

Life Cycle Analysis of chosen heat sources.

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Abstract

Sustainable Development requires an increase in the use of renewable energy sources as opposed to nonrenewable ones. The paper presents a Life Cycle Analysis of chosen heat sources including information concerning environmental impact. The most popular sources to be considered include as follows: natural gas, coal, culm, heating oil, wood and geothermal heat. Prices are taken from the 2002/2003 heating season in Poland. From an economical standpoint the best choices are coal, culm or wood. The heating pump is a worse solution due to the high investment at the starting point of exploitation. From both an ecological and economical perspective the best heating source is wood. The heating pump is a very promising device but a large decrease in the acquisition cost is necessary for it to become a competitive option.

Introduction

Heating sources and transportation are currently the main sources of the air pollution[1,2]. Within this paper the elements of Life Cycle Analysis of the chosen heating sources in Poland are described. It is important to make proper decisions based on both ecological and economical premises. Sustainable Development is one of the policy priorities in The European Union[4]. It prefers renewable energy sources instead of nonrenewable, but the economical efficiency of these sources is an important issue. Users make decisions based on economics, not policy. The authors carried out an analysis of heating sources from the end users' point of view. Prices were taken from the 2002/2003 heating season in Poland. Using the Life Cycle Costing method [2] a financial analysis was carried out to find which heating method is the best for the individual homeowner. The ecological consequences were also investigated in order to compare each method from another perspective. A comparison of ecological and economical results enables the finding of the best solution from both standpoints. This study is important because it indicates that a sustainable solution can also be a cheap solution.

Heating sources analysis

Six heating sources are described: coal, culm, wood, heating oil, natural gas and heating pump. The most important assumptions are: individual house cubature 1000 m³, standard isolation, power output 25 kW, interest rate 7%, loan period 10 years, rate of discount 5,75%, inflation rate 0,9%, energy inflation rate 2,5%.

Calculations are based on five equations [2]. First one calculates future value of present money (1).

$$F_n = P(1 + d)^n \quad (1)$$

where:

F_n – future value of present money [PLN],

P – present value of future money [PLN],

d – discount rate [%],

n – term of loan [years].

From equation 1 present value of future money has to be calculated (2).

$$P = \frac{F_n}{(1 + d)^n} \quad (2)$$

To evaluate future value of general inflation and energy inflation, equations (3) and (4) has been used.

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$$S_n = S_o(1 + g)^n \quad (3)$$

where:

S_n – expenses at year n [PLN],
 S_o – expenses at first year [PLN],
 g – inflation rate [%].

$$E_n = E_o(1 + e)^n \quad (4)$$

where:

E_n – energy savings at year n [PLN],
 E_o – energy savings at first year [PLN],
 e – energy inflation rate [%]

Annual loan payment for a loan amount borrowed for n years at interest rate i was calculated from equation (5).

$$LP = \frac{i(1+i)^n}{(1+i)^n - 1} LA \quad (5)$$

where:

LP – Annual Loan Payment
 LA – Loan Amount
 i – interest rate

Results of the Life Cycle Costing calculations are shown in Fig. 1 and 2.

The best Saving to Investment Ratio is calculated for coal and wood. This result confirms that heat sources are the best from a financial perspective. Payout time is less than one year, so the investment will return in a very short time. More convenient to use but not so cheap is culm. It minimizes servicing time as compared with the former previous heat sources, but the Saving to Investment Ratio is twice as low, meaning that this solution is twice as expensive. Payout time is two years, which is of course connected with the high initial investment. The most expensive heating sources come from heating oil, natural gas and heating pump. Natural gas appears to be a somewhat better solution given that its Saving to Investment Ratio is 1,31 and payout time 5 years. The worst two are heating oil and heating pump. Interestingly the heating pump outdoes heating oil in economical performance compared to tests of the two from previous years, which shows a reverse trend.

A few years ago heating oil became more popular, but now the situation has changed because oil prices have increased and the price of heating pumps has dropped and sustainable heating sources including heating pumps have become more popular. The Saving to Investment Ratio is 0,19 for heating oil and for heating pump it is 0,78. Similarly payout time is better, correspondingly 8 and 6 years.

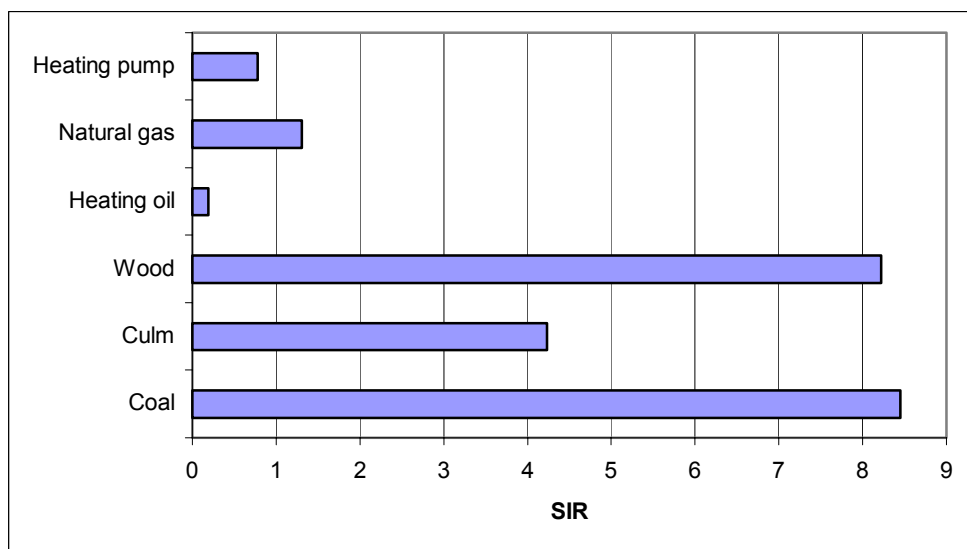


Fig. 1. Saving to Investment Ratio for chosen heating sources.

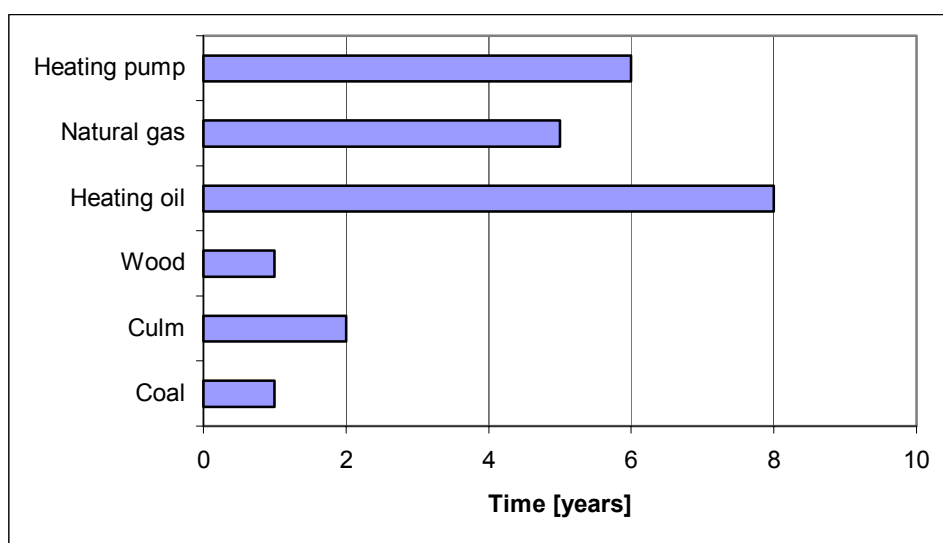


Fig. 2. Payout time for chosen heating sources.

When making a decision regarding which heating source to use, it is important to take into account not only results of financial analysis but also other factors. All the described heating sources have been analyzed as to their environmental impact. Analysis results are described in Table 1. The most polluting sources are coal and culm. The next most polluting is heating oil which together with the unsatisfactory economical results makes it a non rational choice. Natural gas has low emissions compared to the previous three sources. But wood and the heating pump are the most environmentally friendly. During the combustion process wood discharges as many pollutants into the atmosphere as are absorbed from the environment by a plant. For this reason it is very highly promoted by the Sustainable Development community as a source of renewable energy [3,4]. Be performing both a financial and environmental analysis we can say that the worst heating source solution is heating oil and the best one is wood. The heating pump is also a promising heating source but it has to become more popular in order to cause a drop in its initial investment cost.

Tab. 1. Air pollution by analyzed sources.

	Coal	Culm	Wood	Heating oil	Natural Gas	Heating Pump
Air Pollution	SO ₂ [1500 mg/m ³] NO ₂ [400 mg/m ³] ash [630 mg/m ³] and CO	SO ₂ [1500 mg/m ³] NO ₂ [400 mg/m ³] ash [630 mg/m ³] and CO	Emission = plant absorption	SO ₂ [850 mg/m ³] NO ₂ [400 mg/m ³] ash [100 mg/m ³] and CO	SO ₂ [35 mg/m ³] NO ₂ [150 mg/m ³] ash [5 mg/m ³] and CO	No emission to air

Conclusions

1. When making any decisions, even on a small scale, as in a household, it is important to take into account a number of variables not only economic ones.
2. As shown in the paper a sustainable solution can also be an economically beneficial one.
3. The heating pump must become more popular for there to be a decrease in its price so that it may become a more competitive solution.
4. Coal is a very cheap energy source but it should be withdrawn due to its large negative environmental impact.

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