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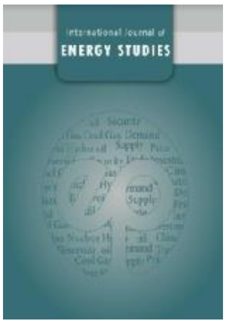

Research Article

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Investigation of optimum external wall insulation thickness of a house two different climate regions

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Highlights

- Calculation wall optimum insulatıon thickness.
- Effect on insulation material for different climate regions.
- Cost analysis when utilization different fuel source.
- Calculation annuel energy saving as well as payback period.

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ABSTRACT

In this study, a residential single-family house with an area of 100 m^2 was modeled utilizing the Design Builder program in order to calculate the optimum insulation thickness of the external wall including 20% window-to-wall ratio (WWR) for two different climate zones Kirkuk, Iraq city as drying hot which showed heating degree day (HDD) and cooling degree day (CDD) rate between (730) and (1700) degrees. Between (2507) and (178) degrees of the year, the heating degree day (HDD) and cooling degree day (CDD) rate were indicated espectively for the Konya, Turkey city as cold climate zone. The results obtained in the cost analysis of the (XPS , EPS, rock wool and glass wool) insulation materials, furthermore, electric was chosen for Kirkuk hot seasons as a energy source as well as selecting natural gas as energy source for Konya cooling seasons and commercially available materials of the two countries were taken into account. The results showed that, the best exterior wall insulation thickness was determined to be X_{opt} = 7 cm and X_{opt} = 19 cm, respectively. At X_{opt} = 9 cm, the greatest rate of XPS for Kirkuk city was roughly 6.7 percent. X_{opt} = 7 cm and X_{opt} = 15 cm findings were achieved as a result of the insulation applied to the building components for Konya. Following that, the energy savings were calculated, and an XPS of 8.3 percent was obtained at X_{opt} = 11 cm. As a consequence, XPS material was determined to be appropriate for two climatic zones. To sum up, XPS material was determined to be ideal for Kirkuk, which has a hot climate, and Konya, which has a cool environment.

Keywords: *Optimal insulation thickness, Payback period, Insulation materal, Energy saving, Design Builder program*

1. INTRODUCTION

Building energy performance, final energy consumption/demand, primary energy consumption/demand, energy costs, CO_2 emissions, etc. and is the annual/seasonal sum of all heating, cooling, electricity, domestic hot water, lighting, and any other energy consuming activity. Building energy efficiency depends on many parameters. There are parameters related to the area such as location, direction, climate, building design-form, surface/volume ratio, plan scheme, materials used, mechanical systems, renewable energies, and occupancy-related usage schedules and habit parameters. All these parameters affect building energy efficiency in a contradictory way. Therefore, high energy efficiency requires optimization of all these parameters to achieve lower overall values such as final/primary energy consumptions, energy costs, and so on, which means high energy performance at the same time. The energy consumed by buildings constitutes a large part of the total consumption, usually 20- 40% [1]. According to the recent Intergovernmental Panel on Climate Change IPCC report, global buildings account for 32% of total final energy use (equivalent to 117 EJ) and 51% of global electricity demand [2]. On the other hand, it showed that energy demand for heating and cooling in urbanizing countries for residential and commercial buildings is projected to increase by 179% and 183% respectively in 2050. The construction industry accounts for more than 1/3 of global energy consumption. Buildings have an impact on long-term energy use; As seen so far, the construction sector is responsible for 40% of final energy use and 36% of CO_2 emissions in Europe [3]. This is a finding that requires great effort to renovate and improve the built environment to minimize the impact of technology and ensure energy efficiency. Since the building envelope cannot be insulated in buildings, indoor climate comfort is not provided, so it consumes a lot of energy. As in other developed countries, there is no regulation focusing on annual energy use by the Ministry of Housing and Construction and the Iraqi Ministry of Planning in the building permits in Iraq. On the other hand, due to the increase in the amount of energy consumed in buildings, the Turkish Standard TS 825, which determines the rules of thermal insulation in buildings in 2013, covers the highest U-values of newly built or existing buildings and for calculated the heating energy requirement in buildings for climates of Turkey cities it has been updated by taking into account the four-degree day zones according to the heating degree days for the arid, hot and temperate climates of the north and west of Turkey. The building envelope is discrete the exterior of the building from the interior. It is the most important factor in determining the temperature of the indoor air and controlling the indoor temperature regardless of the changing external conditions. It also offers sunlight, views outside, and aesthetics. The heat transfer rate from the building envelope can be reduced in two ways. The first is to improve the thermal resistance or decrease the U-value of the building envelope components, taking into consideration the heat storage capacity of the materials, but also perhaps by lengthening (or deepening) the insulation or choosing insulation with lower thermal conductivity. The second goal is to lessen the temperature differential between interior and outdoor environments; however, reducing the temperature will be more difficult if user comfort is taken into account. The mechanical systems will require less energy to heat and cool the building if the heat transfer rate of the building envelope is reduced, making the building more energy-efficient. Heat transfer coefficients (HTCs) for walls, roofs, and floors can range from 0.1 to 0.2 (W/m^2 K), but better windows' U-values can be 0.7 to 1.0 (W/m^2 K) [4]. External insulation, shading, apparent transmission, solar heat gain coefficient (SHGC), and window-to-wall ratio (WWR) are important factors in energy savings for heating and cooling in walls and roofs, increasing building energy efficiency can achieve by reducing the U-values. In addition, the materials used for thermal insulation have low thermal conductivity and low density, have an organic or inorganic structure and are presented in the form of blocks, plates, or mattresses. Cellular insulation, fibrous insulation, granular insulation, and reflective insulation are four types of building insulation materials. In this study, if the Wall- Window ratio (WWR) for a single house was 20% , the optimual exterior insulation thichness is selected for two climate zones. Consequently, various insulation materials that can improve thermal quality and comfort by regulating the insulation of walls and ceilings, and saving and storing more energy than normal are shown in Table 1. In addition, recent research has concentrated on integrating life cycle and energy analyses to determine the appropriate insulation thickness for residential applications. Below is a review of the literature:

Ahmet E. A. [5] according to a life cycle cost analysis, a research was done to establish the best insulation thickness for thermal insulation of buildings in all Turkish city centers. Twelve separate models have been created to establish a viable strategy for all city centers that determines the best insulation thickness based on the buildings' Degree-Day number. The ideal insulation thickness values for XPS, EPS, PUR and rock wool were found to be between 0.9683 and 0.999. Cenker et al. [6] The ideal insulating thickness, energy savings over a 15-year lifetime, and payback times for four Turkish cities, Mula, Kocaeli, Ankara, and Ardahan, are reported in a life cycle cost study. The calculations were also done using six alternative fuels: diesel, natural gas, propane (LPG), electricity, imported coal, and fuel-oil for six insulation material XPS, EPS, PU, PIR, glass wool and rock wool . The ideal insulating thickness, energy savings over a 15-year lifetime, and payback times for four Turkish cities, Mula, Kocaeli, Ankara, and Ardahan, are reported in a life cycle cost study. The calculations were also done using six alternative fuels: diesel, natural gas, propane (LPG), electricity, imported coal, and fuel-oil number 4. The results demonstrate that based on the city ideal insulation thickness ranges between 2.8 cm and 45.1 cm, energy savings vary between 16.4/m^2 and 479/m^2, and payback times vary between 0.078 and 0.860 years. Mustaf S. Mahdi et al. [7] the ideal insulation thickness for a structure in three different climates, Mosul, Baghdad, and Basra, Iraq, was researched. The optimization is based on a ten-year cost study of the life cycle. When the proper insulation thickness is used, yearly savings of ID 10573 (\$10/m^2) per square meter of wall may be realized in Basra. Ebru K. A. et al. [8] for the provinces of Balkesir, Kayseri, Malatya, Mersin, Mula, Anlurfa, and Trabzon, optimal insulating thickness, energy savings, and payback times were computed using a life cycle cost analysis. Based on the calculations, coal was selected as the energy source and the both of EPS and XPS as the insulation material . Insulation thicknesses range from 0.002 to 0.049 m, life cycle energy savings range from 0.629 to 21.047 \$/m^2, and payback periods range from 0.3 to 6.5 years, depending on the fuel type, insulation material, and wall type. Aynur Ucar et al. [9] Foamboa rd 3500, Foamboa rd 1500, extruded polystyrene and fiberglass usonf for calculte the optimal external wall insulation thickness. Coal, Natural Gas, Fuel-oil, Electricity, and LPG energy types were selected for Aydn, Kocaeli, Ar, and Elaz, and energy savings and payback durations were estimated over a 10-year lifetime. According to the findings, ideal insulation thicknesses range from 1.06 to 7.64 cm, energy savings range from \$19 to \$47 per square meter, and payback times range from 1.8 to 3.7 years, depending on the city and fuel type. Abderr et al. [10] date fibres, cluster, glass wool, PU and XPS selected as the insulation material The impact of a thermal insulating material made from recycled cardboard and palm fibers on economic and environmental aspects was investigated. By establishing yearly heating and cooling transmission loads for six Moroccan climatic zones, optimum insulation thicknesses, energy savings, and payback periods were found using a life cycle analysis based on the degreeday concept. The optimal thickness of the insulating materials studied ranges from 0.02 to 0.17 m. Furthermore, the savings range from \$53.78 to \$65.88 per square meter, with a payback period of 1.28 to 2.94 years. Ahmet Fertelli [11] XPS and rock wool for LPG, electricity, fuel oil, coal, natural gas, and geothermal energy energy types, the influence of different wall types on optimal insulation thicknesses, energy savings, and payback times for Aydn, Trabzon, Malatya, and Sivas was evaluated: Insulation thicknesses ranged from 0 to 0.179 m, according to the findings. Depending on the fuel and wall types, energy savings ranged from 0 to 235.053 \$/m^2 and payback periods ranged from 0 to 11.53 years.

Table 1. Basic properties of the insulation material.

Materials	Density ρ (kgm^{-3})	Thermal conductivity κ ($W\ m^{-1}k^{-1}$)	Fire resistance classifies	Organic/Inorganic	Dimensional Change	Water and Moisture Resistance	Sound Insulation	Cost ($/$m^3$)
XPS	28–45	0.03 - 0.04	E	■	+	●	*	45 - 50
EPS	30 -34	0.03 - 0.06	E	■	+	◌	*	60 -70
PU	30 -35	0.02 - 0.03	B - C	■	+	●	*	10 - 30
Mineral wool	30-100	0.03 - 0.04	A1	□	-	○	*	40 - 70
Rock wool	30 - 200	0.03 - 0.04	A1	□	-	○	**	30 - 50
Glass wool	11 - 45	0.03 - 0.04	A1-A2	□	-	○	**	10 - 40

A1: Not flammable, A2: Hardly flammable, B: Never flammable, C: Hardly flammable, E: Rapidly flammable , + : Yes , - : No , ■: Organic , □: Inorganic, ● : High , ◌: Medium , ○: Low , * : Good , ** : Very good
[12][13], (info.tr@rockwool.com), (www.alibaba.com), (www.insulation-info.co.uk)

2. METHODOLOGY

In this study, the general approach was chosen for two different climatic regions, The hot and cold climate regions were considered for both Kirkuk city of Iraq and Konya city of Turkiye , respectively. First of all, the Design-Builder (DB) program was used to model a 100 m^2 single-family house, as shown in Fig. 1. Standard materials and dimensions used in the construction of non-insulated buildings in the two countries were taken to get the U-value and R-values. İn this context, four different types of insulation materials (XPS, EPS, Glass wool, and Rock wool) were chosen for the exterior wall due to their physical properties, which can be easily obtained in the market and the two cities. In the financial calculation of the two countries, prices are based on Turkey's market, Hepsiburada and Terndeyolu, keeping it constant as dollar ($) for the two cities, then testing with 6 different thicknesses (5, 10, 15, 20, 25, and 30 cm). In the building User Profile; we assumed 24/7 residents for the whole year with no distinction between seasons or weekdays. Indoor Temperature Values of the building in use during the day [Set Point (SP)]. And Indoor Temperature Values [Set Back (SB)] when the building is not used during the day. SP = 24 °C and SB = 19 °C for Kirkuk, SP = 22 °C and SB = 17 °C for Konya are defined in the program. The user profile details are given in Table 2. Finally, the optimum insulation thickness, energy-saving, and payback period were calculated with numerical equations and the optimum insulation thickness corresponding to the lowest cost and the most savings value for the analyzed sample building were determined graphically.

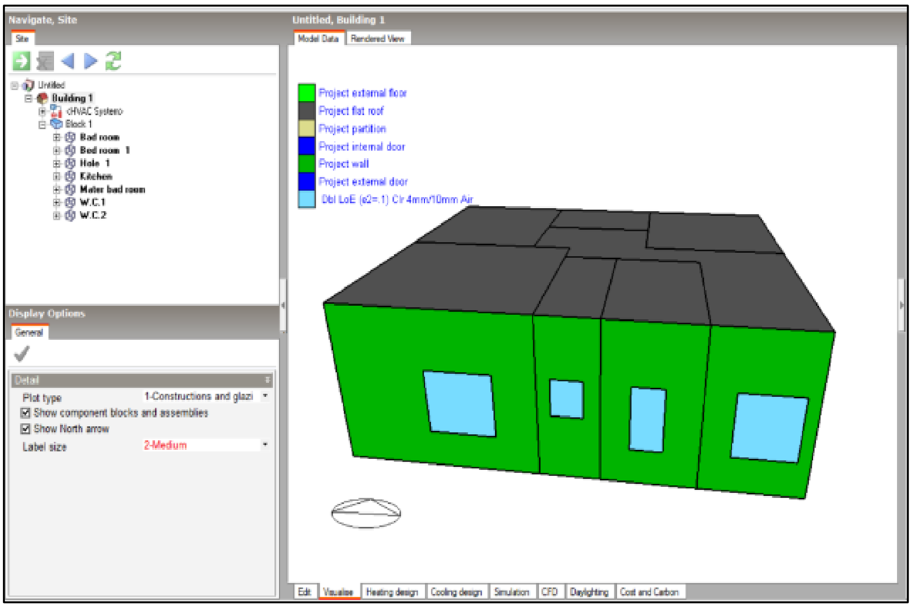

Figure 1. Design Builder drawing of the sample building.

Table 2. The user profile parameters fixed for two cities.

Building occupancy (occupation)	100 m^2
Window type	Triple E-low
Occupancy (floor per person)	20
Hot water consumption ratio (l/m^2 –day)	33
Fresh Air (Fresh Air) l/s	3.5

3. THE STRUCTURE OF THE EXTERNAL WALL

In this study, to calculate the annual primary energy consumption of the two buildings, it is assumed that the building is uninsulated, therefore, taking into account the Iraq and Turkey standard criteria, the Iraqi Ministry of Planning (IMP) standard number 1477 and 1475 and Turkey 'TS 825 - Thermal Insulation Rules in Buildings' standard specifications. According to the results, the exterior wall building components were defined differently from each other in the sample building. When choosing the insulation materials for the Iraqi Ministry of Planning IMP buildings, the wall thickness of the building should be at least 15 cm. U-values are included in the calculations, but any insulation material whose (k) values do not exceed (0.034 - 0.037 W/mK) values should be applied to the thermal conductivity at a warm 40°C face. The insulation material chosen for the exterior wall of the buildings should not contain any moisture-proof material, heat insulation material should not contain any material that will cause corrosion on the surfaces it comes into contact with, and should have an acidity function (10-6). According to TS825, the geography of Turkey is divided into 4 heated regions. Konya is located in the 3rd region, which suggests that the U-values of the building external Wall components in this region should be lower than (0.5 W/m^2 K). In Table 4 the structural features of the uninsulated sample building according to the Iraqi building standards and TS 825 were calculated using the Design-Builder program.

Table 3. Exterior wall building components of the sample building.

City	Materials	Thickness (cm)	Density ($kg/m^{3)}$)	Conductivity (W/m K)	U-Value (W/ m^2 K)
Kirkuk	Cement plaster	3	1600	0.8	0.5
	Brick	20	1920	0.7	
	Plaster	3	1120	0.5	
Konya	lime plaster	2	1600	0.8	0.4
	Reinforced concrete	30	2000	1.1	
	Cement mortar plaster	2	1760	0.7	

4. COST ANALYSIS AND ENERGY SAVINGS

Four distinct insulation materials (XPS, EPS, Glass wool, and Rock wool) were chosen as the most preferred thermal insulation material in this study by considering the heating and cooling periods in different climatic locations at the same time, and two different fuels were employed. In this study, an investigation was conducted in which the optimum insulation thickness of the building was determined according to the life cycle cost analysis. Natural gas is expected to be utilized for building heating in Konya and electrical energy for cooling in Kirkuk in the calculations. Furthermore, the methodologies utilized to calculate the appropriate insulation thickness of the structures were determined based on the number of Degree-Days DD of the building, with Konya requiring just heating and Kirkuk requiring only cooling. In this study, the U-values, Heat conduction coefficient k (W/m K), and Thermal conductor R (m^2 K/W) values were taken from the DB program.

The annual heat loss Qy (kWh/m^2) is calculated using degrees days.

$$Q_{yC} = 24.\ CDD\ .\ U \tag{1}$$

$$Q_{yH} = 86400.\ HDD\ .\ U \tag{2}$$

Here,

$$U = \frac{1}{R_t + \frac{x}{k}} \tag{3}$$

Where,

U; total Heat Transfer Coefficient (W/m^{2}K), Rt; is the thermal resistance of the non-insulated wall (m^2 K/W), x (m) and k (W/mK) are the thickness of the insulation material and is the thermal conductivity coefficient. In (1) and (2) in the equation, “24” is the hour of a day and “86400” is the second of a day.

The Annual Fuel Cost (C_f) is computed by multiplying the annual fuel use by the fuel unit price. The following equation may be used to compute the yearly cost of fuel per unit surface area, often known as the unit price of fuel.

$$C_{Ac} = \frac{Q\,y_C \times C_{el} \times PWF}{COP} \tag{4}$$

$$C_{AH} = \frac{Q\,y_H \times C_{na} \times PWF}{\eta \times Hu} \tag{5}$$

Here,

C_{el}; electricity cost (\$/kWh) and C_{na} is fuel natural gas cost (\$/m^3).

The low heat value of the fuel (H_u) is the unit equivalent of natural gas (J/m^3). The formulae below can be used to compute the Present Value Factor (PWF) based on the function ratios of Interest rate (i) and Inflation rate (g).The parameters used in this equation are given in Table 6 and Table 7.

$$r = \frac{(i-g)}{(1+g)} \qquad Eğer\ (i > g),$$
$$r = \frac{(g-i)}{(1+g)} \qquad Eğer\ (i < g),$$

$$PWF = \frac{(1+r)^N - 1}{r\,(1+r)^N} \tag{6}$$

Where, N: is lifetime and 10 years were taken for this study.

For optimum insulation thickness, total laying cost and total insulation cost are calculated. Insulation cost represents the cost per unit volume of insulation and its thickness.

$$C_f = i_c \times x \tag{7}$$

Here, i_c: insulation soct \$/m^2 and x ; insulation thickness.

For calculate total cost E_{ct}, (\$/m^2),

$$E_{ct}=C_A+C_f \tag{8}$$

Optimum insulation thickness (x_{opt}) can be expressed as the point where the annual cost is lowest. The insulation to be made at this point will provide minimum cost and maximum energy savings.

The optimum thickness for cooling and heating is calculated as follows.

$$x_{optc} = \sqrt{\left(\frac{0.024 \,.\, CDD \,.\, fc. \; PWF. \; k}{i_c \,.\; COP}\right)} - k \,.\, R_t \tag{9}$$

And for heating use,

$$x_{optH} = \sqrt{\left(\frac{86400 \,.\, HDD \,.\, fc \,.\, PWF \,.\, k}{i_c \,.\, Hu \,.\, \eta}\right)} - k \,.\, R_t \tag{10}$$

Energy Saving Es(\$/m^2) has been calculated as follows.

$$E_s = E_{noi} - E_{ct} \tag{11}$$

Here, $Enoi$ and Ect are the building's total cost with and without insulation, respectively.

Payback Period (PAY) of the insulation material can be calculated as.

$$PAY = \frac{ic \times xopt}{Es} \tag{12}$$

Table 4. Parameters used in the calculation of optimum insulation thickness for Kirkuk.

Parameter	Value
Cooling degree day, CDD	1700[14]
Inflation rate, g	0.02[15]
Interest rate, i	0.04
Fuel electricity cost (for cooling), C_{el}, \$/kWh	25
Coefficient of Performance , COP	2.6
Present Value Factor , PWF	0.17

Table 5. Parameters used in the calculation of optimum insulation thickness for Konya.

Parameter	Value
Heating degree day, HDD	2507[1]
Inflation rate, g	0.14[2]
Interest rate,i	0.17[3]
Fuel natural gas cost (for heating), C_{na}, \$/m^3	0.23
Efficiency of the heating system , η	0.90
Low heat value of the fuel , H_u , J/m^3	34.5×10^6
Present Value Factor , PWF	8.69
(https://mgm.gov.tr/)[1] (https://ifs.org.uk)[2] (https://www.tcmb.gov.tr)[3]	

Table 6. Parameters used for optimum insulation.

Insulation Material	*k* (W/m K)	Price (\$/m^2)
XPS	0.034	95
EPS	0.040	77
Glass wool	0.036	58
Rock wool	0.038	65

5. RESULTS AND DISCUSSION

Ensuring the comfort conditions of the building users is one of the most important parameters in the selection of the building's heating system. In addition, minimizing energy use is possible with measures that can be taken while the building is in the design phase or after the existing buildings. In this study, taking into account the climate conditions of the residential building, which is considered to be in Kirkuk and Konya, representing the hot and cold provinces of Iraq and Turkey respectively, was modeled with the DesignBuilder energy simulation program. The findings of the optimal thickness research indicate the evolution of insulation cost, energy cost, and total cost for the different insulation materials tested, based on the climatic conditions of two cities and the thickness of the insulation material. As illustrated in Fig. 2 the ideal insulation thickness for Kirkuk citiy has the lowest value represented by the total cost curve, which is the sum of the energy and insulation expenses. The optimum insulation thickness for the four various type of external insulation materal for Kirkuk city varied 9 cm for XPS,13cm for EPS,19 cm for glass wool and 7 cm for rock wool. In this context, as gave in Fig. 4 the XPS energy saving result by using electric fuel type indicated the higher value nearly 67 $\$/m^2$ compared with other materials type as illustrate in table 7. Consequently, the same procces has been made for Konya as illustrated in Fig.3 the optimum insulation thickness was 11cm for XPS, 15cmm for EPS, 7cm for glass wool and 6cm for rock wool. As well as, in Fig.4 the energy saving results selected natural gas fuel type showen 83 $\$/m^2$ for XPS higher then EPS with was 59 $\$/m^2$ as soon as the reuslts illustrate in table 8. Finaly, as showen in Fig. 5. the anual payback period for Kirkuk's was between two and three years. However, the results for Konya were different, indicating a period of around 6 years.

Table 7. The building results for Kirkuk city.

Insulation materials	Optimum insulation thickness (cm)	Energy save ($\$/m^2$)	Payback period (Year)
XPS	9	67.3	0.21
EPS	13	49.9	0.23
Glass wool	19	38.1	0.23
Rock wool	7	42.2	0.31

Table 8. The building best results for Konya city.

Insulation materials	Optimum insulation thickness (cm)	Energy save ($\$/m^2$)	Payback period (Year)
XPS	11	83.3	0.06
EPS	15	59.1	0.26
Glass wool	7	48.1	0.12
Rock wool	13	54.2	0.60

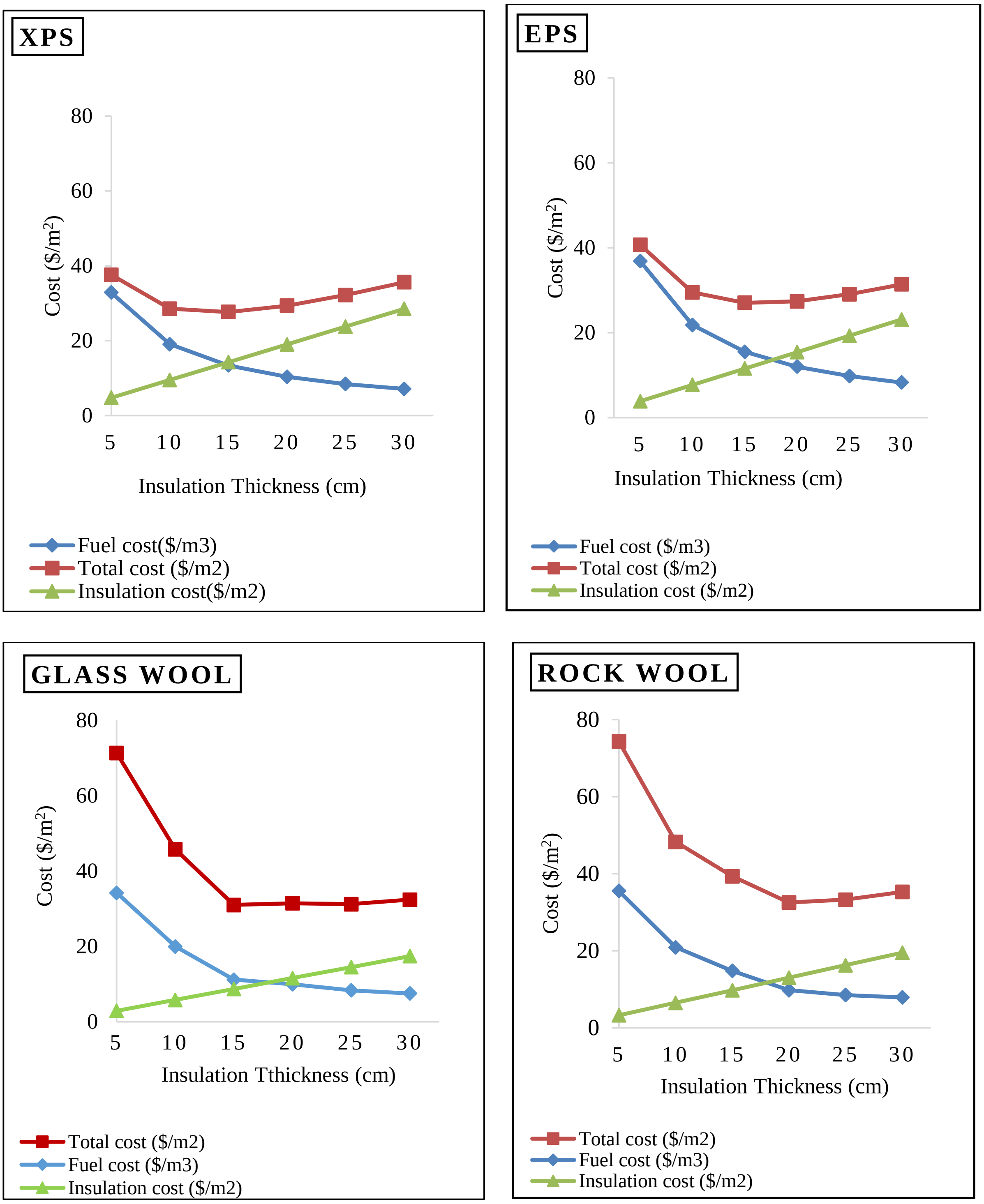

Figure 2. The effect of the insulation thickness requirement for Kirkuk in case of using only electricity.

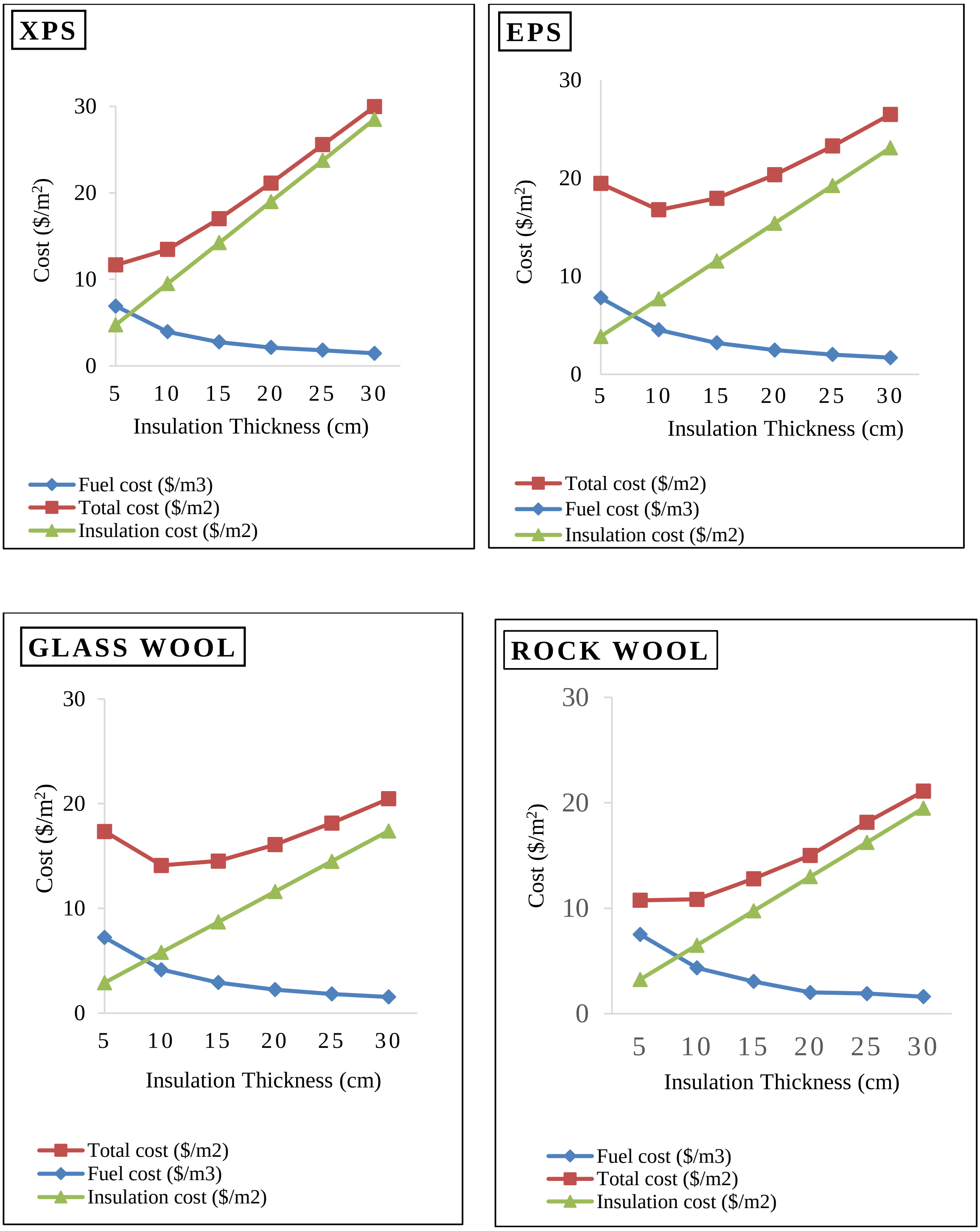

Figure 3. The effect of the insulation thickness for Konya in case of using only natural gas.

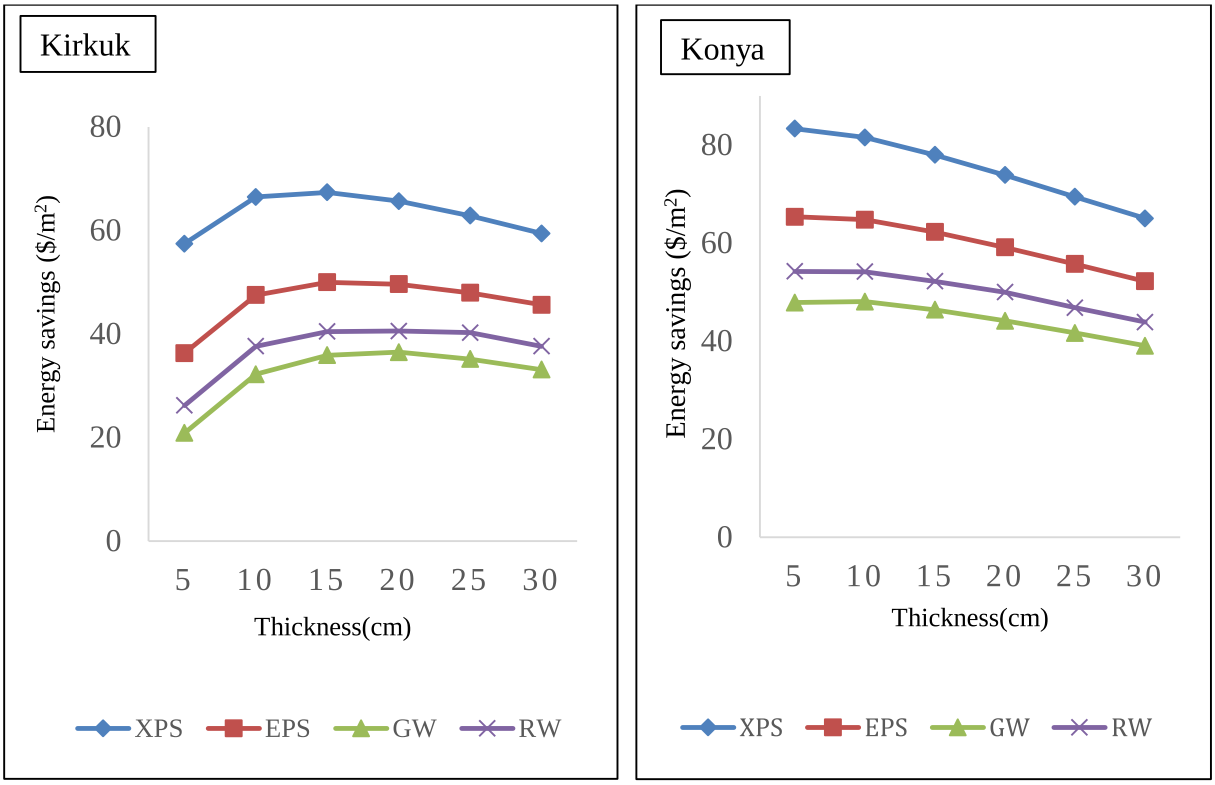

Figure 4. Annual energy savings for case of Kirkuk and Konya city.

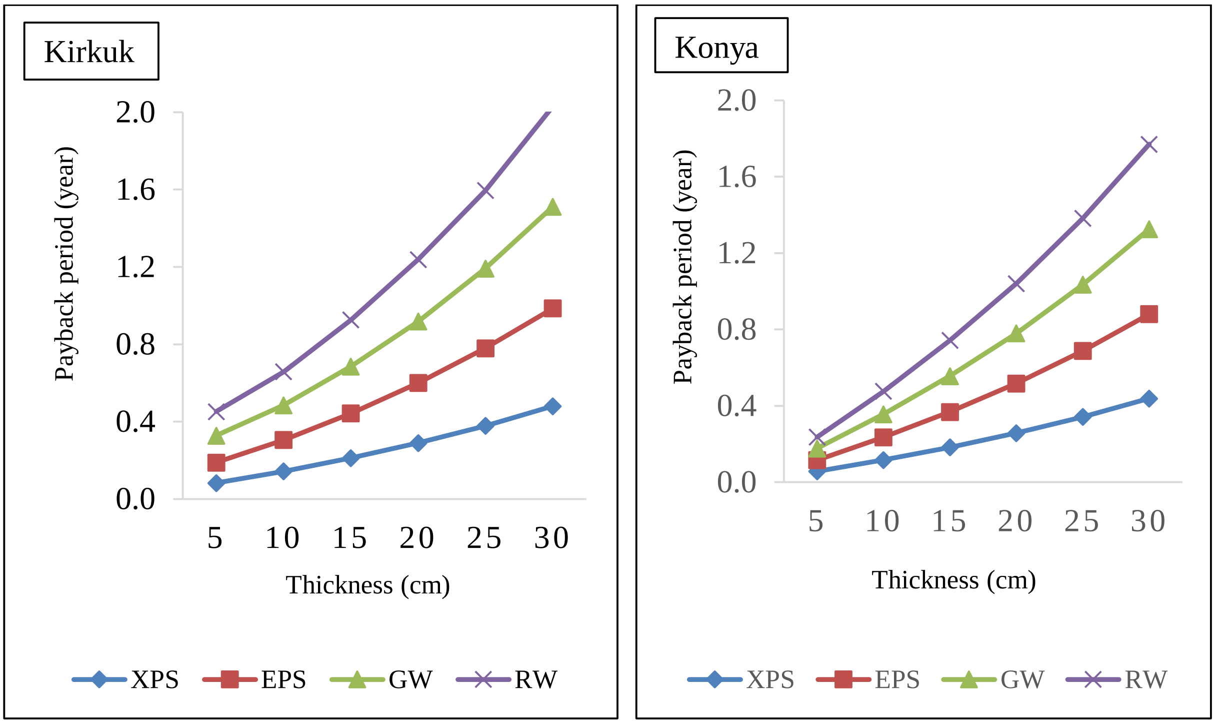

Figure 5. Annual payback period for case of Kirkuk and Konya city.

6. CONCLUSION

According to the climatic conditions of Kirkuk city and the thickness of the insulation material studied, increasing insulation thickness results in a reduction in fuel cost and a linear increase in insulation cost, but total costs decrease and then increase with increasing the insulation thickness after the peak equal to the optimum insulation thickness. It was seen that the comparison of the energy savings of all the insulating materials investigated for the city of Kirkuk if the cooling needs are fulfilled only using electricity as a source of energy. When the savings begin to diminish as the thickness of the insulating material increases, the optimal insulation thickness is reached, and the energy saving value is maximized. The payback period is increased depending on the insulation thickness. Kirkuk city, which is in the hot region, shows that the payback is higher as the degree-days increase compared to the city of Konya. On other hand, when the optimum insulation thickness for Konya is examined, the highest value was relatively XPS compared to other insulation materials, due to its high thermal conductivity, but glass wool insulation material has the lowest optimum insulation thickness values due to its low thermal conductivity. In case the heating need is met by using natural gas, the energy savings related to the insulation thickness examined for the city of Konya show that XPS insulation material provides the highest savings and the lowest savings are Glass wool. İn this respect, Konya, which is located in the cold region, caused a shortening of the payback period while the degree-days increased. This clearly shows that the payback period is shorter, while the cost of applying insulation thickness increases in colder regions. For this reason, it is more advantageous to apply insulation in cold climates.

NOMENCLATURE

C_f	Annual energy cost ($/m^2-year)
C_{Ac}	Total heating cost ($/m^2-year)
C_{AH}	Total cooling cost ($/m^2-year)
C_{el}	The electricity cost ($/kWh)
C_{na}	The natural gas cost ($/m^3)
COP	Coefficient of performance
CDD	Cooling degree-days value (°C)
DD	Degree-days value (°C)
E_{ct}	Total cost ($/m^2)
E_s	Energy Saving ($/m^2)
E_{noi}	Total cost without insulation ($/m^2)
HDD	Heating degree-days value (°C)
g	Inflation rate (%)
Hu	Low heat value of the fuel (J/m^3)
i	Interest rate (%)
i_c	Insulation cost $/m^2

k	Thermal conductivity of insulation (Wm/K)
η	Efficiency of the heating system
N	Lifetime (year)
PAY	Payback period (year)
PWF	Present worth factor
Q_{yc}	Annual cooling loss (kWh/m^2)
Q_{yH}	Annual heating loss (kWh/m^2)
R_t	Total heat transfer resistance (m^{2}K/W)
U	Total heat transfer coefficient (Wm^2/K)
X	Insulation thickness (m)
X_{optc}	Optimum cooling insulation thickness (m)
X_{optH}	Optimum heating insulation thickness (m)

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DECLARATION OF ETHICAL STANDARDS

The authors of the paper submitted declares that nothing which is necessary for achieving the paper requires ethical committee and/or legal-special permissions.

CONTRIBUTION OF THE AUTHORS

Sarah Kazancı: Methodology, Investigation, Writing – Original Draft, Visualization, Writing - Review & Editing, Formal analysis, Resources.

Ahmet Samancı: Methodology, Investigation, Visualization, Writing - Review & Editing.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

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