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Current situation of energy consumption in the Jordanian industry

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Abstract

The current situation of energy consumption in the Jordanian industry is presented. The industrial sector energy consumption represents 22% of the country's total energy consumption. A survey covering about 10% of the total existing industrial firms was conducted for the study. About 90% of the industrial firms are considered small. It was shown that the main sources of energy in the industrial sector are electricity, heavy fuel oil and Diesel fuel. Their combined cost is about 95% of the total energy cost in this sector. Detailed data on fuel and electricity consumption are presented in this paper.

Keywords: Industrial sector; Energy consumption; Jordan

1. Introduction

In Jordan, there has been a growing concern about energy consumption and its adverse impact on the environment. Rational and efficient utilization of energy resources bears special importance for the Jordanian industry. Therefore, multi-faceted information on industrial energy use is essential. Introducing the concept of rational use of energy aims at reduction of the energy consumption to an extent corresponding to the optimum use of all limited economic resources. This definition indicates that those proposals and measures leading to a more rational use of energy have to show advantages over the actual current situation. Energy losses in a large number of industries exist, and the reduction of such losses can improve energy conservation significantly [1]. Jordan imports most of its energy in the form of petroleum products. Therefore, energy

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conservation means less reliance on energy imports and, thus, less greenhouse gas (GHG) emissions. Various studies on energy analyses in different industries have been published [1–4]. In a recent study, it was shown that implementing a few options in the industrial sector could reduce GHG emissions [5]. The most important ones include improvement and use of more efficient electrical motors, lighting and clean boilers and furnaces. In this paper, we present some insights on the situation and current trends in energy consumption in the Jordanian industry. It is based on a survey conducted by the Jordanian Ministry of Energy and Mineral Resources (JMEMR). The total number of samples is 1882 industrial firms, covering most types of industries, at various geographical locations [6]. This number represents about 10% of the existing industrial firms in Jordan.

2. Energy consumption in Jordan

According to a recent study, it was shown that the annual consumption of energy in Jordan is approximately equivalent to 50,000 GW h [7]. Energy consumption in Jordan is divided into three major sectors, namely, industrial, residential and transportation. The energy consumption among these sectors is presented in Fig. 1. The term "others" in Fig. 1 refers to other minor types of sectors such as commercial, government, education, military, etc. A good portion of the energy, ≈22%, is consumed by the industrial sector.

Table 1 shows the distribution of annual energy consumption for different energy sources. In terms of an energy equivalent value, heavy fuel oil and diesel fuel constitute about two-thirds of all fuels consumed. Naturally, a good portion of this fuel is used in electric power generation. Recently, it was reported that about 50% of the diesel fuel and more than 85% of the heavy fuel oil consumed in Jordan are used for electric power generation [8].

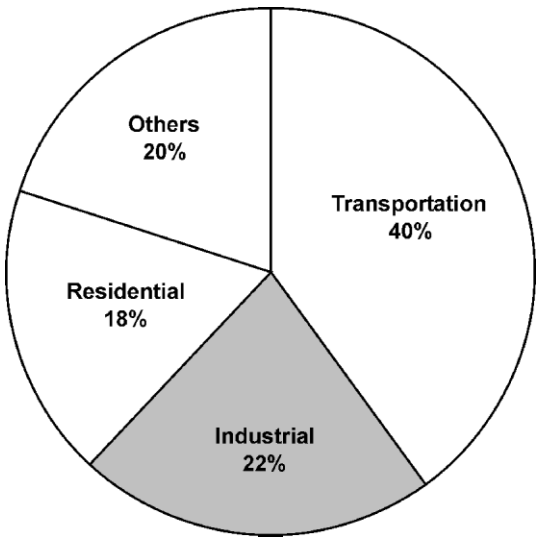

Fig. 1. Distribution of Jordan's energy consumption in various sectors.

Table 1
Jordan's main fuel consumption in 1995

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

3. Description of the industrial firm in Jordan

In this paper, the industrial firms are divided into small, medium and large. Therefore, "small" refers to an industrial firm that is provided with electricity from the national electric grid with low voltage and has a load below 200 kW. Likewise, "medium" refers to a firm that obtains its

Table 2
Sample distribution according to characteristic of industrial firm

Type of firm	Total number of existing firms and percentage (%)	Number of firms in the sample	Percentage of total existing firms (%)
Large firms	534 (2.7)	310	58.0
Medium firms	1468 (7.4)	718	48.9
Small firms	17,792 (89.9)	854	4.8
Total	19,794 (100)	1882	9.5

Table 3
Sample distribution according to geographical location

Location	Number of firms in the sample	Percentage of firms in the sample (%)
Amman	955	50.7
Zarqa	304	16.2
Irbid	172	9.1
Balqa	138	7.3
Mafraq	87	4.6
Madaba	87	4.6
Aqaba	58	3.1
Jaresh	43	2.3
Karak	19	1.0
Ajloun	10	0.5
Ma'an	5	0.3
Tafilah	4	0.2
Total	1882	100

Table 4
Sample distribution according to geographic location and type of industry

Type of industry	Number of firms at different locations												
	Amman	Zarqa	Irbid	Balqa	Mafraq	Madaba	Aqaba	Jaresh	Karak	Ajloun	Ma'an	Tafilah	Total
Mining and quarrying	5	1	0	0	2	0	0	0	1	0	0	0	9
Food and beverage industry	141	56	25	18	23	3	6	8	2	6	1	0	289
Tobacco industry	2	0	0	0	0	0	0	0	0	0	0	0	2
Textile	20	6	1	0	0	0	0	0	0	0	0	0	27
Garment industry	75	5	5	1	1	1	0	0	0	1	0	0	89
Leather	23	2	2	0	0	2	0	0	0	0	0	0	29
Wood industry	84	50	22	42	7	17	9	6	5	0	1	1	244
Paper and pulp industry	7	4	1	2	0	1	1	0	0	0	0	0	16
Press, publishing, and printing industry	28	3	1	0	0	1	0	0	0	0	0	0	33
Coke and petroleum refining industry	1	0	0	0	0	0	0	0	0	0	0	0	1
Chemicals and chemical products industry	25	5	2	2	0	6	0	0	0	0	0	0	40
Rubber and plastic industry	34	0	3	2	2	0	0	0	0	0	0	0	41
Non-metallic mineral products	151	41	55	33	21	25	14	10	3	2	0	1	356
Basic metals	6	2	1	1	0	0	1	0	1	0	0	1	13
Fabricated metals industry	88	56	39	28	6	26	18	17	7	1	2	0	288
Light machinery industry	19	3	0	0	0	1	0	0	0	0	0	0	23
Computers and related products	1	0	0	0	0	0	0	0	0	0	0	0	1
Electronic products	5	1	0	1	1	0	0	0	0	0	0	0	8
Medical and optical products	2	1	1	0	0	0	0	0	0	0	0	0	4
Motor vehicles and trailers	5	1	0	0	0	0	0	0	0	0	0	0	6
Furniture	46	9	5	2	1	0	1	0	0	0	0	0	64
Motor vehicle repair and maintenance	185	57	8	5	23	4	8	1	0	0	1	1	293
Repair and maintenance of household products	2	1	1	1	0	0	0	1	0	0	0	0	6
Total	955	304	172	138	87	87	58	43	19	10	5	4	1882

electricity at medium voltage, the required electrical load for such a firm being >200 kW. Finally, "large" denotes a firm that obtains its electric power directly from the high voltage electric network (132 kV).

According to Table 2, about 90% of the industrial firms in Jordan are considered to be small. Therefore, like most small developing countries with limited natural resources, the type of industry in Jordan is mostly of small scale. Although there are very few large firms (<3%), they consume a large portion of the energy, and thus, they are investigated in depth. Therefore, the sample contained 58% of the large existing firms in the country, whereas the total sample contained only 9.5% of the total industrial firms in the country.

The sample distribution according to geographical location is presented in Table 3. More than 50% of the sample is located in Amman, the largest city and capital of Jordan. More than an additional 30% of the firms are located in the cities of Zarqa, Irbid and Balqa combined. The rest of the sample (<20%) is distributed throughout eight other smaller cities. The detailed geographical sample distribution and type of industry are presented in Table 4.

4. Analysis and discussion

The type of energy or fuel used in the industrial firms is presented in Table 5. It shows that electricity, heavy fuel oil, and diesel fuels are the main sources of energy consumed in the industrial sector. All of the firms require electricity, but on the other hand, less than 1% require heavy fuel oil. Diesel fuel is very popular in the industrial sector with about 11% of firms using it. Other types of fuels, mainly liquefied petroleum gas (LPG), kerosene, wood and coke are also used in about 17% of the firms. Unlike the residential sector, which utilizes solar energy, the industrial sector has not yet utilized this vast, inexpensive and locally available source of energy because such technology has not yet been applied to this sector. Recently, it was reported [9] that about 25% of the dwellings in Jordan use solar water heating in order to reduce their monthly electric bill and, thus, conserve energy.

The distribution of the main energy sources used by the Jordanian industrial sector is presented in Fig. 2. The percentages shown are based on the final cost of energy delivered to the firm. In terms of cost of energy, the figure shows that electricity, heavy fuel oil and diesel fuels are the main sources of energy in the industrial sector. They combine to 94% of the total energy cost. The detailed analysis of these energy sources will be discussed in the following paragraphs.

For example, Fig. 3 represents both the peak and base electrical loads of the industrial firms. More than 65% of the industrial firms in Jordan have designed electrical loads of 25 kW or less.

Table 5
Type of energy and fuel used

Type of energy source	Number of firms in the sample	Percentage of firms in the sample (%)
Electricity	1882	100
Heavy fuel oil	18	1.0
Diesel fuel	202	10.7
Others[a]	314	16.7

[a] The term others include LPG, kerosene, coke, biomass, etc.

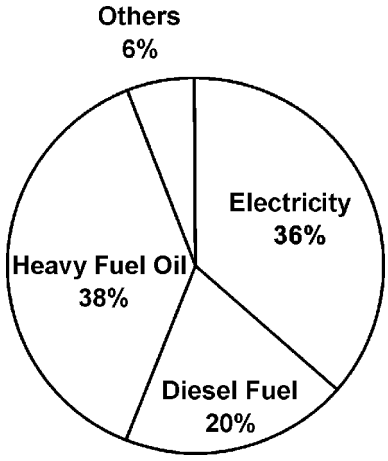

Fig. 2. Main energy sources of industrial sector: distribution is based on the cost or percentage of annual bill paid by the Jordanian industrial sector.

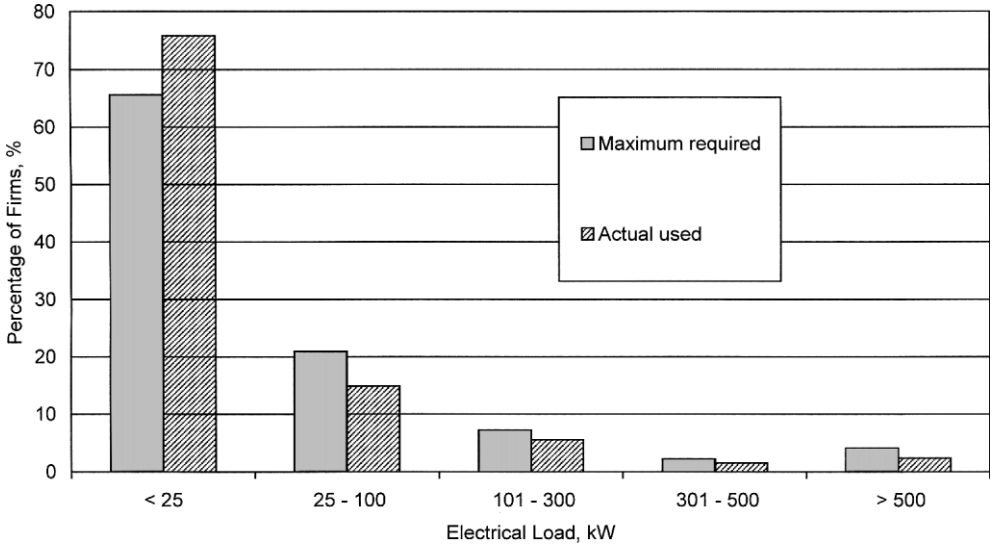

Fig. 3. Maximum and actual power rating capacities.

Table 6
Electricity source

Electricity source	Number of firms in the sample	Percentage of firms in the sample (%)
Electricity purchased from NEPCO	1807	96.1
Electricity on-site generated (none purchased)	25	1.3
Both on-site generated and purchased	51	2.7
Total	1882	100

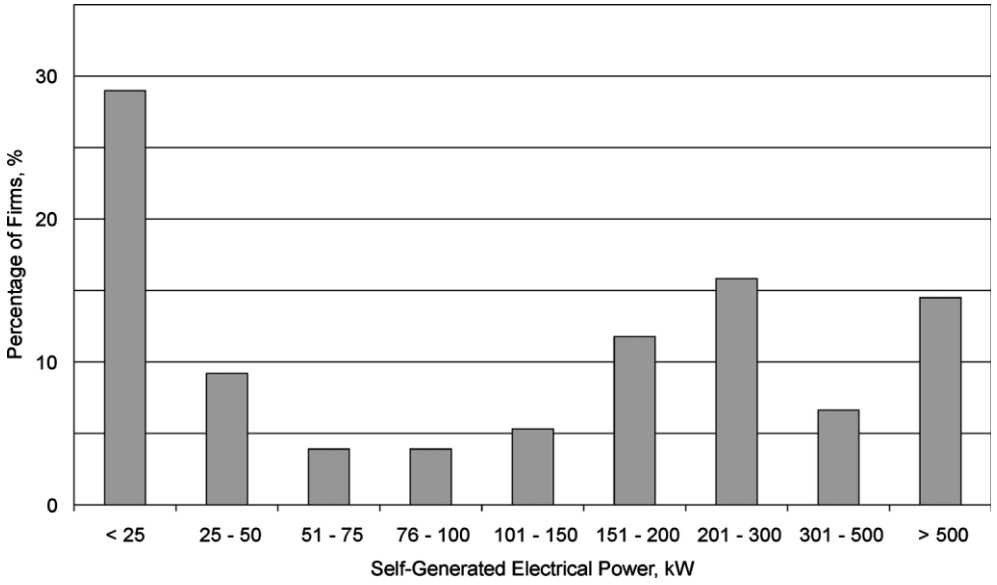

Fig. 4. Self-generated electric power.

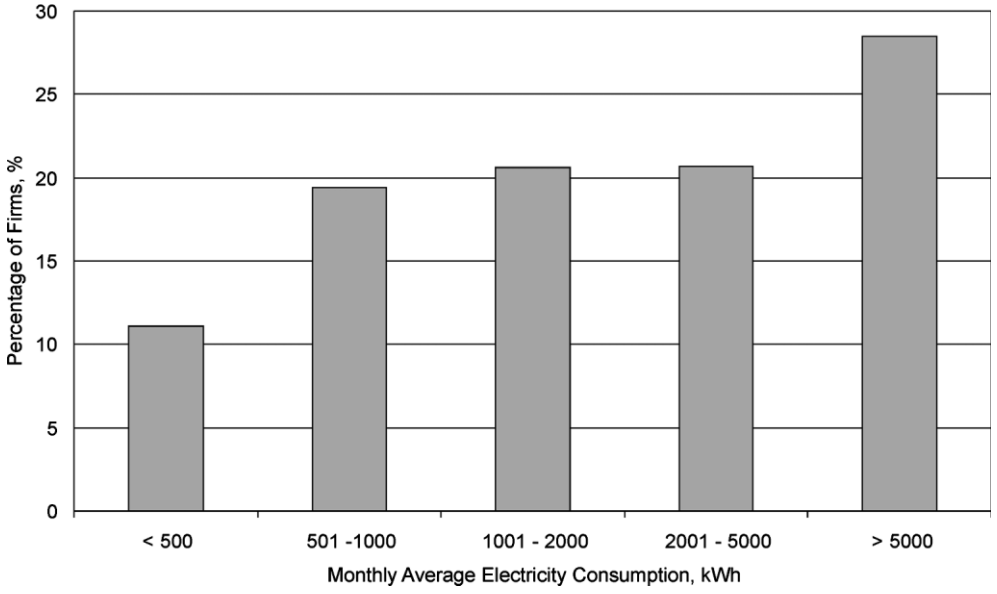

Fig. 5. Monthly average electricity consumption.

Less than 15% of the firms have electric power ratings of more than 100 kW. Fig. 3 also represents the actual or used load in the firm. About 75% of the firms are actually operated at 25 kW or less, and about 10% of the firms run on 100 kW or more of electric power.

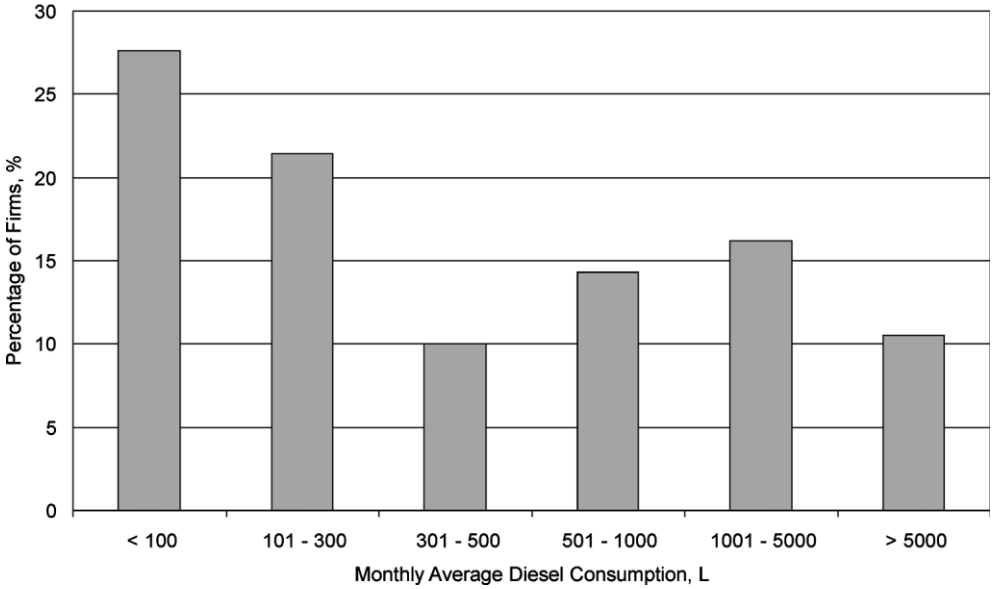

Fig. 6. Monthly average diesel consumption for firms that use diesel fuel.

Electricity is mostly purchased from the National Electric Power Company (NEPCO). Some industrial firms have their own electric power generation units. Table 6 shows that over 96% of the firms purchase their electricity from NEPCO, while just over 1% generate their own electricity, and none is purchased. The reason for this is that they are located in remote areas or they can generate their own electricity at lower costs. Also, less than 3% self-generate part of their electricity and purchase the remainder from NEPCO.

It is interesting to notice that the firms that generate their own electricity are either producing at high or low rates. Hence, the latter can run their business using a diesel engine driven small electric power generator, whereas the former must have their own large thermal power plant. Fig. 4 shows that almost 30% of the firms generate their own electric power at rates lower than 25 kW. Also, about 50% of the firms generate power of more than 150 kW. The monthly average electricity

Table 7
Diesel and heavy fuel oil end use within the firm

Usage	Percentage of firms in the sample that use diesel fuel (%)	Percentage of firms in the sample that use heavy fuel oil[a] (%)
Steam boilers	48.1	61.1
Furnaces	21.4	27.8
Dryers	6.7	11.1
Transportation	82.3	–
Others[b]	22.9	16.7

[a] 17% of firms that use heavy fuel oil spend less than 500 JD per month, while 83% of those firms spend over 2000 JD per month.

[b] The term others include running of some machinery, space heating, etc.

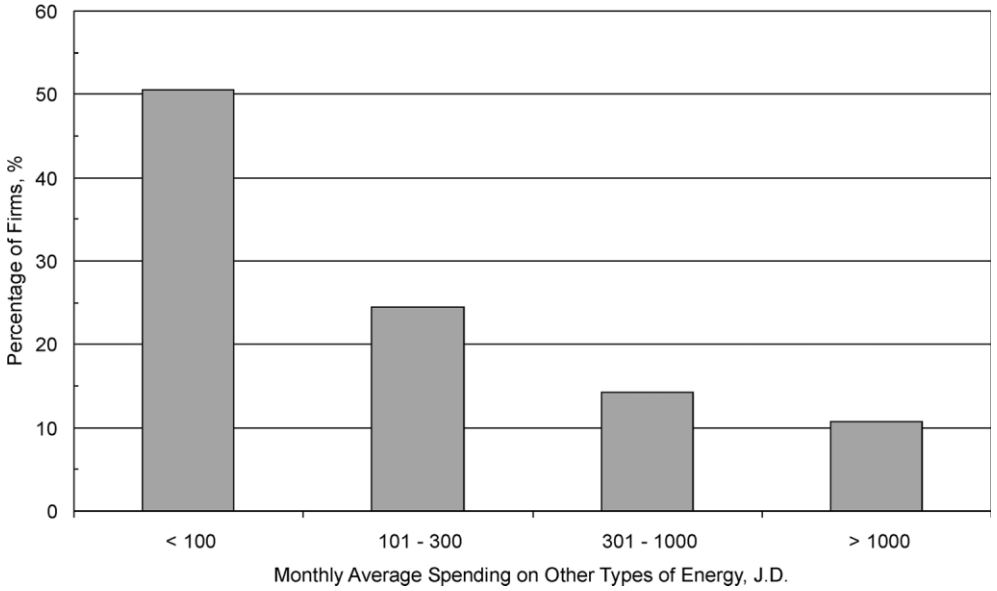

Fig. 7. Monthly spending averages on other types of energy for firms that use them.

Table 8
The attitude of the industrial sector towards energy efficiency related activities

Type of activity	Percentage (%)
Inspection of monthly energy utility bill	35.7
Knowledge of energy prices and tariff	24.0
Eagerness to energy efficiency	6.5
Eagerness to conservation of energy in order to reduce cost	74.4
Willingness to educate employees on energy conservation	9.4
Willingness to consult professionals for energy auditing	2.7

consumption is presented in Fig. 5. Over 25% of the firms consume more than 5000 kW h monthly. On the other hand, about 30% of the firms consume <1000 kW h monthly.

Diesel fuel consumption is presented in Fig. 6. More than 25% of the firms consume 100 l or less of diesel fuel per month. More than 40% of the firms have a consumption of 500 l or more. Diesel fuel is used for different applications. Table 7 shows that about 48% of the firms use diesel fuel in steam boilers, and more than 82% use it in transportation. The table also shows heavy fuel oil consumption. It is mostly used in steam boilers (more than 60%) and furnaces (almost 30%). In addition, the monthly average spending on heavy fuel oil is presented in a footnote in Table 7. More than 83% of the firms that use heavy fuel oil spend 2000 JD (1 JD is approximately equal to 1.40 US dollars) or more per month on heavy fuel oil. The rest (about 17%) spend <500 JD per month on it. Other types of fuel, which include LPG, kerosene, wood, coke, etc., are presented in Fig. 7. More than 50% of the firms spend 100 JD or less per month on these fuels. About 10% of the industrial firms that use them spend 1000 JD or more per month.

The attitude of the industrial sector towards energy efficiency is presented in Table 8. It shows a number of factors concerning energy efficiency and conservation. Only about 24% of the firms know the exact energy prices and tariff, since rates are not fixed. For example, for a large industrial firm, the cost of electricity is priced at 0.23 and 0.45 JD per kW h during the night and day light times, respectively. Very few firms are really eager to use energy efficiently, since the firm must take certain measures and change old bad habits in order to do so. Less than 10% of the firms are willing to spend money to educate their employees on energy conservation through attending training courses, workshops, etc. Less than 3% are willing to consult professionals that give them solutions to conserve energy and reduce cost. However, it is interesting to note that almost 75% of the firms are eager to conserve energy in order to reduce their energy bills. The foregoing shows that in Jordan and in most developing countries as well, energy conservation issues can be discussed, but action is rarely taken, unfortunately. It is, therefore, up to the officials who must begin to implement new programs to improve energy efficiency. For example, the use or introduction of more advanced energy systems can achieve energy conservation. Also, due to the increase in fossil fuel cost, implementing or employing renewable and unconventional energy resources must be considered by the decision makers.

5. Conclusions and recommendations

The characteristic type of industry in Jordan is mostly small. The most popular types of energy sources that are attractive to the Jordanian industry are heavy fuel oil and diesel fuels in addition to electricity. Electricity is widespread, and it is mostly purchased from NEPCO. It can be concluded that on the one hand, the industrial sector is eager to conserve energy in order to reduce cost, while on the other hand, it is not willing to spend money on educating their employees on how to conserve energy or to consult energy professionals on how to conserve energy.

It is recommended that the firms be exposed to using more advanced energy systems. Thus, energy conservation may be achieved. Also, it is recommended that renewable energy sources be employed in the near future by the industrial sector.

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