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Energy analysis of Jordan's urban residential sector

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Abstract

This paper presents some insights into Jordan's energy consumption in the urban residential sector. Eighteen percent of the country's total energy is consumed by the residential sector, which constitutes 84% of the country's residential energy consumption. Diesel fuel, bottled LPG, kerosene, and electricity are the main sources of energy in the urban residential sector. © 1999 Elsevier Science Ltd. All rights reserved.

1. Introduction

Unlike some other countries of the Middle East, Jordan is a non oil producing country with a small population of about 4 million which relies heavily on importation of oil from neighboring countries [1]. Considering the social, economic and technological differences, Jordan can be divided into two main parts, urban and rural. The urban part is somewhat well developed, while the rural part is under-developed, due to a lower standard of living.

In recent years, concern about energy consumption in Jordan has been growing. The residential sector has probably been affected the most by the economic and technological changes that the country has been experiencing. In the 1960s and 1970s for example, kerosene was the main fuel for cooking and water heating in the urban areas of Jordan. Electricity was not widespread and most dwellings did not have electrical appliances such as refrigerators and television sets. Gas cookers and gas heaters also were not common, particularly among low income families. Currently, most people are more conscious of energy conservation due to the direct effects and benefits that they gain from such savings. For example, solar water heating (SWH) is very common in most places since it provides hot water for about 9 months of the year. Approximately, 25%

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of the country's dwellings use SWH systems. In a recent study SWH systems were compared with other water heating systems and found to be the most beneficial [2]. Locality and availability of fuels can create differences in energy consumption. Households with higher income need more commercial energy [3–5].

In this paper an overview of Jordan's energy consumption in the urban residential sector is presented. It is based on a survey made by the Jordanian Ministry of Energy and Mineral Resources (JMEMR) conducted during 1995 [6]. In total, 5440 households were surveyed, covering 12 of Jordan's major cities.

2. Energy consumption in Jordan

According to JMEMR, the annual consumption of energy in the residential sector of the country from different sources of fuel is approximately 9000 GWh. This is equivalent to about 18% of all energy consumed in all sectors. Table 1 shows the distribution of energy consumption for different energy sources. In terms of an energy equivalent value, fuel oil, diesel fuel, and gasoline constitute more than 75% of all types of fuels consumed and represent the main fuels used in electric power generation, industry, and transportation. The total energy can be divided into three major sectors: residential, transportation, and industrial. The distribution of energy consumption in such sectors is presented in Fig. 1. The term "others" in the figure includes other minor sectors such as government, education, military, etc. The transportation sector has the highest energy consumption with about 40% of the total, followed by the industrial sector with 22%.

3. Description of the urban household

The average size of a Jordanian family is 6.65 members, 32.9% of whom are employed. Families with four to eight members represent more than 50% of the total. About 65% of families have an average monthly income of 300 Jordanian dinars (J.D.) or less; 1.00 J.D. is equivalent to 1.40

Table 1
Fuel consumption in Jordan in 1995

| Fuel | Consumption | Energy equivalent (GWh) | Percentage of total |
|-------------|----------------------------|-------------------------|---------------------|
| LPG | 203 000 t | 2820 | 5.6 |
| Gasoline | 478 000 t | 6220 | 12.4 |
| Jet fuel | 244 000 t | 3175 | 6.3 |
| Kerosene | 215 000 t | 2779 | 5.5 |
| Diesel fuel | 1 033 000 t | 13 159 | 26.1 |
| Fuel oil | 1 620 000 t | 19 581 | 38.9 |
| Natural gas | 283 million m ³ | 2600 | 5.2 |
| Total | – | 50 334 | 100 |

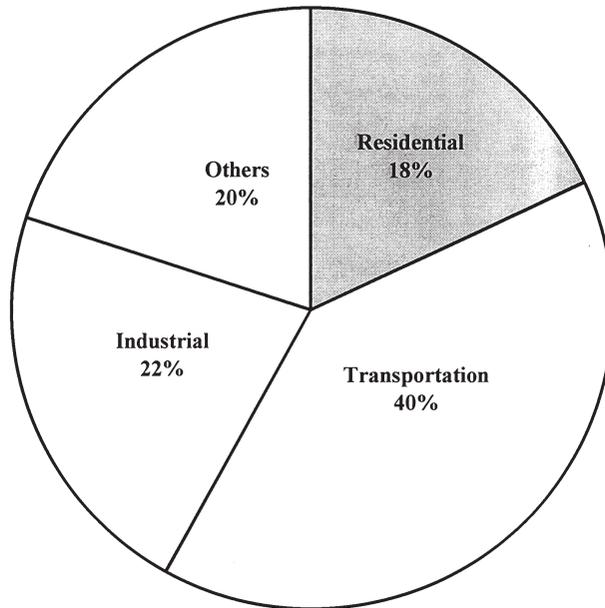


Fig. 1. Distribution of Jordan's energy consumption in different sectors.

US dollars. On the other hand, only 13% of families have a monthly income in excess of 500 J.D. More than 80% of the population in urban communities live in dwellings that range from 50 to 200 m², as shown in Fig. 2. Of all residential dwellings, 27% are rented, while the rest are self-owned or owned by a close relative who does not charge rent. Fig. 3 shows that approximately

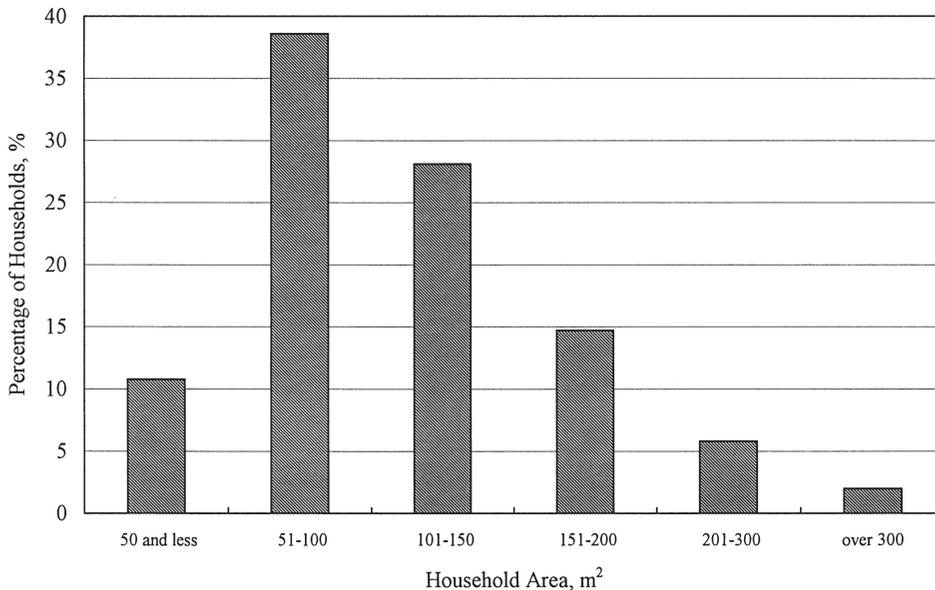


Fig. 2. Distribution of dwellings according to area.

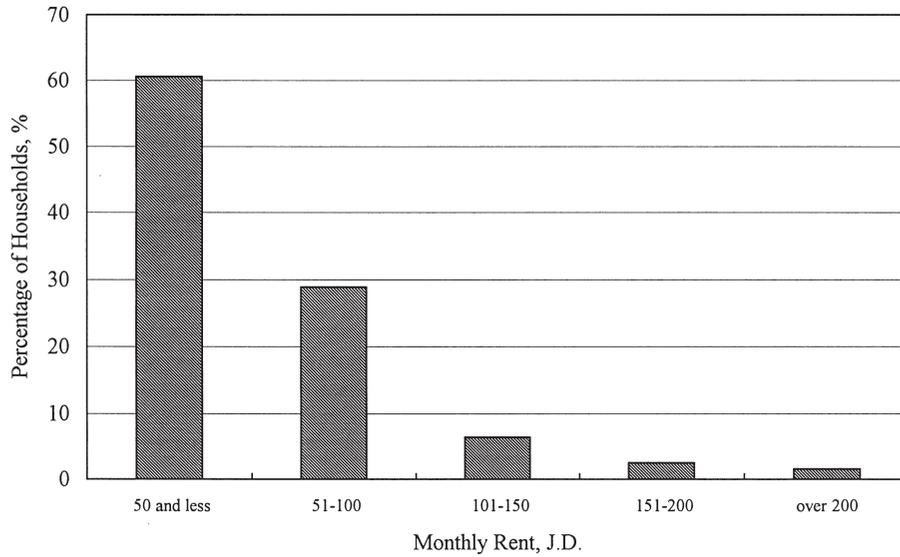


Fig. 3. Distribution of rented dwellings according to monthly rent.

90% of rented dwellings have a monthly rental value of 100 J.D. or less. About 28% of families that own their residence pay a monthly mortgage, and 75% of them pay monthly installments of 100 J.D. or less, as shown in Fig. 4. The year of construction of dwellings is presented in Fig. 5, which shows that more than 85% were built in 1970 or after.

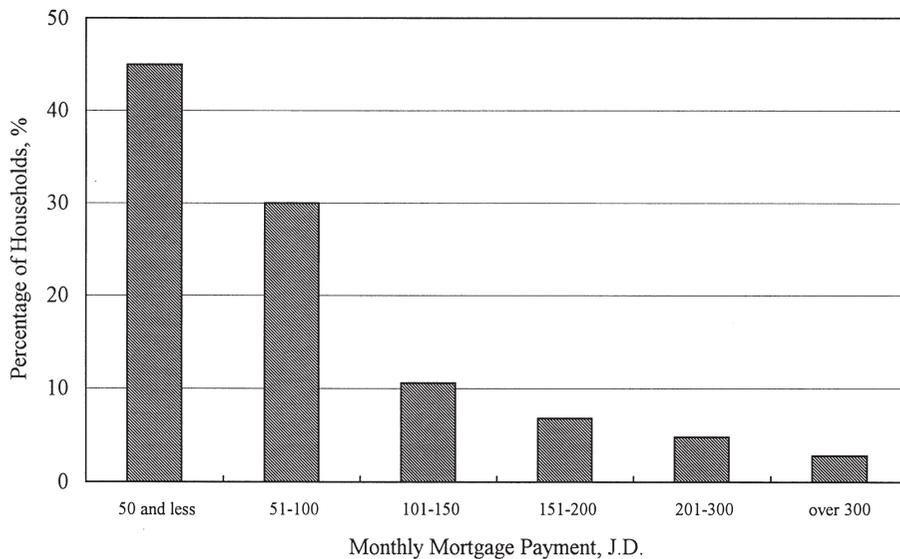


Fig. 4. Distribution of dwellings according to monthly mortgage.

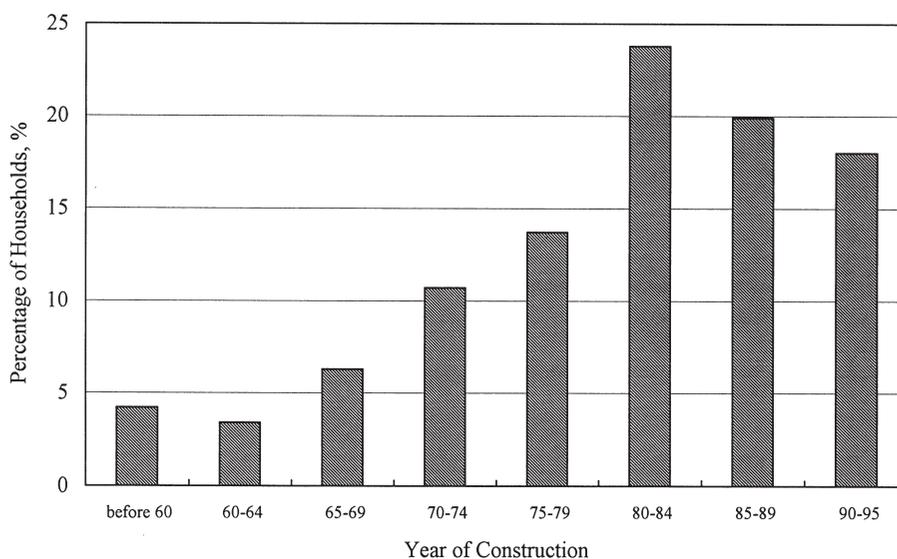


Fig. 5. Distribution of dwellings according to year of construction.

4. Analysis and discussion

The distribution of the main sources of energy consumed in the residential sector of Jordan is presented in Table 2. It is clear that the urban sector accounts for most of the residential energy consumption. The overall energy equivalent for the urban sector is about 84% of the entire country. Therefore, in terms of residential energy consumption, Jordanian society is considered to be mostly urban. In terms of gross energy, bottled LPG is the major source of energy for the entire country, and is used primarily for cooking and space heating. More than 188 000 t of LPG is consumed annually in the residential sector: 122 000 t for cooking and 56 000 t for space heating. On the other hand, considering the urban residential sector of Jordan, diesel fuel is the highest fuel consumed in terms of gross energy—about 178 000 t consumed annually. More than two-thirds is used in space heating. Electricity is used mostly for lighting and running of electric appliances. The distribution of all energy sources used in different applications is listed in Table 3. Portable kerosene heaters are very popular in Jordan; about 78% of households use them for space heating. Bottled LPG portable heaters are also popular, with over 30% of households using this method space heating. Both kerosene and LPG heaters are popular because they are considered to be inexpensive and convenient. Safety is not taken into consideration.

In terms of water heating systems, solar is the most popular, with 27% of households in the urban sector using SWH. It is worth noting that some households on very low incomes cannot afford to have any kind of water heating system. Instead they use other methods such as heating their water on a cooking stove or over firewood; these are not considered as water heating systems in this study.

For space heating, diesel is a commonly used fuel, especially when a central heating system is used. This is usually the case with high-income families who can afford its capital, maintenance and running costs. Only 11.8% of households use diesel-fueled central heating systems. It is used

Table 2
Energy consumption in the residential sector of Jordan in 1995

| Energy source | Entire country | | Urban sector | | Estimated distribution of energy consumption in the urban residential sector | | | |
|---------------|----------------|-------------------------|---------------------------------|-------------------------|--|---------------|-------------|------------|
| | Consumption | Energy equivalent (GWh) | Consumption | Energy equivalent (GWh) | Space heating | Water heating | Cooking | Lighting |
| Diesel fuel | 188 000 t | 2395 | 178 000 t (95%) ^a | 2268 | 128 000 t | 50 000 t | – | – |
| Kerosene | 193 000 t | 2496 | 150 000 t (78%) | 1934 | 94 000 t | 6000 t | 50000 tons | < 100 tons |
| LPG | 188 000 t | 2613 | 148 000 t (79%) | 2054 | 56 000 t | 10 000 t | 122000 tons | – |
| Electricity | 1270 GWh | 1270 | 1088 GWh (86%) | 1088 | 23 GWh | 165 GWh | 10 GWh | 890 GWh |
| Total | – | 8774 | – | 7344 (84%) | – | – | – | – |

^aValues in parentheses represent percentage ratio of energy consumption of urban residential sector divided by energy consumption of residential sector of the entire country.

Table 3

Energy sources used for different applications, expressed as the percentage of households

| Energy source | End use | | | |
|---------------|---------------|---------------|---------|----------|
| | Space heating | Water heating | Cooking | Lighting |
| Diesel fuel | 18.6 | 11.0 | – | – |
| Kerosene | 77.7 | 15.3 | 1.3 | 3.9 |
| Bottled LPG | 30.3 | 14.1 | 97.4 | 0.3 |
| Electricity | 1.9 | 17.8 | 1.8 | 99.6 |
| Firewood | 2.3 | 2.1 | 1.7 | – |
| Biomass | 0.2 | 2.2 | 1.1 | – |
| Solar system | – | 27.0 | – | – |

primarily during the cold winter season and is not used 24 hours per day. The daily average number of hours of space heating in these households is presented in Fig. 6. About 75% of households turn their heating systems on for 4–9 hours per day during the winter season.

The electric appliances that are used in urban household are listed in Table 4. Television sets, refrigerators and washing machines are the most common appliances. As mild summers with low humidity are common in Jordan, the number of residences with air conditioners is small (less than 4%). However, ceiling and portable fans are popular; over 80% of households use fans for space cooling. Some of the appliances that are popular in developed countries are often not so popular in developing countries. Microwave ovens and electric cookers for example, are found in less than 1% of households. This is due to the lower standard of living and the relatively high

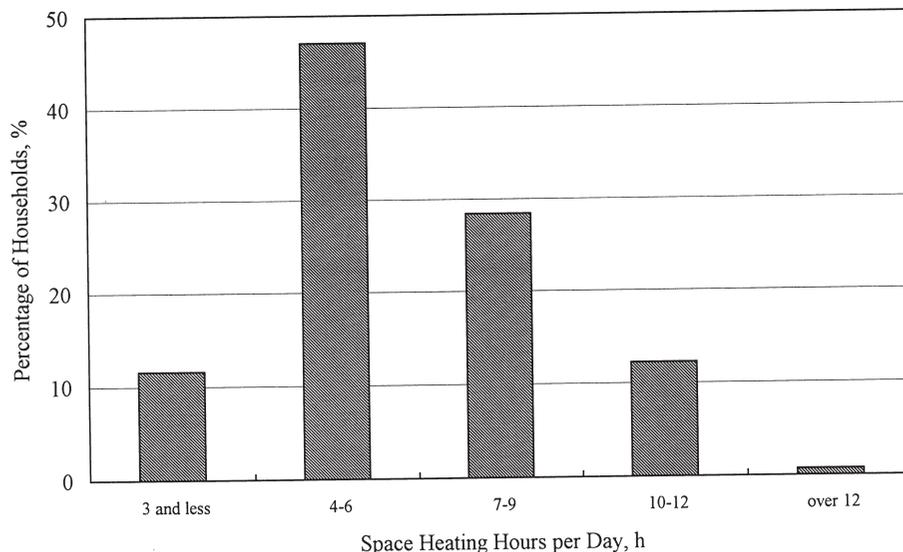


Fig. 6. Distribution of dwellings with diesel-fueled central heating system according to number of daily number of hours of space heating.

Table 4
Percentage of appliances used in urban households

| Type of appliance | Percentage of households |
|---------------------------------|--------------------------|
| Washing machines | 95.2 |
| Regular | 53.2 |
| Full automatic/semi-automatic | 41.1 |
| Washer and dryer | 0.9 |
| Dishwashers | 1.1 |
| Refrigerators | 91.8 |
| Regular refrigerators | 46.4 |
| No-frost refrigerators | 45.4 |
| Freezer | 8.9 |
| Fans | 80.5 |
| Ceiling fans | 37.4 |
| Portable table fans | 43.1 |
| Air conditioners | 3.9 |
| Portable electric space heaters | 1.9 |
| Electric water heaters | 17.8 |
| Electric cookers | 0.7 |
| Microwave ovens | 0.8 |
| Electric irons | 80.0 |
| Vacuum cleaners | 28.7 |
| Stereo/cassette recorder | 66.2 |
| Television sets | 91.9 |
| Colored TV | 84.1 |
| B/W TV | 11.9 |
| Video cassette recorders | 19.4 |
| Hair dryer | 30.4 |
| Electric water pump | 9.1 |
| Personal computers | 2.0 |

cost of electricity. Dishwashers are also very uncommon; only about 1% of residents use them, due to both the high cost of electricity and the scarcity of fresh water. It is interesting to see that about 2% of households have personal computers. It is a small number but it is somewhat noticeable, especially in a developing country with a low standard of living.

5. Conclusions

The total energy consumed by the residential sector of Jordan accounts for 18% of the total energy consumed in the country. About 84% of that portion of energy is consumed by the urban residential sector. In addition to electricity, the main fuels that are used by an urban residential household are diesel fuel, bottled LPG, and kerosene. These sources of energy are primarily used for space heating, water heating, cooking, lighting, and running large appliances.

Diesel fuel, LPG, and kerosene are the most popular systems for space heating. For water heating, SWH is the most commonly used system, followed by electricity. LPG and electricity

are mainly used for cooking and lighting, respectively. The authors believe that this analysis can be applied to other urban residential sectors of neighboring countries with the same standard of living.

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