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A GREENHOUSE MEASURING 500 M^2 SOIL SOURCE HEAT PUMP THE COST OF THE COMMISSIONING WITH ANALYSIS AND A COAL BOILER COMPARISON WITH HEATING SYSTEM

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ABSTRACT

The biggest goal is to increase product yield and protect against natural disasters in greenhouse applications. In order to grow quality products throughout the year, it is vital not to be affected by hot or cold weather conditions. Heating is generally provided by coal boiler systems, while various methods are applied for cooling. In this article, which aims to compare the application of Ground Source Heat Pump (GSHP) as a single air conditioning system capable of heating and cooling with the other system, it is tried to explain that renewable energy can be applied in greenhouses.

Keywords: Ground Source Heat pump, Bore Hole Exchanger, Heat Pump, Greenhouse.

1. INTRODUCTION

Greenhouses have come across as a very preferred agricultural production method in recent years with many advantages. One of the biggest advantages of greenhouse cultivation is undoubtedly being able to grow crops regardless of climatic conditions. Performing cost analysis of Ground Source Heat Pump (GSHP) and Coal Boiler Heating System (CBHS) applications in a greenhouse will give us an idea so that we can see the difference between the two methods.

2. STRUCTURED FEATURES OF THE GREENHOUSE

We need to know the structural properties of the greenhouse where the application will be carried out in order to determine the heat loss and annual heat needs. After determining the heat loss and annual heat requirement, the device capacities will be determined. In light of these values, installation and operating costs will be examined.

2.1. General Dimensions and Coating Material

The width, height, length and ceiling height of the greenhouse to be built are given as follows. (Figure 1)

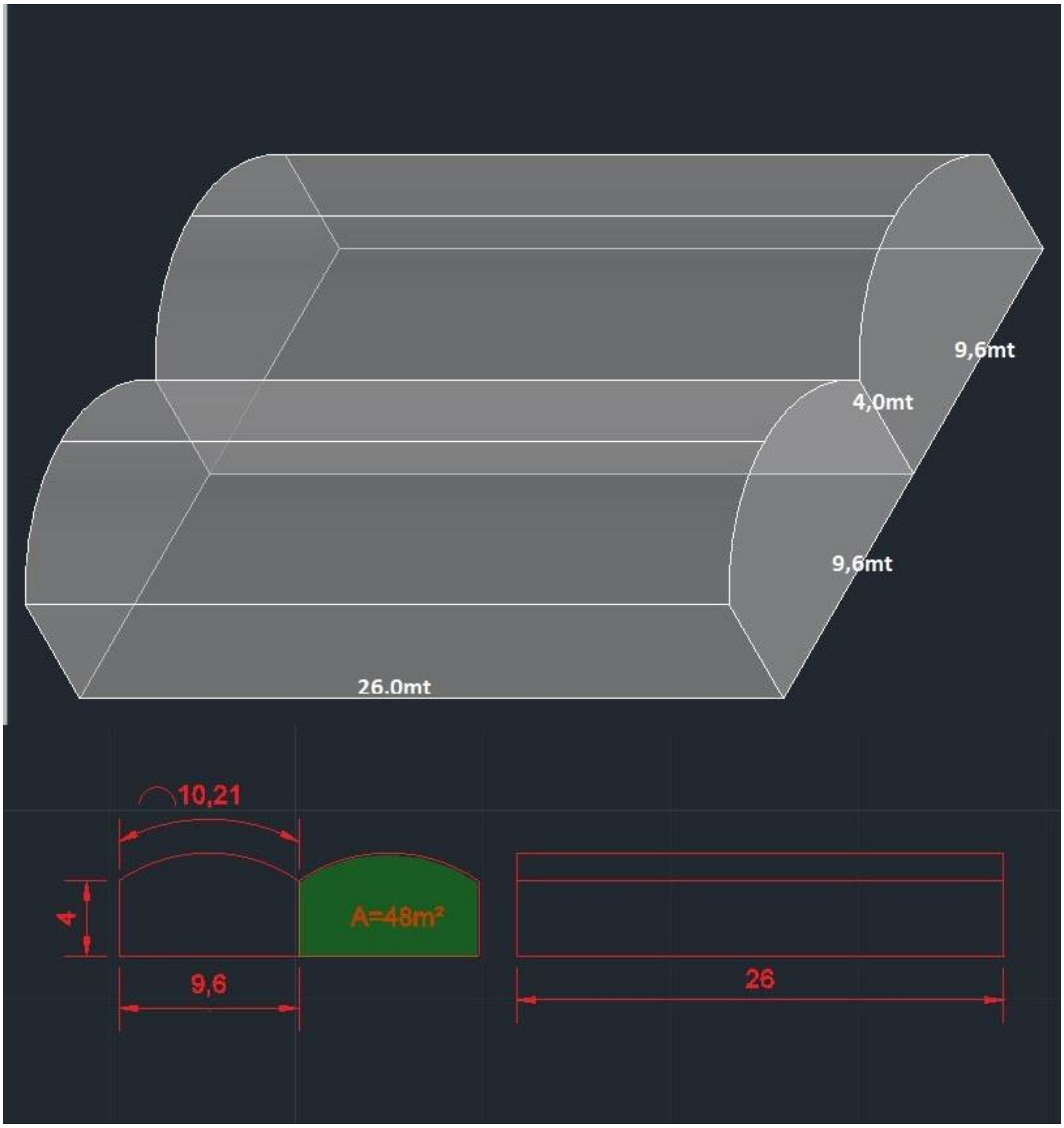


Figure 1 *Greenhouse dimensions*

The material to be used for the greenhouse is selected as a single chamber 8mm thick polycarbonate material with high thermal insulation and light permeability.

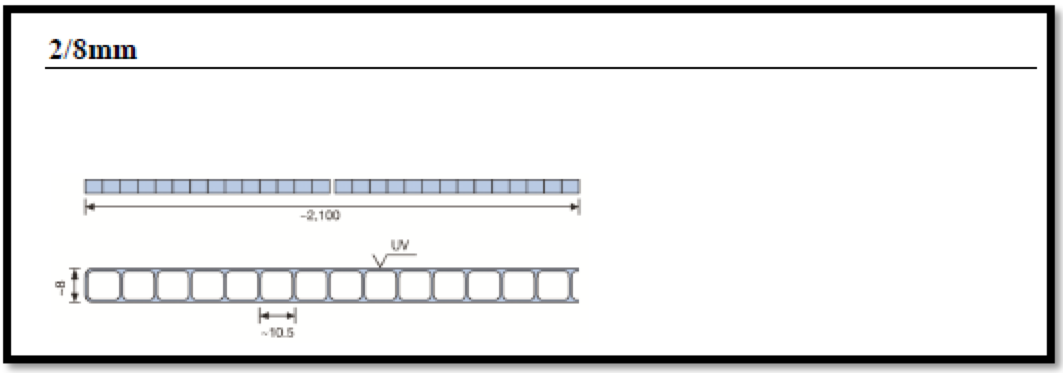


Figure 2 *Properties of polycarbonate sheet to be used in greenhouse coating*

2.2. Total Surface Area and Volume Calculations With Heat Loss

Surfaces that cause heat loss; it is the side walls and ceiling of the greenhouse, where it comes into contact with the outside air. When the surface area is multiplied by the heat transfer coefficient of the material used in these parts, it will show us how much heat we lose on these surfaces. Therefore, we will have to find the external contact surface area first for the heat loss calculation we will make in the future.

Using the area formula

$$A=W*H \tag{2.1}$$

The parameters in this equation are as follows;

A = Area [m^2]

W = Width [m]

H = Greenhouse Height [m]

The front and rear walls in the Gothic structure are each calculated as 48 m^2 by the drawing program. 4 gothic wall areas;

$$A=4*48=192m^2$$

Using the field formula for 2 side walls with external contact;

$$A= (26*4) *2=208 \ m^2$$

Using the field formula for 2 ceiling covers with external contact;

$$A= (10{,}21*26) *2=530{,}92 \ m^2$$

Total external contact surface area;

$$GA= Ag +Ay +At= 192 +208 +530{,}92= 930{,}92 \ m^2 \approx 930 \ m^2$$

If we use the volume formula to calculate the internal volume that will be required to calculate the annual heat requirement;

$$V= Ag*Gs \tag{2.2}$$

The parameters in this equation are as follows;

V = Greenhouse volume [m^3]

Ag = Gothic wall area [m^2]

Gl = Greenhouse length [m]

Using the total volume of the greenhouse in 2 blocks, the volume formula;

$$V= (48*26) *2=2496 \ m^3$$

3. CALCULATION OF HEAT LOSS AND ANNUAL HEAT REQUIREMENT

3.1.1. Heat Loss Account

There is a lot of heat loss in greenhouses due to lightness and ventilation requirements to ensure light permeability. Therefore, devices with high heating capacity are preferred. High heat loss also increases the energy need and, of course, the energy cost.

The method proposed by the NSW (New South Wales Government Department of Primary Industries – Agriculture) [1] will be used when calculating heat loss considering that the greenhouse is in Eskisehir region. In this method, the total heat loss value is equal to the sum of transport and heat loss (QC), infiltration and heat loss (QL) and radiation heat loss (QR).

$$QT = QC + QL + QR \tag{3.1}$$

The equation 3.2 will be used when calculating the total heat loss value, since the amount of heat transfer with radiation is usually negligible.

$$QT = QC + QL \tag{3.2}$$

The heat loss value realized by transport is calculated in kW with the following expression.

$$QC = (U *SA *\Delta T) / 1000 \tag{3.3}$$

The parameters in this equation are as follows;

U = Total heat transfer coefficient [W/m²°C]
SA = Total surface area of greenhouse coverı [m²]
ΔT = Temperature difference, ti – to [°C]
ti = Greenhouse interior design temperature [°C]
to = Outdoor design temperature [°C]

The value of 3.3 W/m²°C in figure 2.2 is used to determine the total heat transfer coefficient (U) for the greenhouse. For ΔT; it was accepted that the external temperature would be 15 ºC at the internal temperature of -9 ºC and it was foreseen that there would be a temperature difference of 24 ºC. If so, if we calculate the value of heat loss realized by transport;

$$QC = (3,3 * 930 * 24) / 1000 = 73,66 \text{ kW}$$

The amount of heat lost as a result of infiltration can be calculated in equations 3.4 to kW.

$$QL = (0,373 * \Delta T * V * E * W) / 1000 \quad (3.4)$$

The parameters in this equation are as follows;

Temperature difference [°C] including ΔT = ti – to
V = Greenhouse volume [m3]
E = Air exchange coefficient (Table 1)
W = Wind factor (Table 2)

If we accept the Air Change Factor from Table 3.1 for the design of a single-storey polyethylene film and metal-frame greenhouse, it will be a relatively average value and a close value for the polycarbonate structure. The wind factor will be used in Eskisehir for the value corresponding to <25 km/h as the average wind speed does not exceed 25 km/h.

Table 1 *Air Exchange coefficient (E) values*

GREENHOUSE DESİGN	WEATHER CHANGE FACTOR (E)
Single layer polyethylene film and metal skeleton	1,0
Double layer polyethylene film and metal skeleton	0,7
Single glass and metal skeleton	1.08

Table 2 *Wind Factor (W) value*

WIND SPEED (KM/H)	WIND FACTOR (W)
<25	1,0
30	1,025
35	1,05
40	1,075

If we calculate heat loss by infiltration according to this equation (3.4);

$$QL = (0,373 * 24 * 2496 * 1 * 1) / 1000 = 22,34 \text{ kW}$$

Back to the QT equation (3.1), our total heat loss;

$$QT = 73,66 + 22,34 = 96 \text{ kW}$$

We found the total heat loss caused by transport and infiltration as 96 kW, according to this value, we can choose our heater capacity not to fall below 105.6 kW with a 10% safety share. If so, a Ground Source Heat pump (GSHP) or Coal Boiler Heating System (CBHS) that can provide 116 kW of heating and approximately 100 kW of cooling power can be selected for this greenhouse.

3.1.2. Annual Heat Requirement Account

Period when heating is needed for Eskisehir region; It is a 6-month period covering November-April. If we calculate the total annual heat requirement from the equation of 3.5 by calculating the heat requirement separately for each month;

$$Q(ay) = U *(Ac /Ag) *(tid - tst - mn) *nn *nd \; [Wh /m^2 \, ay] \qquad (3.5)$$

U = Total heat transfer coefficient [W/m²K]
Ac /Ag = Greenhouse cover surface area / Greenhouse base area ratio
Tid = Greenhouse indoor design temperature [°C]
tmn = Average night temperature value
tst = Average value of night temperature increase due to heat stored in the ground during the day [°C]
nn = Number of night hours
nd = Number of days heated during the month

The annual heat requirement is calculated according to equation 3.4 and given in table 3 below by month.

Table 3 *Year heat requirement*

MONTHS	HEAT NEED (KW)
November	6.262
December	13.519
January	17.482
February	12.342
March	7.617
April	1.739
SUM	**58.961**

The annual heat requirement of the 500 m² polycarbonate cladding greenhouse was calculated as 58.961 kW from table 3.3, kg of this value. Value from Cal unit; 5,070,944 kg. Cal.

4. GROUND SOURCE HEAT PUMP (GSHP) DESCRIPTION

Thanks to the Drilling Heat Exchangers (BHE) placed underground by drilling, we call the devices that obtain higher heat output by taking the heat drawn from the underground. The principle of operation of the device is based on the carnot cycle. This cycle; it is a closed cycle in which energy remains constant, cannot escape outside, works at the highest efficiency and repeats itself constantly. We see this cycle in the figure below (Figure 3).

The sections with the most heat transfer are the sections marked with 2 and 4 in the top graph. In these sections, the heat is drawn by the drilling heat exchanger according to the heating or cooling preference and given to the Evaporator.

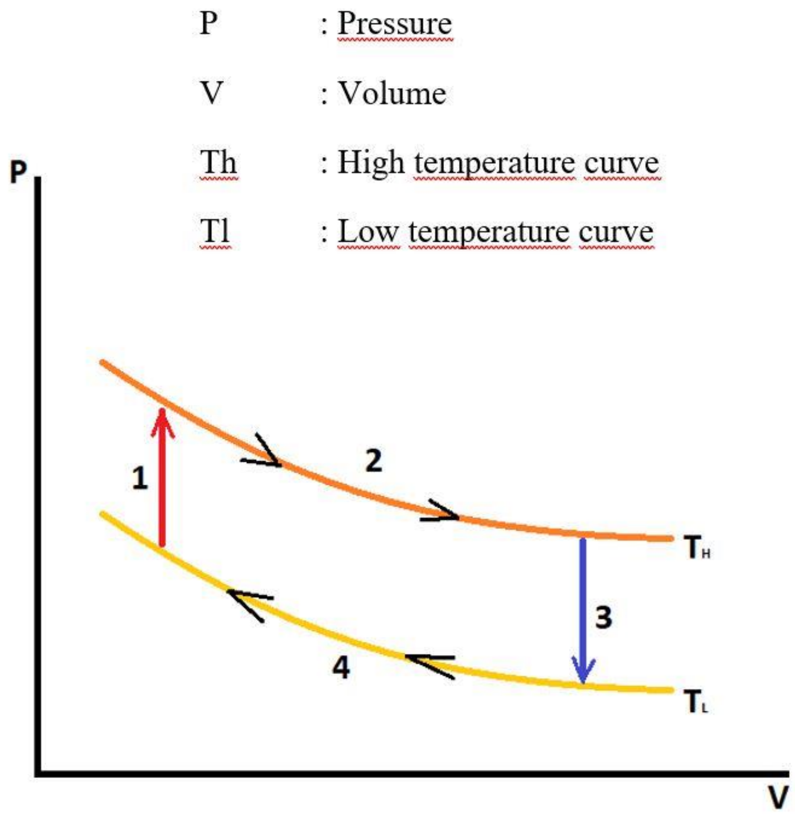


Figure 3 *Carnot cycle*

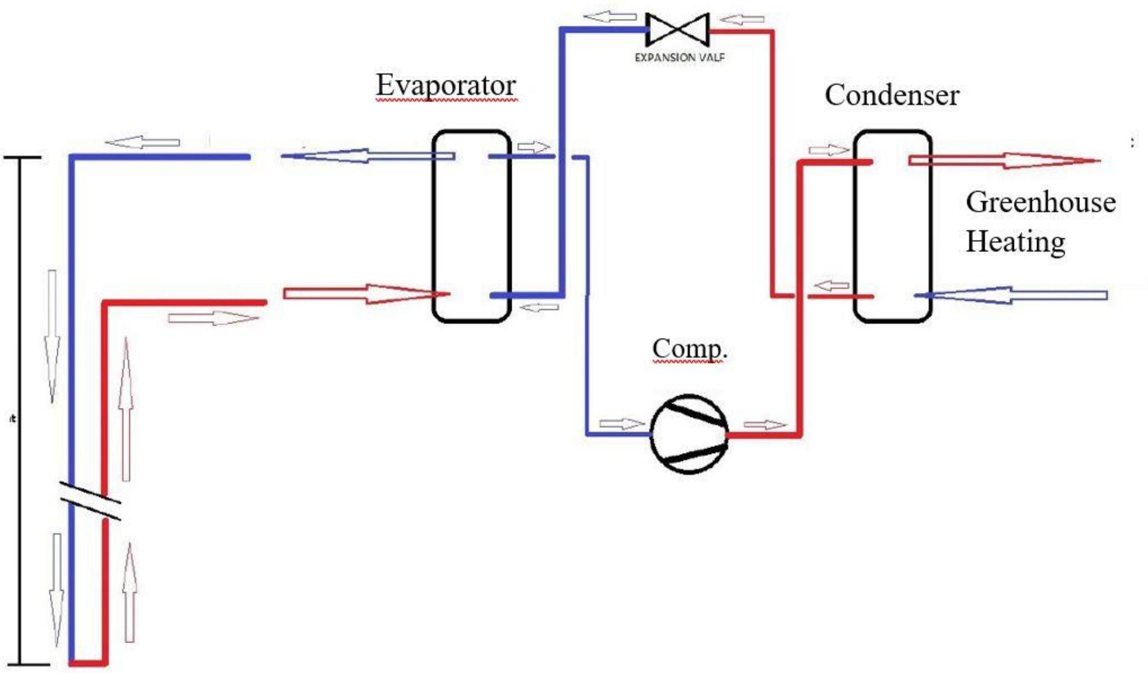


Figure 4 *Ground Sourge Heat Pump Operating principle*

For example, if you want to use in the environment, the output part should be heating (2). Heat transfer in the cooling (4) section is provided to the user through energy wells without any cost. The section shown in the graph (1) is the only part that needs electricity, where the compressor used to compress the gas works with electricity. The part shown in the graph (3) is the part where the gas expands again with the help of the expansion valve after heating (2) work is done in the environment. In this section, it does not cost the user. In summary; This cycle, which takes place for heating, also requires energy only to compress the refrigerant (1). In other stages, the carnot cycle is completed without the need for the science of consuming Electrics. GSHP, which was able to perform this cycle together with the energy well, made approximately 6-8 units of heating using 1 unit of electricity (COP=6-8).

5. COST ANALYSIS

The cost items that we will focus on when conducting cost analysis will be investment and operating (variable) cost. Keeping the air conditioning in the greenhouse stable is very important both in terms of harvesting year-round and in terms of product quality. Therefore, it is right to evaluate the cost of opportunity by ignoring it. By comparing the investment costs for both heating methods and the operating costs for the first 10 years, it can be decided which system will be more beneficial in a long-term investment such as greenhouse.

Unfortunately, using renewable energy is one of the methods with the highest investment costs. External dependence on machine parts and rapid exchange rate increase are the biggest obstacles in this method. However, renewable energy, which is low in operating costs and environmentally friendly, has proven to be a long-term rush.

5.1. GSHP Installation Cost

5.2. BHE Cost

The most important part for GSHP is undoubtedly the earth's crust. It allows us to heat or cool using the heat in the earth's crust. Coefficient Of Performance (COP) is very high on GSHP devices. One reason for this is that the underground temperature is stable and not affected by seasonal changes. The other reason is that heat transfer is carried out in a large mass by the ingenuity of Drilling Heat Exchangers (BHE) (Figure 5). This large underground mass cannot be easily heated and cooled, and a very large amount of heat, depending on the number of BHE, allows us to draw or store heat. Drilling Exchangers, which account for **37%** of the GSHP investment cost, are the most important part in terms of investment cost as well as GSHP performance. It must be calculated very precisely both for COP and for the cost of investment. In order to find the number of BHEs, we must know the following parameters, respectively.

1. Heating capacity needed (kWh)
2. Coefficient of Performance (COP) of GSHP device
3. Borehole Heat Exchanger Specific Heat Drawing Capacity (W/m)

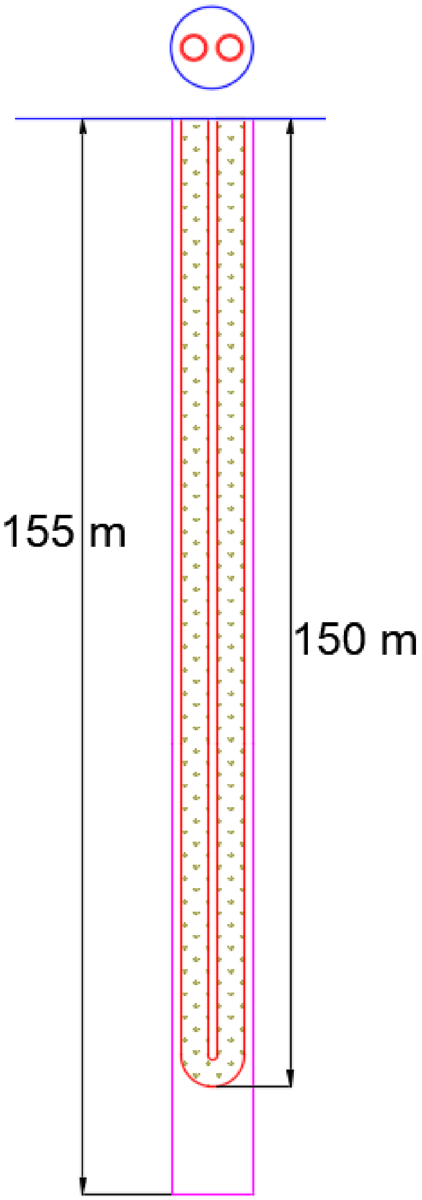


Figure 5 *Section Of Bore Hole Exchanger*

Heating capacity from these parameters; In the first sections it was calculated as 96 kWh, together with a 10% safety share, we will accept 105 kWh for the amount of BHE. Most of the heating needs will be withdrawn from the underground by GSHP and this amount will be calculated according to Coefficient of Performance. COP in Heat Pumps; The ratio of heating capacity to energy consumed. Cop 6-8 range for GSHP devices. The COP ratio for GSHP to be used for this greenhouse will be 6. Accordingly, GSHP will consume 1/6 of this electricity while generating 105 kWh of heat. Accordingly;

$$105 \text{ kWh} / 6 = 17{,}5 \text{ kWh}$$

If so, GSHP will consume 17.5 kWh of electrical energy per hour during its maximum capacity and will be able to provide 105 kWh of heating in the greenhouse by drawing 87.5 kWh of heat from the underground. How much BHE does it take to draw 87.5 kWh of heat from the ground? To answer this question, we need to find the specific heat-drawing capacity of bhe one meter long. In fact, in order to determine this value precisely, a guide BHE should be placed in the area where the greenhouse will be built and a thermal response test should be performed. This is essential for an air conditioning of this capacity, especially for an investment with high costs. This test is not carried out because GSHP application is almost nonexistent in our country. Therefore, this selection is made from the following table (table 4) in accordance with the ground structure.

Table 4 *Specific heat drawing capacities according to ground structure (W/m)*

UNDERGROUND STRUCTURE	SPECIAL HEAT DRAW CAPACITY
DRY, SANDY	20-40 W/m
WET, ROCK	50-60 W/m
GROUNDWATER FOUND	70-90 W/m

Since it is known that there is groundwater close to the surface in the area to be built in the greenhouse, a value of 80 W/m, which is between **70-90** W/m, can be used. If so;

87,5 kWh*1000=87500 W/80 =1093,75 m BHE

A total of 8 wells, each 150 m long, 7 pieces and 100 m long one, will be drilled and placing 1100 m BHE in these wells will be enough for the greenhouse. Drilling service, piping cost, injection and labor total meter price is obtained from the market as 200 TL/m +VAT (20€). Accordingly, our total BHE cost;

1100*200 =220.000,00 TL

5.3. GSHP device cost

Although GSHP has a lot of applications in the world, unfortunately it is not very well known in our country. For this reason, manufacturers have developed their policies in Turkey mainly to sell AirBorne Heat Pumps. Therefore, although this is not his main job, there are very few manufacturers who can produce as special orders on demand. This, of course, increases the cost of the device. The manufacture of a device with 105 kWh heating and 86 kWh cooling power costs approximately 176,000,00 TL +VAT (17,600€).

5.4. Fan Coil cost to be used in greenhouse

One of the biggest advantages of TKIP is that the device can be used in heating and cooling mode. Therefore, devices similar to the air conditioning unit will be placed in the greenhouse. Hot water will be sent to these internal units (Fan Coil) in the range of 35-40ºC in heating mode and cold water in the range of 5-10ºC in cooling mode. In heating or cooling mode, it will be enough to use 7 of these internal units that can provide the desired temperature homogeneously in the greenhouse for 500 m² greenhouse area. Total cost of internal units with a unit price of 9,000,00 TL +VAT (900€);

7*9.000 =63.000,00 TL

5.5. Installation elements and assembly workmanship costs

The cost of installation elements and assembly workmanship is given in the following table (table 5) in a list.

Table 5 *Installation and labor costs*

COST ITEM	Amount	P. Price	Sum
Circulation Pump (25 m³/h)	2 adet	750 €	1500 €
Expansion Tank	2 adet	300 €	600 €
Battery Tank 1000 LT	1 adet	950 €	950 €
The connection is and collectors	1 adet	3000 €	3000 €

Labor	1 adet	2250 €	2250 €
SUM			8300 €

Since the current exchange rate of euro/TL is 10 TL, the total cost is 83.000.00 TL.

5.6. Mold and concrete costs

It is important to include BHE and the pipeline from there to the boiler room in a concrete canal, both to use the upper area and to isolate these sections. Therefore, it is right to take into account the cost of a concrete canal as seen in the Figure (Figure 6).

Figure 5 *BHE concrete canal application*

Total 40 m² mold workmanship and 10 m³ c25 concrete cost in concrete channel application for eight BHE;

$$(40\ m^2 * 50\ TL) + (10\ m^3 * 250\ TL) = 5500{,}00 TL$$

Table 6 *GSHP Sum investment cost*

COST ITEM	AMOUNT
BHE Cost	220.000,00 TL
GSHP Device Cost	176.000,00 TL
Fan Coil Cost	63,000,00 TL
Installation Elements and Labor cost	83.000,00 TL

Mold Concrete Cost for Canal	5.500,00 TL
TOTAL COST	**547.500,00 TL**

5.7. Coal Boiler Cost

A coal boiler with a capacity of 116 kWh is easily available from the market. The average quality device will cost approximately 14,200.00 TL (1420 €).

Table 7 *Installation and labor costs*

COST ITEM	AMOUNT	PRICE	SUM
Circulation Pump (Wilo 25 m³/h)	1 piece	750 €	750 €
Expansion Tank	1 piece	500 €	500 €
48 mm iron pipe	1200 m	1.81 €	2172 €
The connection is the goods. And collectors	1 piece	2000 €	2000 €
Labor	1 piece	2250 €	2.250 €
SUM			4250 €

Iron pipes, which are used as heat transmission devices in greenhouses, are the most commonly used method. In this method, heating is provided by circulating the water heated by the coal boiler in the 48 mm thick iron pipes laid on the floor of the greenhouse with a certain frequency. When 70 ºC of water is circulated in these pipes, approximately 96 Wh heat is transferred from each 1 m pipe. In so, into the greenhouse; It is necessary to lay 105000W/96 = 1093 m pipe. This amount can be determined as 1200 m taking into account the device capacity and the distance between the boiler greenhouse.

Table 8 *Total investment cost of coal boiler*

COST ITEM	AMOUNT
116 kWh Coal Boiler	14.200.00 TL
Plumbing and the cost of labor	42,500,00 TL
TOTAL COST	**56,700,00 TL**

5.8. GSHP Operating Cost

Energy consumption will be the most important expense item in GSHP operating cost. When calculating this consumption, the annual heat requirement and the COP value of the GSHP device are used. The annual heat requirement calculated in previous sections is 58,961 kW (5,070,944 kg). Cal) (Table 3) can be found using an annual consumption COP (6) value. Annual electricity consumption as GSHP will meet 1/6 of the heat needed by the greenhouse from the electricity grid;

$$58.961\ \text{kW}/6 = 9827\ \text{kW year}$$

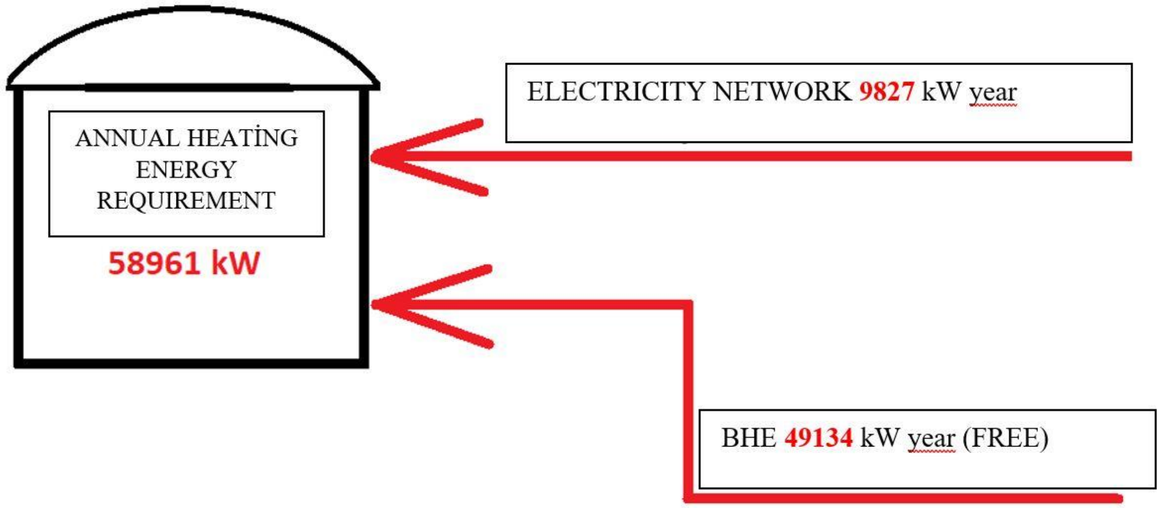
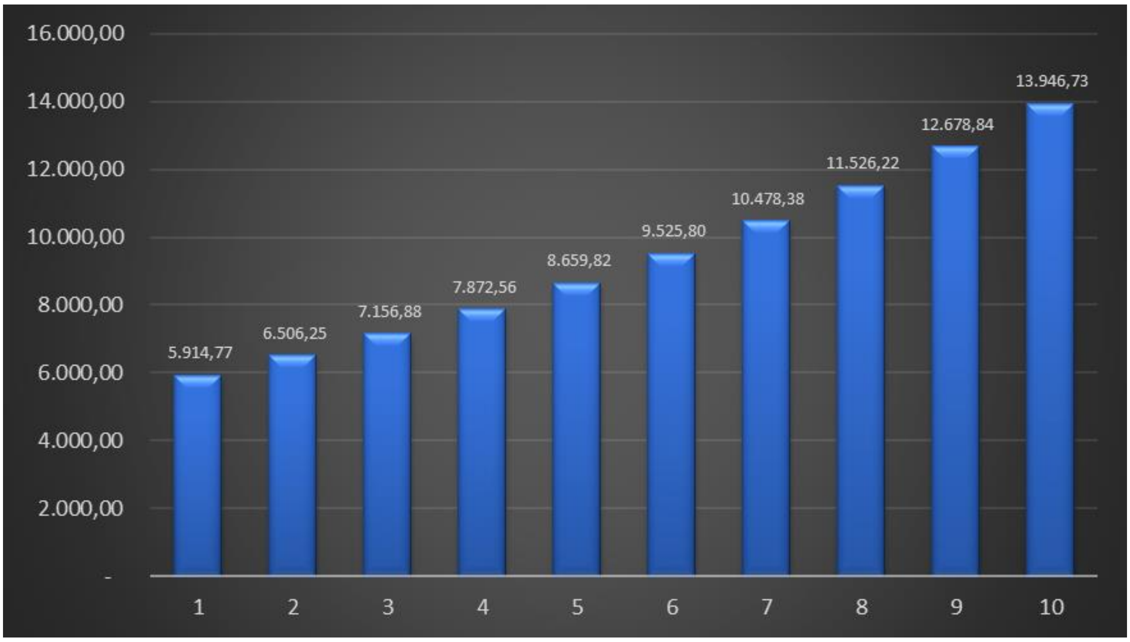


Figure 6 *GSHP heat requirement diagram*

In the light of these data, the operating cost of the investment for the first 10 years is seen in table 9. The increase in the price of electricity consumption when creating the table was accepted as 10% annually.

Table 9 *GSHP 10-year energy consumption price*

	CONSUMPTION (Kw)	UNIT PRICE (TL)	AMOUNT (TL)
2020	9827	0,60	5.914,77
2021	9827	0,66	6.506,25
2022	9827	0,73	7.156,88
2023	9827	0,80	7.872,56
2024	9827	0,88	8.659,82
2025	9827	0,97	9.525,80
2026	9827	1,07	10.478,38
2027	9827	1,17	11.526,22
2028	9827	1,29	12.678,84
2029	9827	1,42	13.946,73
		SUM	**94.266,25**



Graphic 1. *GSHP 10-year energy consumption price*

GSHP devices and Fan Coils do not need periodic maintenance. They do not fail easily because they provide electronic control within themselves. If there's a problem with the mains or water lines, it protects itself. Thanks to its software that can provide remote access, there is no need to keep it under surveillance. Since it does not produce solid waste, there is no waste disposal problem. Naturally, there is no need for additional employment for this job. There is no risk of explosion or fire. Therefore, it is exempt from many regulations and the burdens stipulated by these regulations. Since there is no CO_2 oscillation, there is no filter or chimney cost. For these reasons, the operating cost can be considered limited only to electricity consumption.

5.9. Coal Boiler Operating Cost

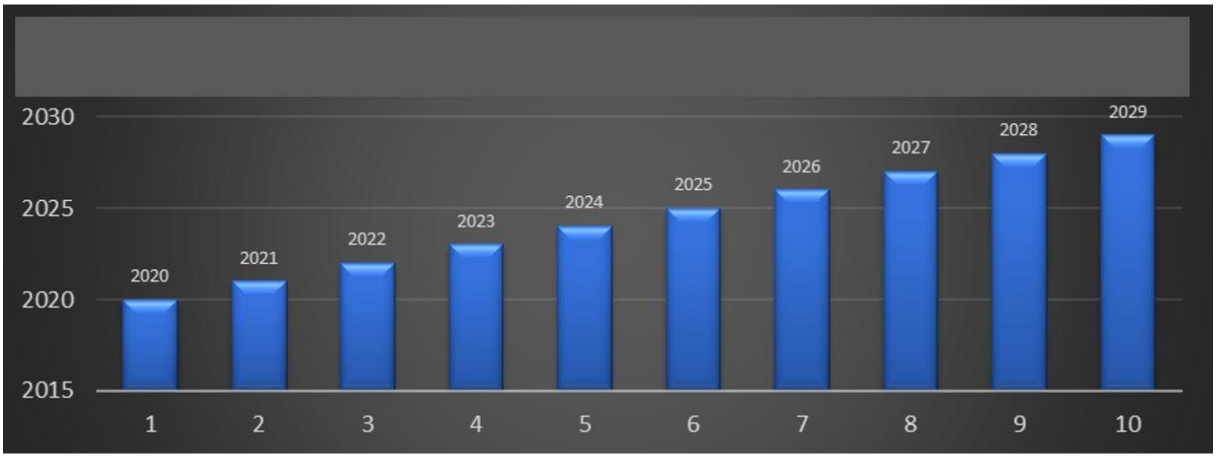
When examining the cost of operating a coal boiler, it will be required to employ a staff member who will take care of the boiler system, except for the annual coal consumption cost. These personnel must be skilled personnel who are trained to burn the boiler. These personnel will have to do things like feeding coal according to the coal needs of the boiler, monitoring boiler pressures for safety, cleaning the boiler and throwing the ash out. If we examine these two cost items.

5.10. Annual coal consumption cost

Annual coal consumption will be determined according to the annual heat requirement. In order to make this calculation, it is necessary to know the thermal value of the coal to be used and the price of tons. Heat value 7500 kg. The ton price of imported coal, which is Cal, is 1300,00 TL +VAT on the market. According to these values, the first 10 years of coal costs are given in table 10. The increase in the price of imported coal was accepted as 10% per year when the table was created.

Table 10 *10-year energy consumption cost for Coal Boiler*

year	CONSUMPTION (kg)	UNIT PRICE (TL/kg)	AMOUNT (TL)
2020	10.400	1,30	13.520,00
2021	10.400	1,43	14.872,00
2022	10.400	1,57	16.359,20
2023	10.400	1,73	17.995,12
2024	10.400	1,90	19.794,63
2025	10.400	2,09	21.774,10
2026	10.400	2,30	23.951,50
2027	10.400	2,53	26.346,66
2028	10.400	2,79	28.981,32
2029	10.400	3,07	31.879,45
		SUM	**215.473,98**



Graphic 2 *Kömür kazanı için 10 yıllık enerji tüketim maliyeti*

5.11. Annual Labor Cost

The 6-month employer cost of the personnel who will ship and manage the boiler room, ensure that the coal burns well and empty and dispose of solid waste is 23.407.82 TL (table 11).

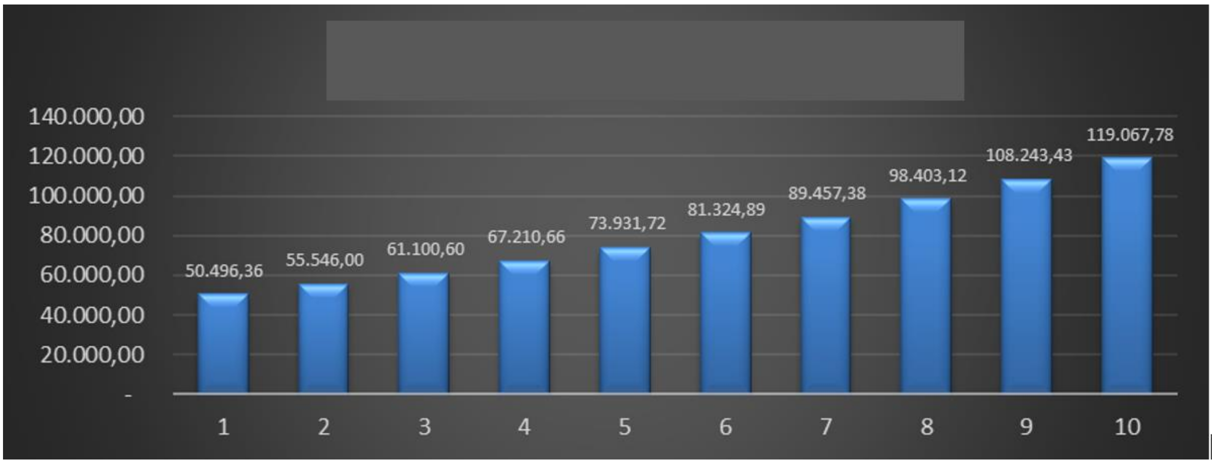
Table 11 *6 months cost of a single worker to the business*

Gross to Nete Salary Account												
	gross	SSK Worker	Unemployment Worker	Monthly Income Tax	Stamp Duty	Cumulative Tax Base	Net	Minimum Livelihood Discount	Total Seized	SSK Employer	Unemployment Employer	Total Cost
January	2943,00	412,02	29,43	375,23	22,34	2501,55	2103,98	220,73	2324,71	456,16	58,86	3458,03
February	2943,00	412,02	29,43	375,23	22,34	5003,10	2103,98	220,73	2324,71	456,16	58,86	3458,03
Mart	2943,00	412,02	29,43	375,24	22,34	7504,65	2103,98	220,73	2324,71	456,16	58,86	3458,03
April	2943,00	412,02	29,43	375,23	22,34	10006,20	2103,98	220,73	2324,71	456,16	58,86	3458,03
November	2943,00	412,02	29,43	500,31	22,34	27517,05	1978,90	220,73	2199,63	456,16	58,86	3458,03
December	2943,00	412,02	29,43	500,31	22,34	30018,60	1978,90	220,73	2199,63	456,16	58,86	3458,03
sum	35316,00	4944,24	353,16	4903,71	268,08	30018,60	24846,83	2648,76	27495,59	5473,92	706,32	20748,18

A worker's weekly working time is legally 45 hours and it is mandatory by labor law to use a week's holiday. Within this information, it is necessary to have a worker for the boiler room during the night periods, legally and in order to maintain product quality. The employer cost of a job for 6 months was TL 20,748.18, which is TL 41,496.36 for 2 workers. The right to eat 1 meal per day will be 20*2=40 TL for both workers, which is 40*30=1200 TL per month. To include monthly IAS expenses and OHS costs, this figure will be 6*1500=9000 TL annually. As a result, our annual labor cost for dispatching and managing the boiler room in the greenhouse; 41.496.36+9.000.00= 50.496.36TL. 10-year cost with 10% CPI per year given at table 12.

Table 12 *10 years of labor costs for coal boiler room dispatch and administration*

YEAR	LABOR COSTS (TL)
2020	50.496,36
2021	55.546,00
2022	61.100,60
2023	67.210,66
2024	73.931,72
2025	81.324,89
2026	89.457,38
2027	98.403,12
2028	108.243,43
2029	119.067,78
SUM	**804.781,93**

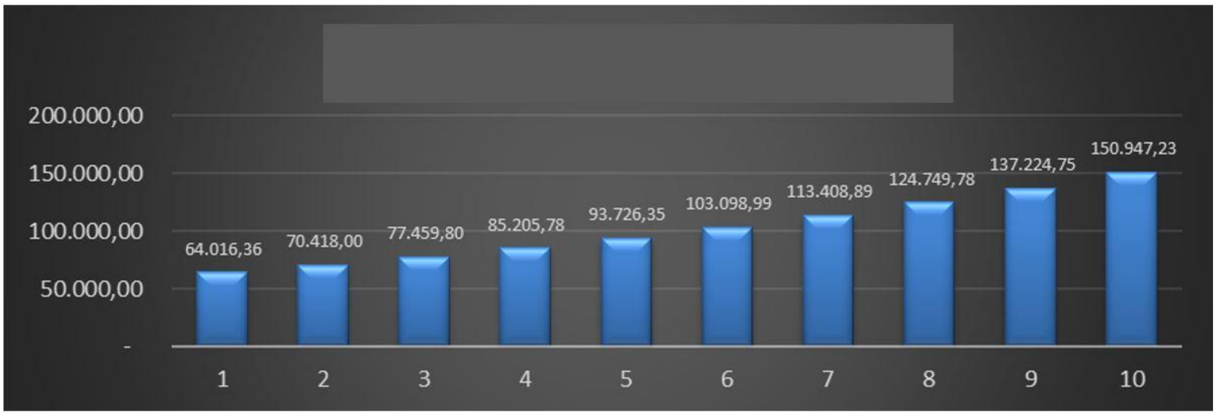


Graphic 3 *10 years of labor costs for coal boiler room dispatch and administration*

It will of course be possible with a coal boiler to keep the greenhouse at the desired temperature, but it is also obvious that cooling cannot be done. Therefore, product continuity will not be provided for 365 days, which will negatively affect the cost of operating the greenhouse as it will reduce the product quality and continuity of the greenhouse. If we ignore such indirect effects and cooling costs that may occur as a result of the operations that can be done to cool the greenhouse, the 10-year operating cost of the greenhouse will be like table 13.

Table 13 *10-year operating cost for coal boiler*

YEAR	FUEL COST (TL)	LABOR COST (TL)	TOTAL OPT. COST3
2020	13.520,00	50.496,36	64.016,36
2021	14.872,00	55.546,00	70.418,00
2022	16.359,20	61.100,60	77.459,80
2023	17.995,12	67.210,66	85.205,78
2024	19.794,63	73.931,72	93.726,35
2025	21.774,10	81.324,89	103.098,99
2026	23.951,50	89.457,38	113.408,89
2027	26.346,66	98.403,12	124.749,78
2028	28.981,32	108.243,43	137.224,75
2029	31.879,45	119.067,78	150.947,23
SUM	**215.473,98**	**804.781,93**	**1.020.255,91**



Graphic 4 *10-year operating cost for coal boiler*

5.12. Comparison Of Costs

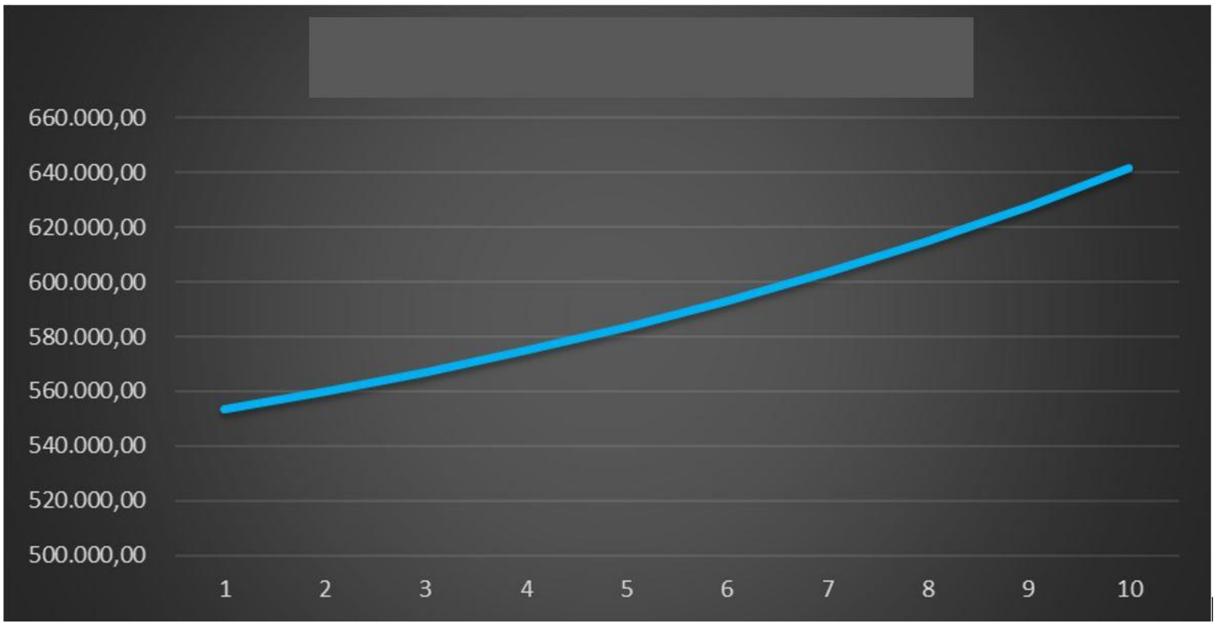
Investment and operating costs were calculated in detail in both systems to make a healthy comparison. It would be very accurate to analyze cumulative costs for both methods by examining and comparing the investment cost and 10-year operating cost separately.

5.13. GSHP İnvesment and 10 Year Operating Cost

We can see the investment and 10-year operating cost of the GSHP system cumulatively in table 14 from the first year of the investment.

Table 14 *GSHP cumulative cost for the first 10 years*

year	INVESTMENT M.	Business MAL.	cumulative
2020	547.500,00	5.914,77	553.414,77
2021		6.506,25	559.921,02
2022		7.156,88	567.077,90
2023		7.872,56	574.950,46
2024		8.659,82	583.610,28
2025		9.525,80	593.136,08
2026		10.478,38	603.614,46
2027		11.526,22	615.140,68
2028		12.678,84	627.819,52
2029		13.946,73	641.766,25



Graphic 5 *GSHP cumulative cost for the first 10 years*

The operating cost of the GSHP system for the first 10 years corresponds to 17% of the initial investment cost. The cumulative cost curve in Graphic 5 starts at a high value in the first year with the effect of investment cost, but follows a horizontal course in subsequent years.

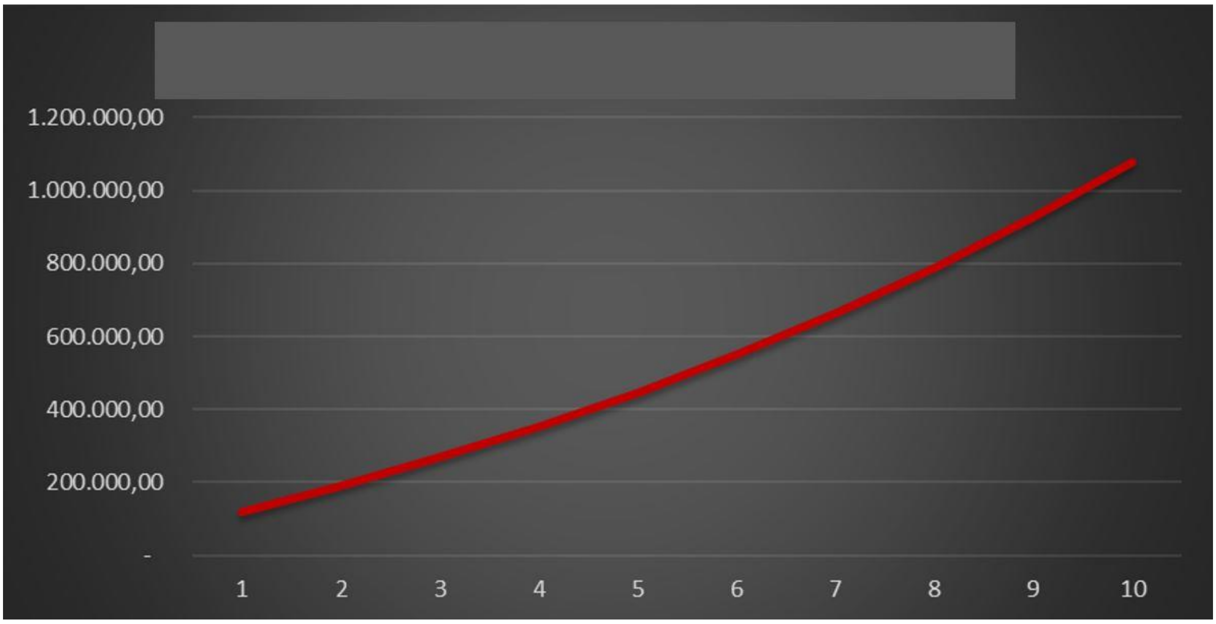
5.14. Coal Boiler İnvesment And 10 Year Operating Cost

We can see the investment and 10-year operating cost of the coal boiler system cumulatively in table 15 from the first year of the investment.

Table 15 *Coal boiler cumulative cost for the first 10 years*

YEAR	INVESTMENTS	OPERATING COST	CUMULATIVE
2020	56.700,00	64.016,36	120.716,36
2021		70.418,00	191.134,36

2022	77.459,80	268.594,15
2023	85.205,78	353.799,93
2024	93.726,35	447.526,28
2025	103.098,99	550.625,27
2026	113.408,89	664.034,15
2027	124.749,78	788.783,93
2028	137.224,75	926.008,68
2029	150.947,23	1.076.955,91



Graphic 6 *Coal boiler cumulative cost for the first 10 years*

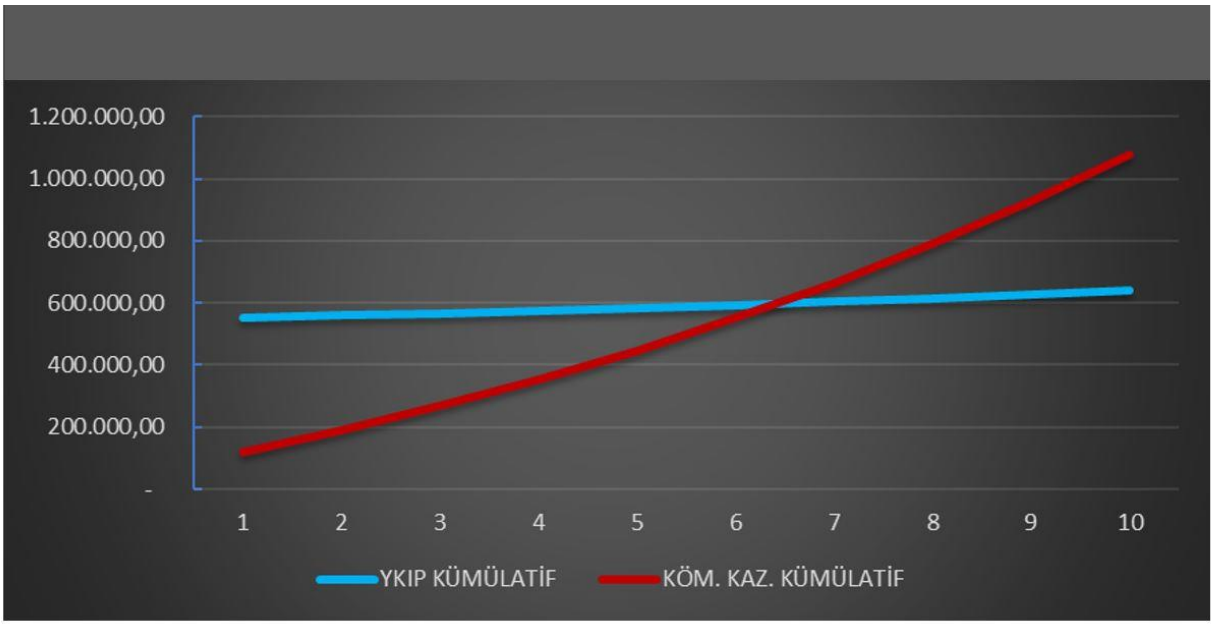
The 10-year operating cost of the coal boiler system corresponds to 18 times the initial investment cost. The cumulative cost curve in the Graphic (Graphic 6) starts at a low value in the first year but is aggressive in subsequent years.

5.15. Comparison of Costs

According to graphic 7, the cumulative costs of the two systems appear to have intersected in year 6. GSHP air conditioning system has transferred the enterprise to a profit of TL 435,189.66 after 10 years. (Table 16)

Table 16 *Comparison of cumulative costs of* GSHP and Coal Boiler for the first 10 years

YEAR	GSHP CUMULATIVE	CBHS CUMULATIVE	DIFFERENCE
2020	553.414,77	120.716,36	-432.698,41
2021	559.921,02	191.134,36	-368.786,67
2022	567.077,90	268.594,15	-298.483,75
2023	574.950,46	353.799,93	-221.150,53
2024	583.610,28	447.526,28	-136.084,00
2025	593.136,08	550.625,27	-42.510,81
2026	603.614,46	664.034,15	60.419,69
2027	615.140,68	788.783,93	173.643,25
2028	627.819,52	926.008,68	298.189,16
2029	641.766,25	1.076.955,91	435.189,66



Graphic 7 *Comparison of GSHP and CBHS cumulative costs for the first 10 years*

6. CONCLUSION

If a job is not done as it should and the final quality product cannot be reached, there can be no bet on the cost of that product to the enterprise. Because without the product, investments and efforts will be wasted. If the first purpose of the greenhouse operator is to grow a quality and efficient product, it is imperative that it invests in a system for at least heating. According to the financial analysis, GSHP is the ideal choice for this purpose. When making this comparison, it should not be overlooked that the coal boiler system is used only for heating, while the GSHP system is used for air conditioning. The 365-day standard product quality and continuity of air conditioning is proof that the GSHP system is more conducive to using the advantages of greenhouses throughout the year. The greenhouse; Considering that the life of BHE is at least 50 years, it can be operated as a profitable, environmentally friendly and exemplary greenhouse for many years, with minor renovations to be carried out only in other parts. The fact that the initial investment cost is too high is, of course, the biggest obstacle to this environmental system. However, the incentives of the State and European union cannot be ignored in these high investments. The fact remains that limited energy sources will one day run out or cannot be used to avoid further carbon emissions. We need to stop looking at renewable energy sources as a choice and realize that this is now a necessity.

REFERANCES

[1] Şehmus ATAKUL (Agricultural Engineer), Determination of the use of renewable energy sources in Diyarbakir province greenhouses with energy simulation technique, 2014.