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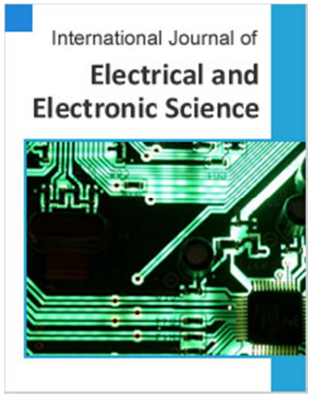

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Approach to Jordanian Energy Resource Efficiency Management Using Energy Efficiency Practices

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Abstract

This paper presents a useful way to maintain the operation of the Jordan Electric Power System in an effective, economic and with minimal losses. The paper discusses available technologies for energy-efficient equipment and energy conservation methods. The total volume of energy imports and the corresponding increase in energy demand have been provided. On the basis of the Jordanian strategy to ensure the security and reliability of electricity supply, as well as to reduce reliance on fuel oil, basic information on the development of the domestic sector and the refining sector and the evolution of production and Electric power consumption in Jordan have been presented. The main content of the document focuses on the main tools of support of conservation and management of the energy. Support tools such as energy and public awareness, energy regulation and energy information programming have been demonstrated and explained.

1. Introduction

In Jordan, there has been a growing concern about energy consumption and its adverse impact on the environment. The rational and efficient use of energy resources has a special importance for the Jordanian industry. Therefore, multifaceted information on the use of industrial energy is essential. By introducing the concept of rational use of energy aimed at reducing energy consumption to a degree corresponding to the optimal use of all limited economic resources, this definition indicates that those proposals and measures that lead to a more rational use of energy They have to show advantages over the actual current situation. Energy losses in a large number of industries exist, and reducing such losses can improve energy conservation significantly [1]. Economic growth based mainly on industrialization, combined with population growth and urbanization, has created an increasing demand for energy. Energy growth in developing countries has recently taken place due to major developments in a number of areas, such as the residential, commercial, and industrial and transportation sectors [1, 2]. Conserving energy will undoubtedly save investment in the development and generation of electric power capacities, while consequently improving the nation's current economy [3, 4]. The five-fuel strategy recognizes renewable energy resources as the economy's fifth fuel after oil, coal, natural gas and hydroelectricity. A 10-year action plan for accelerating growth in Jordan (2015-2025) emphasizes the security, reliability, and cost-effectiveness of energy [5].

2. Status of Energy Consumption in Jordan

Jordan is a rapidly growing country, both as a result of its demographic population and due to an influx of refugees over the last decade. Due to the lack of indigenous energy resources, and given that any shortage of supplies will threaten the stability of the country in the midst of an unstable region surrounded by unstable countries due to armed conflict, Jordan depends heavily on its imports to meet the growing demand for energy [6].

Demand is expected to double to 15.08 Mtoe (million tons of oil equivalents) by 2020 from 7.58 Mtoe in 2007. The main objectives of Jordan's updated Energy Master Plan is to reduce dependence on imported energy, With a target for the renewable energy (RE) meeting (ie 600-1000 MW wind, 300-600 MW solar energy and 30-50 MW biomass) of energy demand by 2020 [6]. The prices of energy imports have increased in recent years, which have caused a sharp fall in the Kingdom budget, which has led the Government to act. Table 1 shows the final demand for commercial energy by sector and the trend of the final energy used by sectors from 2008 to 2016 [7].

Table 1. *Jordan Sectoral distribution of electrical energy consumption.*

	2008	2009	2010	2011	2012	2013	2014	2015	2016
The domestic sector	4459	4926	5219	5548	6126	6265	6580	6723	6833
Industrial sector	3128	2981	3258	3445	23461	3517	3877	3614	3610
The commercial sector	1925	1978	2148	2269	2427	2415	2358	2380	2390
Water pumping	1713	1761	1867	1939	1955	2076	2287	2320	2340
Street lighting	284	310	315	334	305	291	316	340	350
Total	11509	11956	12843	13535	14274	14564	15418	15377	15323

The Demand for primary energy in 2016 was 9320 thousand tons of oil equivalents (TTOE), with a growth rate of 5.0%. Consumption Average per capita Primary energy in 2016 was approximately 1310 kg of oil equivalent (Kgoe) compared to 1280 kg of oil equivalent (Kgoe) in 2012 as shown in Table 2. At present, the country is in an economic risk situation, provided that Egypt's natural gas supply will never return to record levels. [8]. As a result, the government was forced to discuss and adopt alternative strategies to provide the country with the necessary primary energy. These include importing liquefied natural gas (LNG) and focusing on renewable energy (RE) and energy efficiency (EE) on a more urgent basis.

Table 2. *The demand for primary energy in Jordan.*

Year	Total energy demand (TTOE)*	Growth Rate %	Primary Energy Capita (kgoe)
2009	7739	5.5	1294
2010	7357	4.9	1204
2011	7457	1.4	1194
2012	8206	10.0	1280
2013	8157	0.6	1243
2014	8461	3.7	1261
2015	8944	5.7	1280
2016	9320	5.0	1310

*It includes quantities of coal consumed by some industries since 2012

2.1. Crude Oil

Jordan's proven crude oil reserves are very small, and are currently limited to the Hamza oil field located near the southern borders with Saudi Arabia. The following chart illustrates Jordan's crude oil production in the Al Hamza oil field over the last decade. Figure 1 show, domestic production of crude oil has been declining over the past period, with some analysts suggesting that the Hamza oil field used to produce more crude oil in the 1990s than today. Annual domestic production of crude oil actually declined around 41% from 2008 to 2011, and by 2014, it had a total of 17 oil wells, but produced only 20 oil barrels/day, according to a statement made by the Minister of Energy. This indicates that the capacity of this oil field has not developed during the past period. The decline in output has been attributed by some analysts to the participation of weak or in some cases "imaginary" foreign companies in oil exploration activities in Jordan. This has recently been underscored by the energy committee. This statement came after several international firms were awarded oil exploration and development contracts during the previous period, with no concrete results from their operations [9, 10].

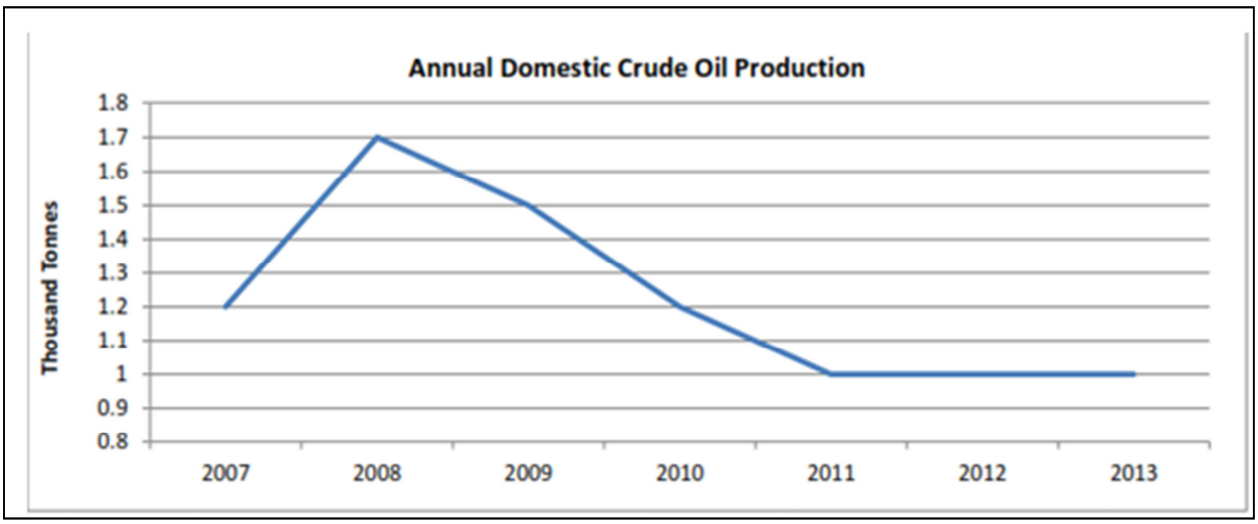

Figure 1. *Domestic production of crude oil.*

2.2. Imports

Due to the scarce exploration and development of existing resources, Jordan had to continue to rely on crude oil imports to meet its energy needs. Prior to 2003, Iraq offered Jordan an annual oil subsidy of $ 300 million per year. After 2003, Jordan went on to use more natural gas and fewer petroleum products for its electricity generation needs. But the halting of imports of Egyptian gas implied a return to depend on traditional petroleum products to meet the energy needs. The next Figure 2 shows the value of oil imports during the previous period. The first thing to note is the increase in the total volume of energy imports, which corresponds to the increasing energy demand over this period, the drop in natural gas imports from the Egypt beginning in 2010, and the slowdown in domestic production as noted above. In total, the volume of petroleum imports increased by almost 30% from 2012 to 2016 [11, 12 and 13].

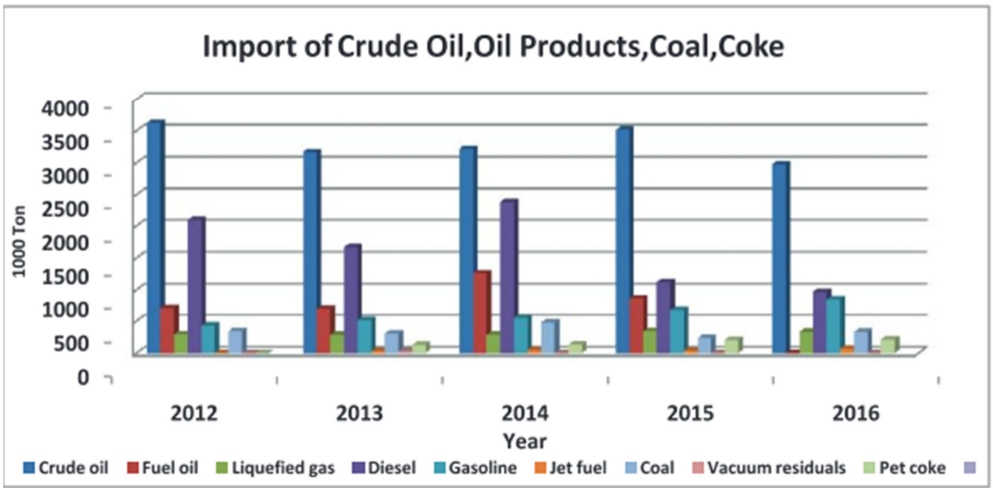

Figure 2. *Imports of crude oil and petroleum products.*

2.3. Natural Gas

As shown in Figure 3, global natural gas production increased by an impressive 7.8% following its slump in 2009, where production declined by 3.2%, in 2011, however, production decelerated to a 2.5% growth, reaching 3,365.8bcm (billion cubic meters). America produces some 30.6% of the world production, and it registered a strong 4.9% increase in production in 2011. The CIS countries also managed a 2.6% increase in production, buoyed by the 2.7% increased production in Russia. Meanwhile, Asian production was somber in spite of an 8.7% rise in China's production, due to declines in output in India, Indonesia, Japan, and South Korea. Africa and the Pacific both experienced drops in their output of 6.1% and 1.8%, respectively, but the star of the show was the Middle East, which hiked up production by a whopping 11.1%, increasing its output from 471.6bcm in 2010 to 524.1bcm. Iran and Saudi Arabia are the largest producers of natural gas in the region.

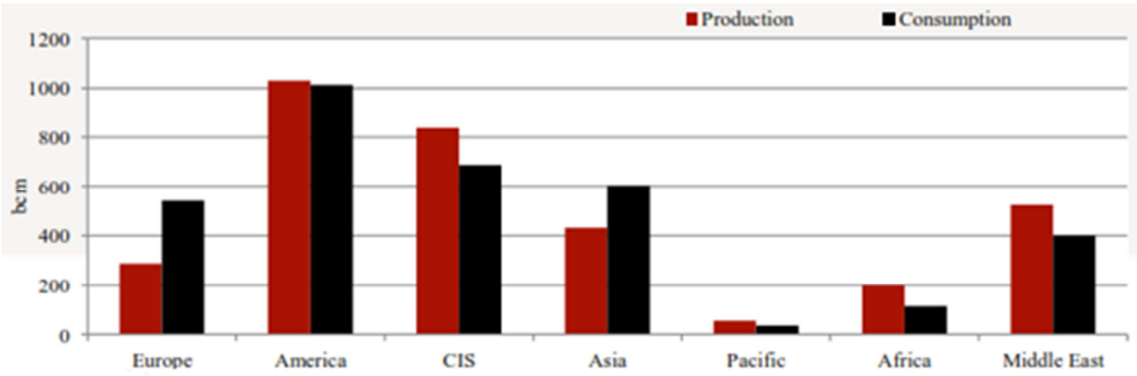

Figure 3. *Natural gas production and consumption.*

Global consumption declined in 2009 by 2.3% to 3,065.1bcm in response to both higher gas prices and weak economies. In 2010, the recovery in demand surpassed production, with an 8.2% increase in consumption. Alongside the slowdown in production in 2011 was a slowdown in consumption growth to 2.8%, reaching 3,394.5bcm. Weakened economies in Europe led to a 9.0% drop in gas consumption, largely as Germany, the United Kingdom and the Netherlands reigned in their usage. All other regions of the world displayed positive growth in consumption, with America's demand rising 2.8% to 1,013.0bcm, Asia's demand increasing by 7.9% to 602.4bcm, and CIS's demand reaching 686.3bcm from 666.5bcm in 2010 [14, 15].

2.4. Electricity

The demand for electricity had increased and reached 3% in 2016, the highest rate recorded by household and street lights and reached 7%, 4% respectively. The overall amount of electricity imports through interconnection network with Egypt and Syria reached 334 GWh registering a decrease e of 45% comparing to year 2015. The Ministry of Energy and Mineral Resources and the National Electricity Power Company made several actions to meet the growing demand.

2.5. Electricity Generation and Consumption

The volume of electricity generated in 2016 reached 19390 GWh registering a growth of 2. 5% of that in 2015 while the electricity consumed for the same period reached 16669 GWh recording a growth of 3% approximately comparing with that in 2015. However, the Peak load of the electricity system has recorded 3250 MW in 2016 pointing a decrease of 1% compared to that in 2015. The following Tables 3, 4 and 5 demonstrate the development of production and consumption of electricity as well as the distribution of the consumption and the rate across sectors [16-18].

Table 3. *Growth of electricity production and peak load during 2012-2016.*

Year	Peak load (MW)	Growth rate %	Electricity Generated GWh	Growth rate %
2012	2880	3.2	16595	13.3
2013	3100	7.6	17261	4.0
2014	3020	2.5	18704	8.4
2015	3300	9	18911	1
2016	3250	1	19390	2.5

Table 4. *Sectorial distribution of electricity consumption and growth rate during 2012-2016 (GWh).*

Sector Year	Household	Industry	Commercial	Water pumping	Street lights	Total	Growth rate %
2012	6126	3461	2427	1955	305	14274	5.5
2013	6265	3517	2415	2076	291	14564	2.0
2014	6580	3877	2358	2287	316	15418	5.9
2015	6938	4013	2460	2426	336	16173	5
2016	7448	3939	2447	2485	350	16669	3

Table 5. *Percentage of sectorial consumption of electricity during 2012-2016.*

Sector Year	Household	Industry	Commercial	Water pumping	Street lights	Total %
2012	43	24	17	14	2	100
2013	43	24	17	14	2	100
2014	43	25	15	15	2	100
2015	43	25	15	15	2	100
2016	46	23	15	15	2	100

In addition to utilities, there are also a number of industrial companies that generate electricity in their own plants, where some of them feed the excess electricity to the Jordanian networks. However, due to the circumstances in the region,

import has stagnated completely from Syria since 2012 or reduced from Egypt

3. Supportive Tools of Energy Conservation & Management

The support tools and current methods are other ways for successful energy technology and conservation policy. There are three classified approaches for the supportive tools known as energy and public awareness, energy regulations, and energy information and programming. The three classified approaches illustrated briefly in figure 4. A discussion and explanation of the main points in each approach are introduced in the following paragraphs.

3.1. Energy and Public Awareness

Public awareness could implement policies and programs focused on creating mass awareness and extending simplified information and knowledge about energy conservation topics. In order to achieve this purpose, it is possible to use available methods and techniques, like video, films, radio, TV, communication and networking, posters, and advertisements in public facilities, i.e. cultural centers. It is also possible to use, the local press to get wide coverage in the field of energy conservation [19, 20]. Exhibitions are a very important medium for direct publicity for a vast number of people within a short period of time. The exhibitions could present samples for new energy efficient devices and renewable energy equipments, e.g. solar water heaters, photovoltaic lighting and others. Publicity handouts and brochures in local languages should also be distributed. It is also important to introduce such exhibitions in remote areas for more publicity of the new technical ideas. Organizing conferences, seminars, symposia's, meetings and workshops could bring about mutual interaction, fresh information exchange in specialized fields of knowledge and more awareness among the people [21, 22].

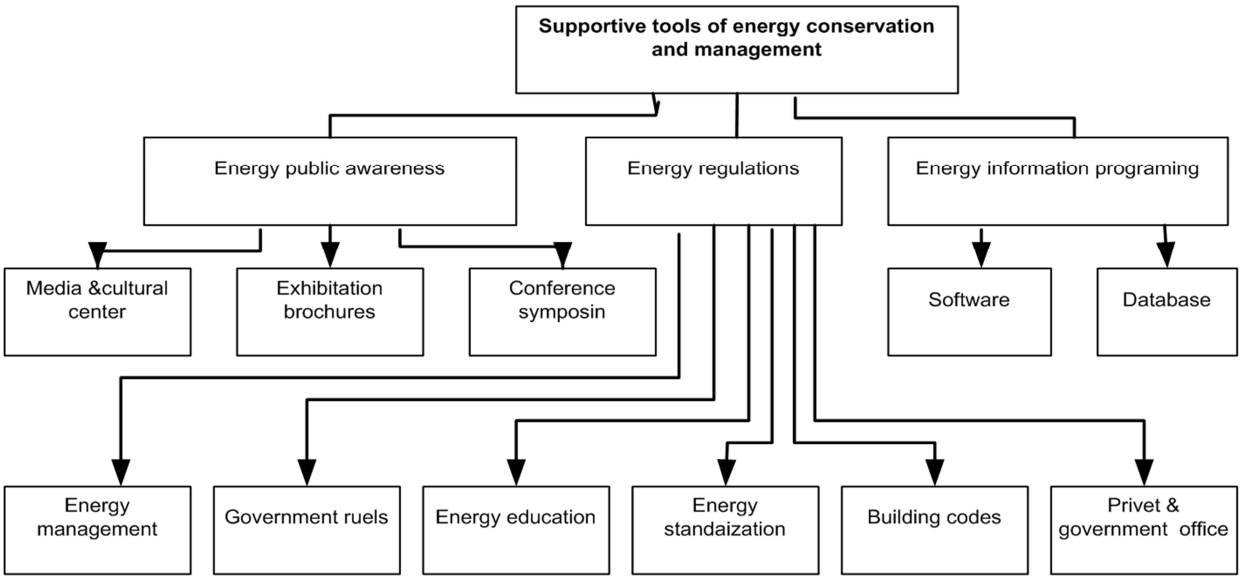

Figure 4. *Supportive tools of energy conservation and management.*

3.2. Energy Awareness

Energy awareness is the understanding of energy consumption. Energy awareness is affected by a number of factors. One of these factors is the visibility of energy consumption. Increasing the level of visibility reduce the level of energy consumption by up to 20%, Factors that increase energy awareness of their nature are financial and enforcing ones. Depending on how financially concerned occupants are greatly affects energy consumption. Environmental impacts may also increase energy awareness as more people are starting to think about what effect their energy use has on the environment. This factor varies and very much depends on how ecologically minded an individual is [23, 24].

3.3. Energy Regulations

Energy regulations are essential for any successful energy policy. Proper energy management includes a number of these regulations for energy consumption and direct / indirect electrical charges. Includes variable electric power tariff (kWh) for base and peak loads. Decision-makers on energy could initiate rules and laws to reduce energy losses in various sectors through the incorporation of energy conservation technologies [25, 26]. Energy education is another way of establishing a sound energy education system in the field of energy conservation by introducing new courses for conventional and renewable energy sources. Such education schemes may include basic energy principles, consumer cues and relevant environmental effects. It may also include the development of new laboratory experiments in schools, universities and technical schools. It is also important to pursue academic research work and graduate studies in collaboration with industry in order to solve problems directly related to conservation and energy management.

A recent study aimed to identify strengths and weaknesses as well as to define the level of knowledge related to energy education among older students in engineering faculties in Jordan. He reviewed existing curricula in different engineering disciplines at B.Sc. Level from the energetic point of view. Special attention has been given to RE education with the aim of identifying the level of awareness among older students enrolled in engineering programs related to the energy situation in Jordan, energy efficiency, RE and, and the use and Applications, and 6 private are offering energy-related courses in their curricula for various engineering disciplines. These courses are believed to help undergraduate students receive more intensive education in energy efficiency fields and it. However, the necessary human and technical resources related to energy efficiency and RE is very limited in these universities and almost absent in some cases [26].

3.4. Energy Information and Programming

Information is a link between a system and its environment. The relationship between information and knowledge in energy could be simplified in Figure 5.

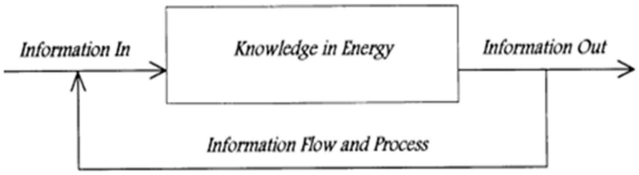

Figure 5. *A simplified diagram for energy knowledge and information.*

Energy information may include the latest scientific and technological advances published in useful books, periodicals, reports and journals [29]. Energy information packages should be provided to decision makers, planners, researchers and the public [30]. Software for energy projects should be designed and built to solve problems related to energy conservation and management. This is a useful way to keep the entire energy system running under investigation. More recently, the importance of creating a suitable data bank has been very important in increasing research methodology, such as energy consumption and conservation. Activities in the field of energy databases that could be included [31, 32]:

a) Database on local projects and agencies involved in the field of energy conservation.
b) Technical installation directory of various equipment and devices.
c) Database of the latest energy technologies.
d) Database network of national and international levels.

4. Conclusions

The goal of electrical energy conservation in Jordan can be achieved through the use of the efficient modern energy technologies. Efficient utilization of energy resources, diversification of electrical sources, and minimizing of the wastages in the electrical power system are essential factors for any successful energy policy. Thus, as being done in other parts of the world, raising the public awareness, implementing the proper energy regulations, educating individuals at different levels about energy conservation empowers their capacity and preferences to support and take part in reaching the goal of reducing the dependency of the imported energy. Immediate actions, at all levels, in the fields of energy conservation in order to efficiently operate and economically produce sustainable energy generation systems.

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