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Some prospects of energy savings in buildings

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Abstract

The results of a recent survey on energy consumption in the residential sector of Jordan were used to evaluate energy conservation in residential buildings. Space heating accounts for 61% of the total residential energy consumption with kerosene as the most popular fuel used for heating. In light of the fact that only 5.7% of dwellings in Jordan's urban areas have been provided with wall insulation and none with roof thermal insulation, the heating loads were calculated for a typical single house using different insulation materials. It was shown that energy savings up to 76.8% can be achieved when polystyrene is used for both wall and roof insulation.

1. Introduction

Jordan has no indigenous fossil fuels. The use of fossil fuels completely depends on imported oil from neighboring countries. Oil imports are affected by the political situation of the whole region. For a number of times, Jordan has had to switch its oil supply due to regional conflicts such as in the case of the Gulf War in 1990. Jordan's 1995 population was approximately 4 million and increasing at a yearly rate of 3.6% [1]. Accordingly, the population of Jordan is estimated to reach 6.6 million in the year 2010. In 1995, Jordan consumed about 4400 ktoe [2]. This energy consumption is distributed between the transportation, industrial, residential and commercial and public sectors with 40%, 22%, 18% and 20%, respectively.

Energy consumption is rapidly increasing due to the population increase and urbanization. Residential energy requirements vary from region to region, depending on climate, dwelling type and level of development. The climate of Jordan may be divided into three main categories

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according to the topography of the country, namely low, medium, and high mean temperature climates which are directly related to the altitude.

There are several ways that energy efficiency in the residential sector can be addressed. According to Stewart [3], they may include building envelope, energy using systems and public awareness campaigns. In a recent study, energy savings were evaluated for specific improvements in the building envelope, such as reduction of window infiltration and wall insulation [4].

This paper is intended to provide some insights into the general state of energy consumption in the residential sector and its trends in Jordan. Since space heating accounts for large amounts of residential energy consumption, special attention will be given to the relationship between the existing conditions of the dwelling and energy consumption.

2. Analysis and discussion

A survey was designed and conducted by the Ministry of Energy and Mineral Resources to evaluate energy consumption and its trends in the residential sector in Jordan [2]. The effect of socio-economic variables, the effect of altitude on energy consumption and the potential of using renewable energy as an alternative were among the many variables included in the survey. The sample size was 7120 households, distributed as 5440 and 1680 for urban and rural households, respectively. The survey covered all regions of the country, the northern, middle and southern parts of Jordan. The use of different types of energy sources in both urban and rural households is illustrated in Fig. 1. In urban areas, 99.6% of the homes use both electricity and LPG fuel, which are the highest. On the other hand, 8.4% of the residents use firewood, which is the lowest. In rural areas, LPG is the highest energy source, where it scored 98.9%, and diesel fuel is the lowest with a value of 14.3%.

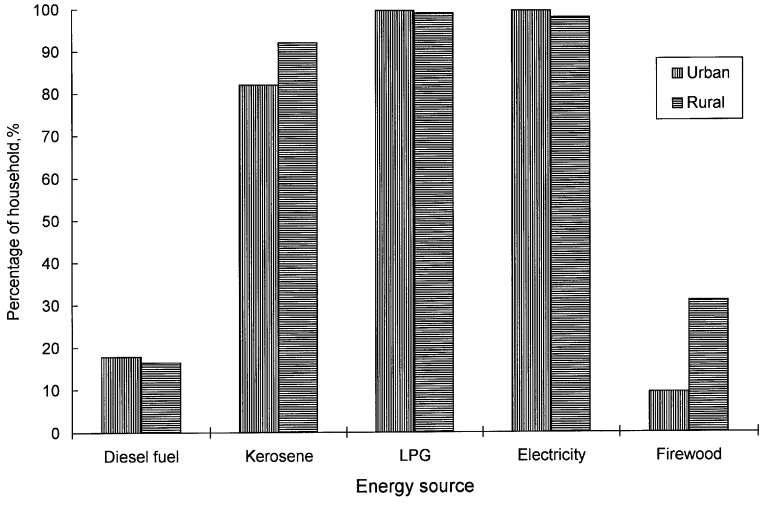

Fig. 1. Residential use of different energy sources in urban and rural areas.

One of the crucial findings of the survey is that space heating represents 61% of the total energy consumed in the residential sector. In this discussion, the energy used for space heating and factors that effect the consumption of this energy will be considered in detail for both urban and rural areas. Fig. 2 depicts the percentage use of different fuels for space heating. Kerosene is the highest, representing 63.2% and 75.0% among the fuels used for heating in both urban and rural areas, respectively. LPG has the second highest rating with 30.2% and 20.5% for urban and rural areas, respectively. Although there is an increase in the percentage of dwellings that are equipped with central heating systems in both urban and rural areas (11.8% compared to 7.3% in the urban areas and 2.0% compared to 0.5% for the rural areas for the years 1995 and 1986 [5], respectively), still most households use the traditional kerosene, diesel and LPG heaters.

In light of this fact, when talking about energy saving measures regarding space heating, it is more convenient to focus on the building envelope rather than the heating systems. Table 1 shows the dwelling year of construction in both the urban and rural areas. It is clear that 61.7% and 62.6% of the dwellings were constructed in 1980 and later for the urban and rural areas, respectively. Table 2 shows the distribution of dwellings in the urban and rural areas according to the house areas, the range of 51–100 m^2 being the most frequent, and 101–150 m^2 the second most frequent for both the urban and rural areas.

The year of construction, area, which represents the external shell area, type of dwelling (e.g. attached, or detached) and number of storeys are important factors in determining the energy requirements for space heating. In Jordan, 53.6% of the dwellings are of the single house type and

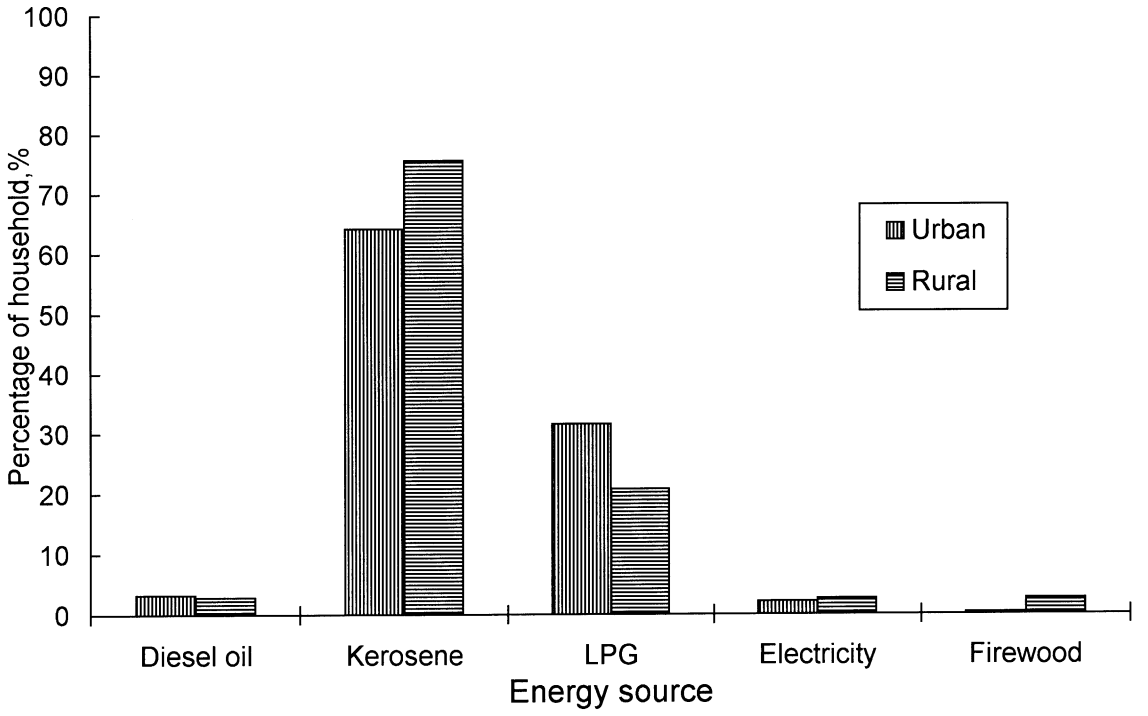

Fig. 2. Use of different fuels for space heating in urban and rural areas.

Table 1
Dwellings year of construction for urban and rural areas

Construction year	Urban (%)	Rural (%)
1990–1995	18.0	19.8
1985–1989	19.9	20.1
1980–1984	23.8	22.7
1975–1979	13.7	12.4
1970–1974	10.7	11.7
1965–1969	6.3	6.0
1960–1964	3.4	3.4
Before 1960	4.2	3.9

Table 2
House area distribution for urban and rural areas

House area (m^2)	Urban (%)	Rural (%)
50 and less	10.8	11.5
51–100	38.6	34.6
101–150	28.1	32.6
151–200	14.7	14.9
201–250	3.9	4.0
251–300	1.9	1.8
301–350	0.8	0.1
351–400	0.7	0.5
401–450	0.2	–
451–500	0.1	0.1
More than 500	0.3	0.1

the apartment type accounts for 45.2%. This fact and the fact that the maximum number of storeys in any residential building cannot exceed four according to municipal regulations will increase the space heating energy requirements. Considering wall insulation, only 5.7% and 3.7% of the dwellings have been provided with wall insulation in the urban and rural areas, respectively. Figs. 3 and 4 show the types of insulating materials that are in use for the urban and rural areas, respectively. According to the survey, none of the dwellings has ceiling thermal insulation, although 49% of these have waterproof systems. Fig. 5 shows that cement blocks are the most popular construction material for walls. Their use reaches 63% in both the urban and rural areas. Reinforced concrete is used in 94.4% and 97.7% of the roofs in the urban and rural areas, respectively.

Using the average temperature of the heating months in Jordan, where they start in October and end in April, and considering a typical single house dwelling with an area of 100 m^2 with cement block walls and reinforced concrete roof, the heating loads were calculated for the following cases: (1) without roof or wall insulations (2) with wall but without roof insulations (3) with roof and wall insulations. The results are shown in Figs. 6–8 for the three different insulation materials used. These materials are polystyrene, rock wool and air gap, respectively. Taking the peak load of case # (1) as a basis for comparison, savings were calculated for the other two cases of different insulating materials. The results are shown in Table 3.

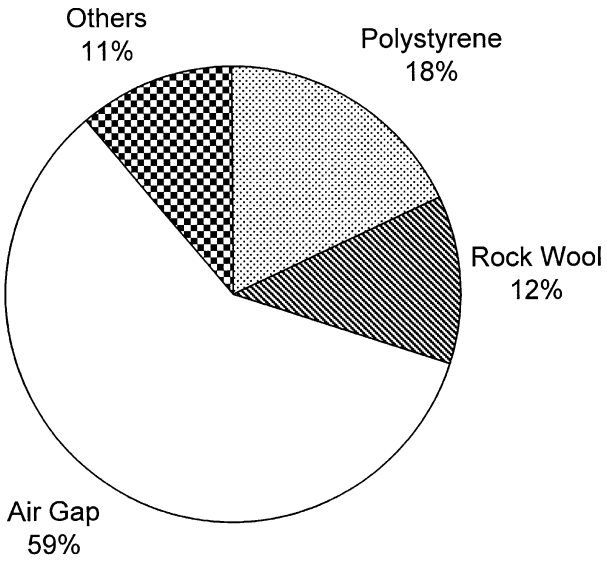

Fig. 3. Type of insulation materials used in urban areas.

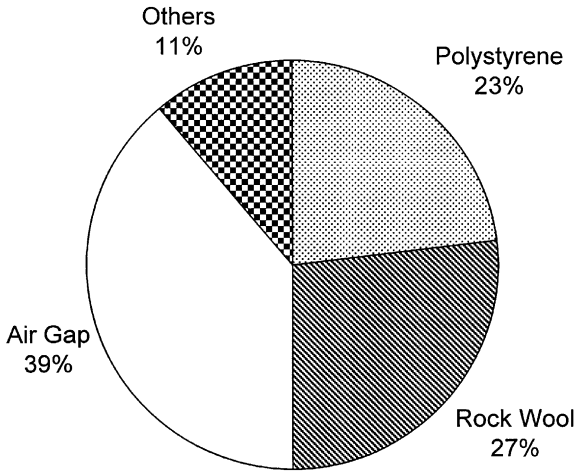

Fig. 4. Type of insulation materials used in rural areas.

The energy saving measures in building envelopes are various. They may include wall insulation, roof insulation, caulking, the use of insulated entry doors and window performance issues, such as glazing area, glazing type, installation of double glazed windows and storm windows. Because of the limitations of the conducted survey, wall and roof insulations were the only measures that were considered in the analysis, where it was shown that savings up to 76.8% can be achieved for insulating both the roof and walls. By considering wall insulation only, the heating loads were calculated for the three used insulating materials. The results are shown in Fig. 9, from which it is clear that polystyrene is the most effective insulating material, followed by rock wool,

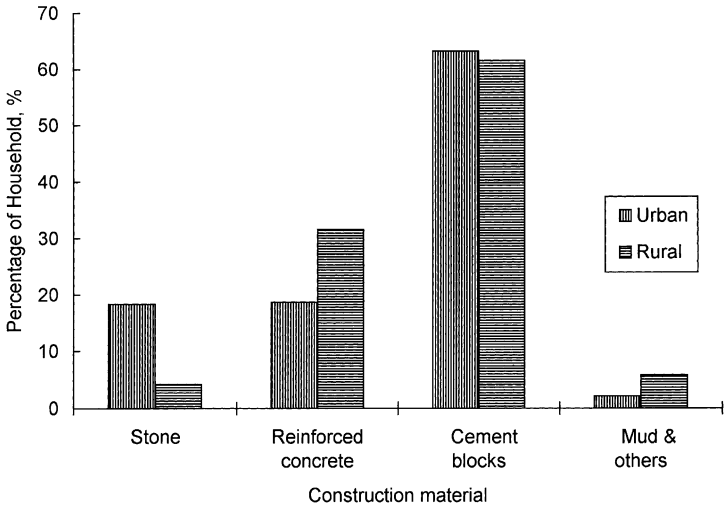

Fig. 5. Constructing materials used in urban and rural areas.

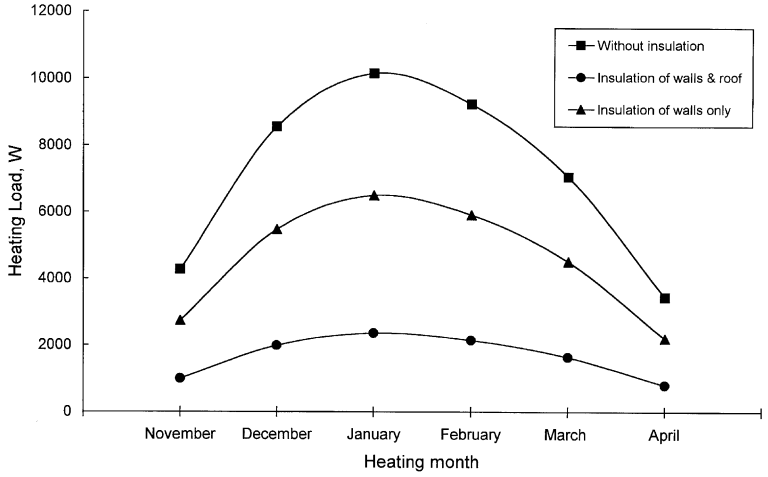

Fig. 6. Heating loads using polystyrene.

and then air gap, which is the least. Their corresponding energy savings are 36%, 34% and 5.4%, respectively. Other parameters are important too. It is reported that the installation of double glazed windows can reduce heat loss by as much as 36% [6]. It is recommended to design and conduct a special survey to enable analyzing the effect of building envelope on residential energy savings in Jordan. This survey may include measures concerning the heating systems too, such as water heater storage tank insulation, hot water pipe insulation, duct insulation and furnace efficiency.

In addition to considering other traditional fuels to compare their efficiency in space heating besides kerosene, renewable energy technologies should be considered for space heating. SWH

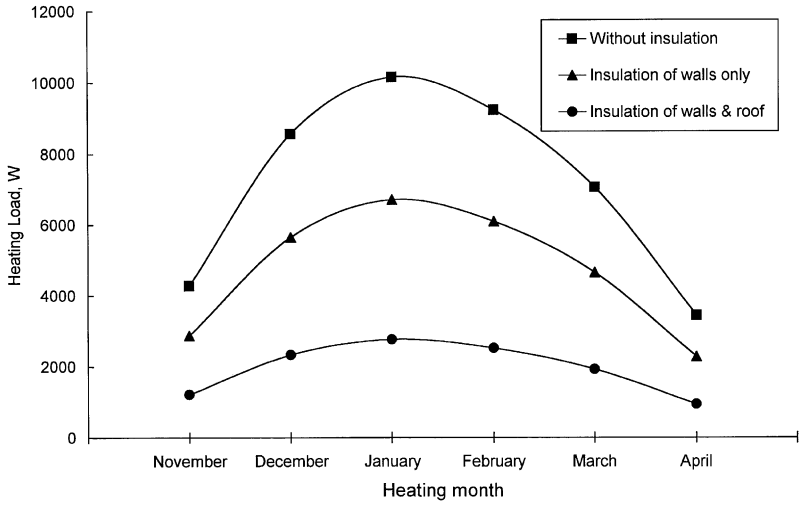

Fig. 7. Heating loads using rock wool.

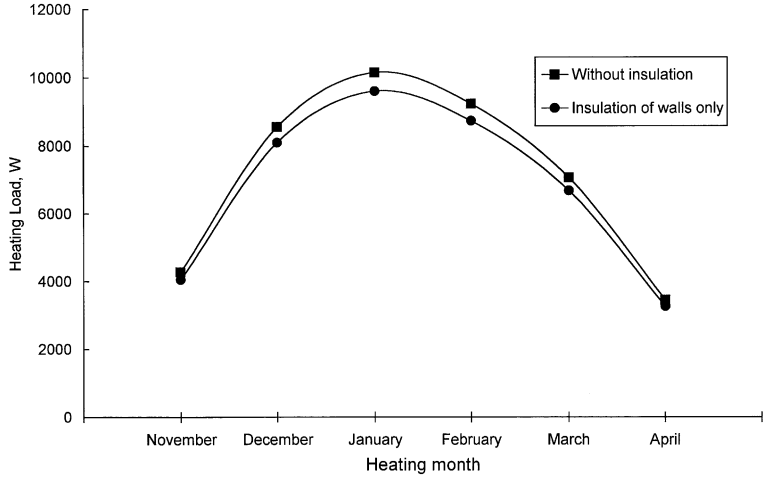

Fig. 8. Heating loads using air gap.

Table 3
Savings achieved by using different insulation materials

Case	Insulating material (%)		
	Polystyrene	Rock wool	Air gap
Insulation of walls only	36.0	34.0	5.4
Insulation of walls and roof	76.8	72.8	–

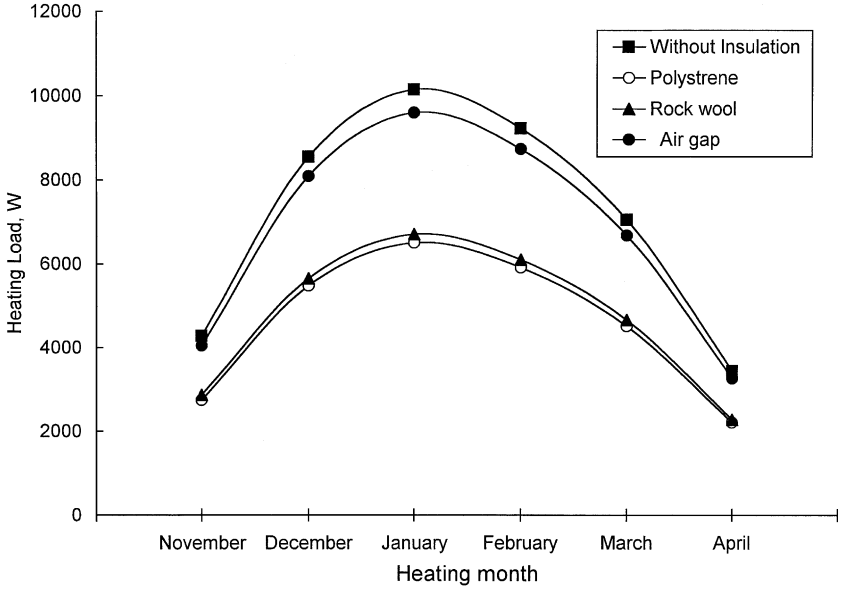

Fig. 9. Heating loads when wall insulation is used for the different materials.

systems are popular in Jordan, about 24% of the dwellings being equipped with this system. Mohsen and Akash [7] evaluated the domestic SWH system in Jordan, and found that it was the most beneficial when compared to the other systems used. The use of wind energy for water pumping and water desalination was considered in two separate papers by the authors [8,9]. Considering the monthly average wind speeds for different locations in the country, it was found that there are some locations where wind energy is promising and it can be used for both water pumping and desalination.

3. Conclusions and recommendations

Wall and roof insulation can produce energy savings up to 77%. It is shown that polystyrene is a better insulating material than either rock wool or air gap insulation. In order to maximize the benefit from solar radiation, buildings should be oriented to maximize the solar heat gain in winter and designed with a large southern facing glass expanse to utilize the available solar radiation during the winter.

The scary figures are those on roof and wall insulations, i.e. currently, roofs have no insulation and only 5.3% of buildings have wall insulation. From Table 3, it would be very important to enforce the use of insulation material for walls and roofs by the Jordanian Building Code.

It is recommended that technologies of renewable energy (wind and solar) concerning heating systems should be considered in Jordan. Technical and economical feasibility studies of such systems are recommended to be performed.

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