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Evaluation of Economic Justification of using Geothermal Heat Pumps for Ventilation (Case study: Building of Agriculture Jahad Organization of Hormozgan Province)

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Abstract- Limitations of fossil resources and high level of contamination of these materials has made important renewable energy, including geothermal energy. The goal of this paper is evaluation of economic adjustment of usage of geothermal energy (heat pump) to cool building of Agriculture Jahad Organization of Hormozgan Province, Iran. Therefore, within the estimate of costs and benefits of project, the economic evaluation for use of heat pump system has been conducted through three methods of Net Present Value (NPV), Service life Standard (SL) and period of payback (POP). The results show that using geothermal heat pumps for this building is not economical now.

Classification JEL: P28, Q32, Q57

Keywords- *Renewable energy, Geothermal energy, Economic evaluation, Geothermal heat pump system*

I. INTRODUCTION

Today, energy is the most important motor of economic-social developments for countries, so it requires management and planning. Efforts to obtain new energy resources take place together with development of technology and needs of societies. Primary energy resources were not able to respond demand. Fossil resources could not supply all demands because of their limitations, high economic value, and excess contamination. Consumption of fossil fuels has threatened environment and ozone layer by production of pollutant and greenhouse gases and makes earth warmer progressively. Therefore, using new energies, including geothermal energy, is necessary.

II. LITERATURE

Geothermal energy is a renewable one that is obtained by heat of melted masses and fission of radioactive materials in the earth. Despite of other renewable energy resources such as sun, wind, wave,… , this resource has a continuous origin. Geothermal energy is the internal heat of earth that is transferred by a fluid such as water vapor, hot water, or both. Geothermal heat pump system is one of the applications of renewable energies which is considered as geothermal energies because of using earth heat gradient. This system is one of the heating-cooling systems that is very important because of its low energy consumption. Desirable function of geothermal heat pumps caused their progressive development in the world. The installed capacity of geothermal heat pumps in the world till 1995 was equal to 1,854 MW, till 2000 equal to 5,275 MW, till 2005 equal to 15,723 MW, and till 2010 equal to 35,236 MW. It is anticipated that this level will be increased up to 744,000 MW till 2050.

III. METHODOLOGY

Eq. (1) is used to transfer future cost or income to base year:

$$P = \frac{F}{(1+i)^n} \qquad (1)$$

in which,

$(1+i)^{-n}$: Transformation factor
P : Present value
F : Future value
i : Interest rate or discount rate
n : Duration (year)

Eq. (2) is used to transfer present cost or income to a future year:

$$F = P(1+i)^n \qquad (2)$$

Eq. (3) is used to convert annual installments (annual costs) to their present values. The expression inside parentheses is called “Present factor of annual installments”:

$$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right] \qquad (3)$$

IV. ANALYSIS OF PROFITABILITY OF INVESTMENT PLAN

A. *Investment Payback Period (IPP) method*

In this method, the duration that net profit compensates investment cost is calculated. Therefore, payback period is the number of years in which sum of obtained profit is equal to investment, or is the period in which investment becomes zero.Eq. (4)

$$I = \sum_{t=0}^{p} f_t \tag{4}$$

In which,

I : Investment

f_t : Annual net profit

P : Payback period

B. *Net Present Value (NPV) method*

This method gives present value of costs minus present value of incomes. In other words, it demonstrates net profit obtained from total project life in present (eq. (5)).

$$NPV = -I + \sum_{t=0}^{n} \frac{(TR - TC)_t}{(1+r)^t} = -I + U(P \mid u, i, n) \tag{5}$$

If NPV is positive, we accept a project; if it is negative, we reject a project.

C. *Service Life (SL) criteria*

Service life is the duration in which NPV becomes zero or present value of costs is equal to their present value of incomes (eq. (6)):

$$NPV = -I + U(P \mid u, i, n = ?) = 0 \tag{6}$$

The main problem is that it does not consider after-service flows.

D. *Findings of research*

Now, 130 gas coolers are used to cool building of Agriculture Organization of Hormozgan Province, each 18,000 btu/hr, and 30 gas coolers each 36,000 btu/hr. Therefore, the same level of heat pumps must be used to cool this building.

V. ECONOMIC CALCULATION OF GEOTHERMAL HEAT PUMP PROJECT

A. *Costs*

1) Initial investment: This includes cost of purchase and installation of heat pumps. We need 130 heat pumps each 18,000, and 30 heat pumps each 36,000. Cost of purchase and installation for each 18,000 pump is Rls.80 million, and for each 36,000 pump is Rls.120 million. Thus,

130 × 80,000,000 = 10,400,000,000 Rials for each 18,000 pump

30 × 120,000,000 = 3,600,000,000 Rials for each 36,000 pump

The costs for ground coils are:

130 × 60,000,000 = 7,800,000,000 Rials

30 × 80,000,000 = 2,400,000,000

Consequently, total investment cost is:

Total investment = 10,400,000,000 + 3,600,000,000 + 7,800,000,000 + 2,400,000,000 = 24200000000 Rials

The cost of annual exploitation is equal to 2% of total investment:

Annual cost = 24200000000×./02 =484000000 Rials

B. *Benefits of this project*

Benefits of this project are:

a) Benefits due to economical consumption of electricity. By heat pumps, there is no electricity consumption, so this is an income.

b) Benefits due to environment non-pollution. External costs are those costs that are incurred to society and environment due to production, transmission, and conversion of energy, but they are not included in goods or services prices. Neglecting environmental costs cause destructive effects for resources and destabilizes electricity production system. Therefore, estimation of environmental costs is necessary.

To obtain these benefits, we must calculate electricity consumption of each gas cooler. Here, 18000 coolers consume 1,900 W and 36000 coolers consume 2,200 W. These coolers are in service 8 hr/day for 265 day/year (9 months). Therefore, their daily consumption is:

130 × 1900 W × 8 = 1,976,000 Wh/dau = 1,976 kWh/day

30 × 2200 W × 8 = 528,000Wh/dau = 528 kWh/day

Total daily power consumption = 1976 + 528 = 2,504 kWh/day

Total monthly power consumption = 30 × 2504 = 75,120 kWh

Total annual consumption = 265 × 2504 = 663,560 kWh

Now, we calculate power consumption of these coolers by tariff of Ministry of Power. It should be mentioned that building of Agriculture Organization of Hormozgan Province is considered as a public group in power consumption. Energy prices for public consumptions are shown in table 1.

TABLE I. ENERGY PRICES FOR PUBLIC CONSUMPTIONS

Energy price (kWh/Rials)		
Low load (11pm-7am)	Medium load (7 am-7 pm)	High load (7pm-11am)
550	1100	2200

Note: Each month is considered 30 days
Source: Electricity Distribution Company of Hormozgan

As mentioned before, these coolers work 8 hours per day (8 am-4 am). Therefore, they work in medium-load hours. Thus:

Monthly consumption = 75120 × 1100 = 82,632,000 Rial

Annual consumption = 82,632,000 × 9 = 743,688,000 Rial

Therefore, if we use heat pumps instead of gas cooler, we save Rls.743,688,000 per year, and this is benefit of this project. Next, we quantify environment pollution of power plants and include it in the benefit of this project.

Table 2 shows emission of pollutant greenhouse gases of power plants. Tables 3 and 4 show social costs of energy division and power plants, respectively. In fact, these costs show the amount a society must pay to compensate environment damages by production of electricity.

TABLE II. EMISSION OF POLLUTANT GASES OF POWER PLANT DIVISION (2010) (TON)

Gas type	NOx	SO2	SO3	CO	SPM	CO2	CH4	N2O
Emission	574,741	497,354	3,538	137,857	25,528	154,777,386	3,522	531

Source: Energy Balance Sheet of 2010

TABLE III. SOCIAL COSTS OF ENERGY DIVISION (2002) (MRIALS/TON)

Gas type	NOx	SO2	SO3	CO	SPM	CO2	CH4	N2O
Emission	4,800	14,600	N/A	1,500	34,400	80	1,680	N/A

Source: Energy Balance Sheet of 2010

TABLE IV. SOCIAL COSTS DUE TO EMISSION OF POLLUTANT GASES OF POWER PLANT DIVISION (2010) (MRIALS)

Gas type	NOx	SO2	SO3	CO	SPM	CO2	CH4	N2O
Emission	2,758,756,800	7,261,368,400	N/A	206,785,500	878,163,200	12,382,190,880	5,916,960	N/A

Source: Findings of this research

Therefore, sum of social costs due to emission of pollutant gases from power plants in 2010 is equal to Rls.23,493,181,740. Since gross production of power plants of country in 2010 was equal to 232,954,800 MkWh, then,

Social cost of 1 kWh in 2010 = $\frac{23,493,181,741}{232,954,800} \cong 101\ Rial$

Consequently, total costs of external effects is Rls.67,019,560/yr. Therefore, if we use heat pumps instead of gas coolers, we save Rls.67,019,560/yr from social costs, that is considered as benefit of this project.

Total benefit = 743,688,000 × 67,019,560 = 810,707,560

Initial investment = 24,200,000,000 Rials

Annual cost = 484,000,000 Rials

It should be mentioned that useful life of a heat pump is 30 years.

Table 5 shows a brief of costs and benefits of this project.

TABLE V. BRIEF OF COSTS AND BENEFITS

t	0	1	2	3	4	5	6		30
Cost	24,200,000,000	484,000,000	484,000,000	484,000,000	484,000,000	484,000,000	484,000,000	…	484,000,000
Benefit	810,707560	810,707560	810,707560	810,707560	810,707560	810,707560	810,707560	…	810,707560
Net profit	24,200,000,000	326,707,560	326,707,560	326,707,560	326,707,560	326,707,560	326,707,560	…	326,707,560

Findings of research

It is assumed that investment is supplied by government. Thus, we use social interest rate (10%) that Ministry of Power used in its projects.

VI. INVESTMENT PAYBACK PERIOD (IPP) METHOD

Table 6 shows net profit and unreturned capital.

TABLE VI. NET PROFIT AND UNRETURNED CAPITAL (RIALS)

t	0	1	2	3		74	75
Net profit	24,200,000,000	326,707,560	326,707,560	326,707,560	…	326,707,560	326,707,560
Unreturned capital	24,200,000,000	-23,873,292,440	-23,546,584,880	-23,219,877,320	…	-23,640,560	303,067,000

Findings of research

Therefore, IPP for this project is about 75 years.

$$\text{IPP} = \frac{Initial\ investment}{Annual\ net\ profit} = \frac{2{,}420{,}000{,}000{,}000}{326{,}707{,}560} = 74.07 \text{ years}$$

Since IPP is greater than useful life of project (30 years), then this project is rejected.

VII. Net Present Value (NPV) method

Table 7 shows costs and benefits of this project.

TABLE VII. BENEFITS AND COSTS OF PROJECT (RIALS)

t	0	1	2	3	…	30
Cost	24,200,000,000	484,000,000	484,000,000	484,000,000	…	484,000,000
Benefit	0	810,707,560	810,707,560	810,707,560	…	810,707,560

Findings of research

For decision-making, it is enough to have a positive NPV to accept the project. Since NPV<0, then the project is rejected.

VIII. Service Life Criteria (SLC)

Table 8 shows net profit of project.

TABLE VIII. NET PROFIT OF PROJECT (RIALS)

t	0	1	2	3	…	30
Net profit	-24,200,000,000	324,707,560	324,707,560	324,707,560	…	324,707,560

Findings of research

Thus, service life of this project is about 41 years and 46 days. Therefore, since useful life a geothermal heat pump is 30 years, this project is rejected.

IX. Conclusion and proposals

Therefore, we see using heat pumps is not economically justifiable by three methods. Of course, limitations of fossil reserves and their undesirable environmental effects demonstrate broad support of government and industries. Thus, it is proposed that government invest in geothermal heat pumps to decrease environment pollutions and provide stable development. Long-term benefits can help government to assign resources optimally.

References

[1] Ahmadian, Majid (2002), "Economy of renewable resources", SAMT, 1st edition.

[2] Oskunejad, Mohammad Mahdi (1996), "Engineering economy or economic evaluation of industrial projects", AmirkabirUnirversity of Technology, 4th edition.

[3] Baghramian, Alfred (1994), "Situation of new energy resources in the world", MA Seminar of Electricity Engineering, TarbiatModarres University.

[4] Energy Balance Sheet (1996), Deputy of Energy Affairs, Energy Planning Office, Tehran.

[5] Energy Balance Sheet (2002), Deputy of Energy Affairs, Energy Planning Office, Tehran.

[6] Energy Balance Sheet (2010), Deputy of Energy Affairs, Energy Planning Office, Tehran.

[7] Sharifi, Alimorad; Fotuhi, Dara; Teymuri, Behzad (2001), "Final cost model of electrical energy in Khur and Biabanak", Collection of Papers of 3rd National Energy Conference, Tehran.

[8] Energy Global Council (1996), "New renewable energy resources", Translated by: New Energies Office of Ministry of Power, Atlas Press, 1st edition, Tehran.

[9] Kazemi, Khalil; Rahimi, Gholamreza (2005), "Calculation of finished cost of power production from different resources considering environment provisions", Quarterly of Energy Economy Studies, No. 7.

[10] Kord, Bahman (2000), "The role of new energies in supplying energies of rural regions of Iran", MA thesis, TarbiatModarres University, Nov. 2000.

[11] Mazre'ati, Mohammad (2004), "Social costs due to consumption of fossil fuels on residents of Tehran", Quarterly of Energy Economy Studies, No. 3.

[12] Malek, Bizhan (1997), "A review on future energy production sources", Collection of Papers of First National Energy Conference, Tehran, May 1997.

[13] Arif,Hepbasli (2005), "Thermodynamic analysis of a ground–source heat pump system for district heating", International Journal of Energy Research, No. 29, 671-687.

[14] Carbon (2009), "Emission trading coming home", www.point carbon.com

[15] European Climate Exchange (2009), Monthly Report,June 2009, www.exc.com

[16] Islam Sardar,M.N. (1993),"The role of renewable energy in the energy system", Energy Economics, Vol. 17, No. 2.

[17] Kulsum, Ahmad (1994), "Renewable energy technologies",The World Bank, Washington DC, January 1994.

[18] Yuehong, Bi (2009), "Comprehensive energy analysis of a ground-source heat pump system for both building heating and cooling modes", Applied Energy, No. 86, 2560-2565.