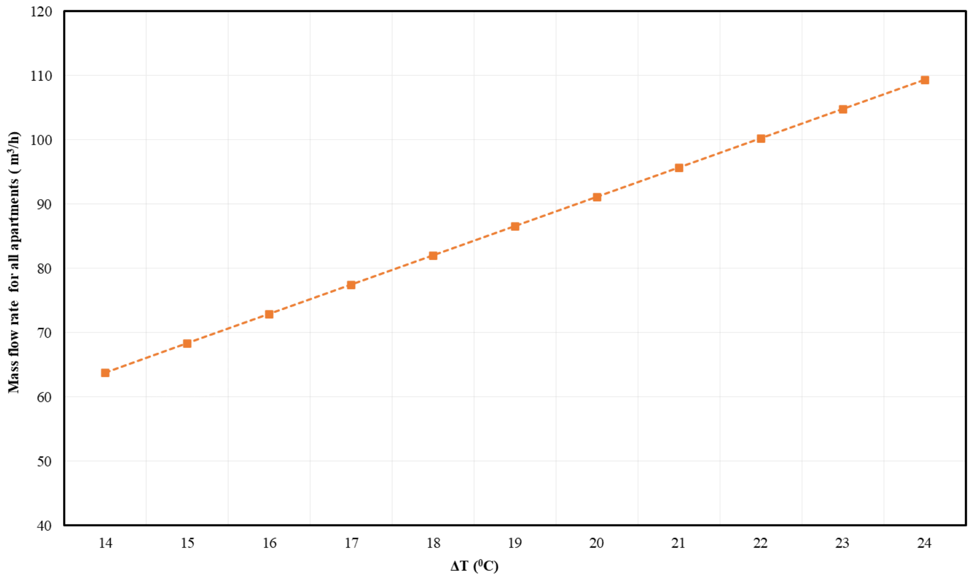

Figure 16 Temperature difference between inside and outside area versus mass flow rate for all apartments.

According to the plant's treatment department and the test results for the water, 4 ppm (4 mg/l) should be added from polymer organic materials. Calculate it based on the flow rate.

$$\frac{4ppm \times 82.08\ flow\ rate}{1000} = 0.33\ L/h = \ 950\ L/season\ .$$

The annual cost for water treatment is equal to 1900 $

5.2 Initial project cost

According to the manufacturer's recommendations, the main tube diameter for GRE tubes is 8 inches. Branching tube diameter according to the manufacturer's recommendations for GRE tubes is 1 inch.

Table 4 The Primary Cost of the Project

Item	Product name	Description	Unit	Quantity	Unit price EXW Price	Total price EXW Price
1	**GRE pipe**	6m length with 2 flanges, DN200, PN2	set	335	US$155.70	US$52,159.50
2	**GRE pipe**	6m length with 2 flanges, DN32, PN2	set	170	US$37.50	US$6,375.00
3	**gate valve**		pcs	1	US$38.00	US$38.00
4	**shut down valve**		pcs	70	US$28.00	US$1960.00
5	**flow rate sensor**		pcs	1	US$630.00	US$630.00
6	**heat sensor**		pcs	2	US$81.00	US$162.00
IN TOTAL					**US$61,324.50**	

5.3 The annual cost of the current heating system

During the previous 5 years, the average amount of diesel that was consumed was 500000 liters per year, and the average price of diesel was 0.68 $ per liter; this resulted in a total cost of 500000*0.68, which is equal to 340000 $ each year. While in the current system it's noticed that these costs (340000 $ each year) are needed for 5 years as shown in Figure 17.

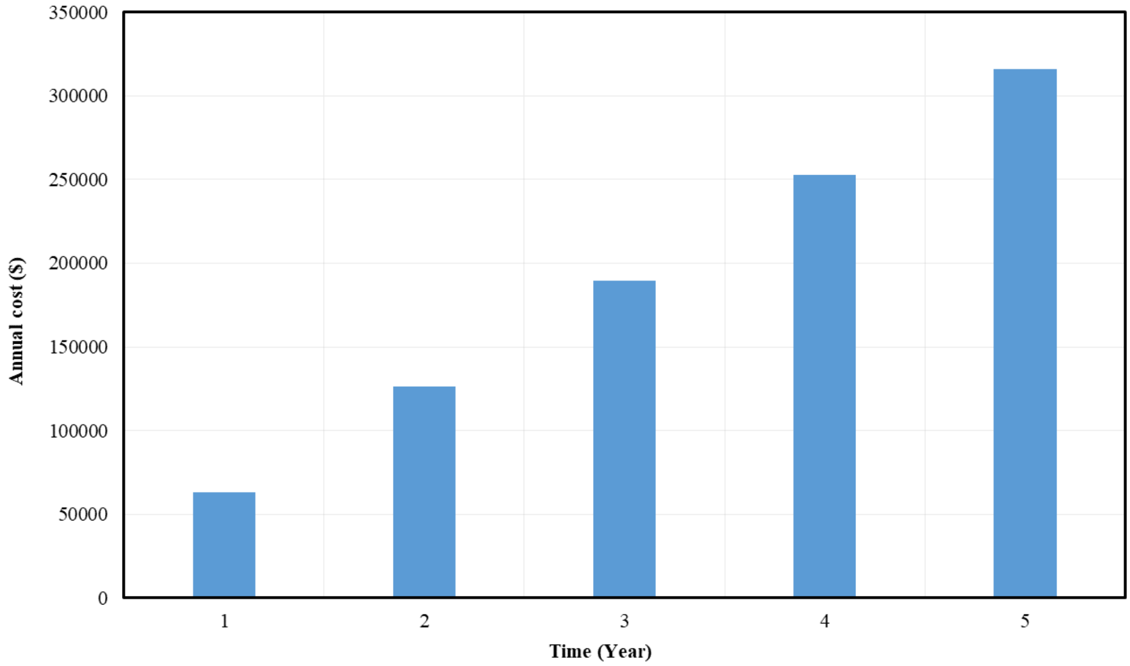

Figure 17 Annual cost for new system for 5 years

6. Conclusion

It was found that the heat consumed load is 3828 kW, so 82.08 m^3/h of flow is needed to cover all residential structures and 0.33 L/h of treatment to deal chemically with water before it enters the network. These tubes' diameters were determined by first estimating their flow rate. In each building, there will be an 8-inch main water line, by which 1-inch sub-water lines or streams to distribute the water.

The initial cost of the project was 63,500 $, and the annual cost would be 1,900$, including organic materials added to water treatment and occasional maintenance. Comparing the annual cost of diesel in the current heating system (340,000$), the project was quite feasible for the company.

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