SEISENSE Journal of Management
Vol 1 No 5 (2018): DOI: https://doi.org/10.5281/zenodo.1452373, 16-37
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Jordan Energy Sector Choices and Challenges

Malek Khalaf Albzeirat — School of Manufacturing Engineering, Universiti Malaysia Perlis, Malaysia
Falah Mustafa Al-Saraireh — Department of Mechanical Engineering, Mutah University, Mutah, Jordan
Muhammad Iqbal Hussain — School of Manufacturing Engineering, Universiti Malaysia Perlis, Malaysia
Rosmaini Ahmad — School of Manufacturing Engineering, Universiti Malaysia Perlis, Malaysia

Energy is the lifeline for the whole of the service and industry sector in any country. Any imbalance in the energy sector is reflected on other sectors and the standard of living in the country. Energy problems are one of the most complex challenges facing governments. Especially in countries that rely on external energy sources. This situation is increased complexity by the presence of immediate changes in international relations and in fuel prices. Jordan is among the countries that depend on foreign energy sources and is located in the most volatile regions of the world in middle of the Middle East. Jordan is suffering from a permanent energy crisis that needs solutions which are compatible with many factors that may affect energy choices and decisions and alternatives available to get out of this crisis. Therefore, this study will attempt to focus on the Jordanian situation and identify the challenges and available choices. A comparison will be made of the available alternatives through Analytical Hierarchical Process (AHP). The results show that the priority of the energy solutions is to expand the mining of uranium and shale as well as to expand the construction of renewable power plants, as well as maintenance and modernization of existing plants and the establishment of new refineries.

Keywords: Energy Sector, Analytical Hierarchical Process

Introduction

Since the beginning of civilization, energy was an important factor in human civilization the world has witnessed wars for energy in recent decades, and this shows its importance. In addition, the world has witnessed diversified sources of energy after being confined to specific sources. In the past, energy sources were limited to the natural sources, such as burning plant residues and plant oils. At that time, the uses of energy were limited to lighting and cooking within the scope of individual production. With the development of civilization, the demand for energy has increased, and it has become a community need that is not limited to the personal things like cooking, heating etc. In other words, it has become an essential interfere in everything that surrounds human life and industry area. Consequently, the installation of producing energy has emerged. At the beginning, they were associated with mining operations to extract coal, oil, and gas to be used in the energy production. These three materials, i.e. coal, oil and gas, were the most important sources of energy. Despite the importance of these sources, there are other factors that attract the scientific research towards searching for new energy alternatives. The most prominent of these factors are cost, restrictions in the places where they are found, the limited quantities of oil and gas (Jaber, Elkarmi, Alasis, & Kostas, 2015; Luo, Wang, Dooner, & Clarke, 2015; Mahlia, Saktisahdan, Jannifar, Hasan, & Matseelar, 2014; Rahim & Liwan, 2012), as well as factors related to the environment and global climate (da Graça Carvalho, 2012; Hu et al., 2016; Nejat, Jomehzadeh, Taheri, Gohari, & Majid, 2015; Schaeffer et al., 2012), politics and international relations (Boussena & Locatelli, 2013; Ozawa, 2016; Stirling, 2014). These factors are considered as negative factors required for the search of alternatives for energy, as well as examining the processes of improving and developing the available power plants through the lowest costs and the available capacities. The problems in the energy sector are not limited to natural resources but are also influenced by many factors such as international relations, economic conditions and regional stability. As a special case in this paper, Jordan suffers from several problems in the energy sector. This study will attempt to review the challenges facing the energy sector in Jordan and its implications for trying to develop future solutions to the energy problems in Jordan.

Background

The concept of energy on Earth passed through many stages, where energy was limited to its concept of physical energy, mobility and life functions, and then evolved to encompass the things that are heat-emitting, such as the sun and the fire produced by combustion of wood, Oil and gas, and alternative energy based on modern technology. Currently, there is a diversity of energy sources. Figure 1 shows the primary energy sources (Keyhani, 2016):

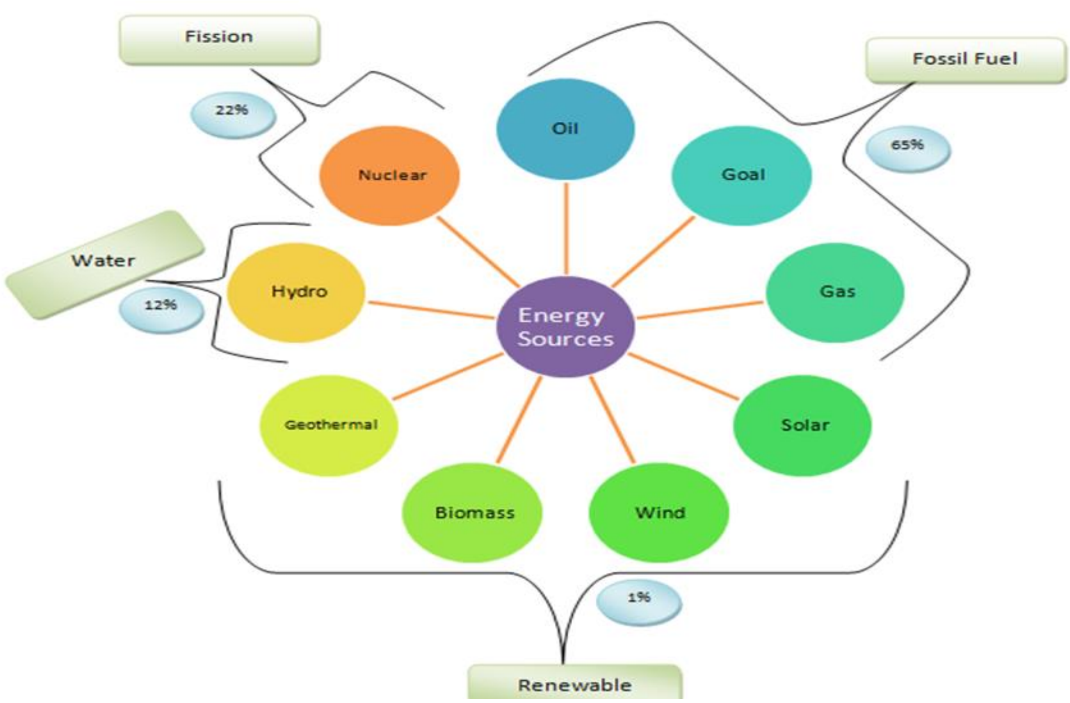

Figure 1 - Primary Energy Sources

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In general, the energy sector includes many companies such as, oil and gas exploration companies, coal mining companies, oil and gas companies, transport companies, storage companies, refineries, oil industry companies, power generation companies, electric transport companies, and distribution companies. Energy is found in the following forms; Kinetic energy, Potential energy, Electricity, Nuclear Energy. Electricity is the main axis in the energy sector, and the process of production of electric power is carried out through the power generation plants. According to the International Energy Agency, Table 1 shows the main sources of electricity production and the production ratios of each source.

Table 1 - Main Sources of Electricity Generation (International Energy Agency)

NO	Type of Energy	Percentage of Amount
1	Fossil Fuel	65%
2	Hydroelectric	16%
3	Nuclear	11 %
4	Biofuels and Waste	3%
5	Renewable Energy and	4%
6	Other Sources	1%

Based on Table 1 and the reviewing of previous studies (Albzeirat et al., 2018), the most important types of power plants include the following:

- Fossil Power Plants: is a power station which burns a fossil fuel, such as coal, natural gas or petroleum to produce electricity.
- Tidal Power Plants: is a power station which converts the energy obtained from tides into electricity.
- Wave Power Plants: convert the energy of waves to electricity.
- Solar Power Plants: convert the energy of solar heat to electricity.
- Wind Power Plants: convert the energy of winds to electricity.
- Hydroelectric Power Plants: convert the energy of gravitational force of flowing water to electricity.
- Geothermal Energy Power Plants: convert the earth through natural processes to electricity.
- Biomass Energy Power Plants: is one of the renewable energy sources, which refers to living and recently dead biological material that can be used as a fuel in power plants.
- Nuclear power plants: is using uranium as fuel to generate a large amount of electricity.

The establishment of electrical stations is based on several factors according to the perspectives of each country, as follows:

- Environmental factors such as global warming.
- Economic factors represented by the inability to absorb the high prices of fossil fuels.
- Industrial factors are the ever-increasing need for energy.
- Demographic factors.

It is important to identify alternatives available in the energy sector. Analytical Hierarchical Process (AHP) - one of the most popular mathematical methods used in the decision-making process among a range of alternatives- is the method of hierarchical analysis, as it has extensive uses (Badri et al., 2016; Hussain Mirjat et al., 2018; Koç & Burhan, 2015; Malkawi & Azizi, 2017).

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Energy Sector in Jordan

Jordan depends on gas and oil in the production of electric power. More so, Jordan imports the energy sources from abroad at high cost, which has been affecting the Jordanian economy. The energy sector in Jordan is based on companies operating in the energy field of:

Importing oil and gas: Jordan depends on the system of land and sea transport in the transport of oil and gas. In addition to pipelines, imports are through the Ministry of Energy and intermediaries in the oil and gas trade. According to reports issued by the Ministry of Energy for previous years, the average daily consumption of different fuels is estimated at 120 thousand barrel of oil per day with a lost percentage during land and sea transportation is estimated at 0.0003. The port of Aqaba is the main terminal for receiving oil and gas, which is transported by oil tankers or pipeline. Figure 2 shows gas pipeline between Jordan and Egypt. The main section of the pipeline through Egypt and Jordan is 36" in diameter, with compressor stations located approximately every 200km – providing for a maximum annual gas discharge of 10.3 billion cubic meters. The pipeline's capacity could be increased by 50% by roughly doubling the number of compressor stations (to every 100km). It is clear in the map that the pipeline extending in Egyptian territory is located in a conflict zone.

Figure 2 - Pipeline between Jordan and Egypt

Power generation through power plants: includes thermal power plants that rely on fossil fuels (gas, oil), as well as renewable energy plants that include (solar, wind). There are also nuclear power plants that are still under construction. Imported natural gas is the primary source of fuel for electricity generation. The total efficiency of these stations is about 41% according to the performance indicators of the companies engaged in the generation.

Electrical transmission is the bulk movement of electrical energy from a generating site, such as a power plant, to an electrical substation. The interconnected system in Jordan consists of the main generating power stations, 132 kV and 400 kV transmission network, this transmission network interconnects the power stations with the load centers and different areas in the kingdom. The system also includes the 230 kV, 400 kV tie lines with Syria and 400 kV tie line with Egypt and the distribution networks which serve about (99.9 %) of the total population in Jordan. Currently, the total system installed capacity is about 3186 MW. The total length of 132 kV network and above is about (4121) km- circuit and the total installed capacity of the substations is (10303) MVA. The efficiency of performance is 98% according to the performance indicators of the company working in the field of electric transmission. Figure 3 shows the main electrical transmission network in Jordan. It is clear that the transmission lines extend within most industrial and residential areas and major cities and it also extends within the main border points with Egypt, Iraq, Syria and Saudi Arabia and this indicates the ease of conducting electrical connection with neighboring countries.

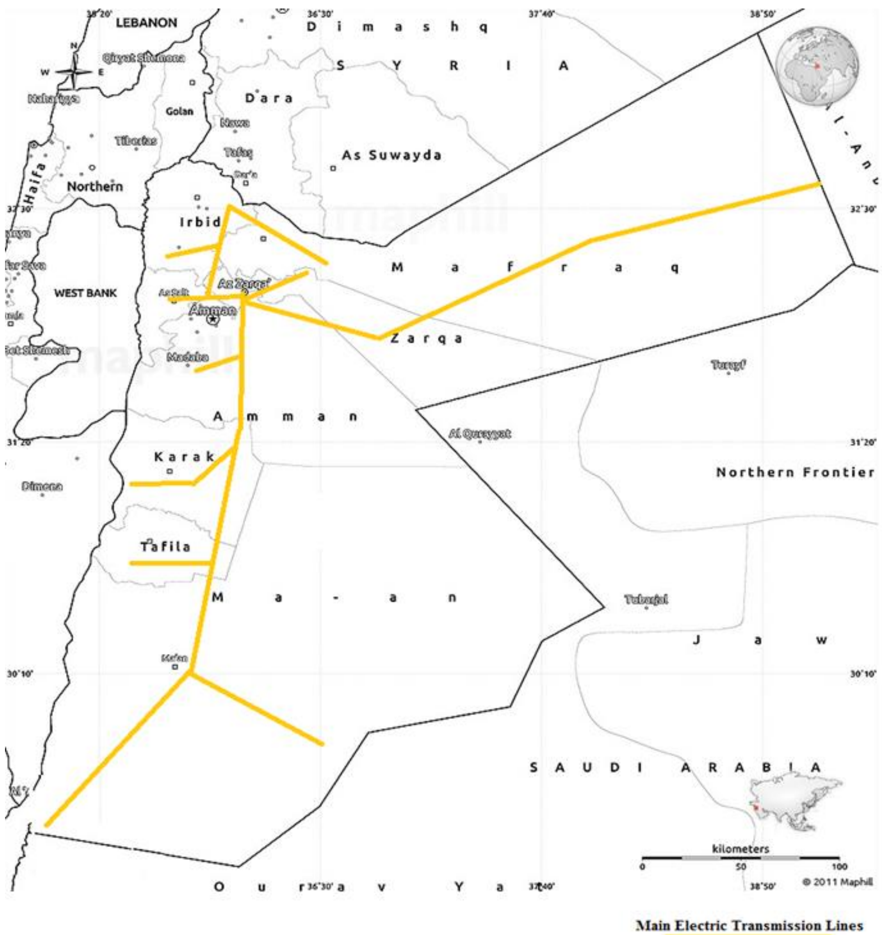

Figure 3 - Current Electric Grid and Interconnection in Jordan

Distribution: Is the process of distributing electricity to customers after the arrival of electric power by the electric transmission company. In Jordan, there are three companies operating in the field of distribution. Distribution is carried out according to the division of the regions (Southern, Central and Northern). According to the reports issued by the Ministry of Energy, the loss of energy in these companies is 14%. Exploration of oil, gas and oil shale: Despite the existence of Jordan in a Middle East region. However, oil and gas exploration companies has not succeeded in finding these materials in Jordan, many experts predict the presence of oil in eastern Jordan, southern Jordan and the Dead Sea. Several studies have also indicated that there is a huge wealth of oil shale ores in the Jordanian desert areas

According to (Dyni, 2006; Qian, 2003). Jordan has the eighth highest reserve of oil shale in the world and in an estimated quantity 4000 Million Tons. Figure 4 above indicates the geographical distribution of the location of rock shale in Jordan.

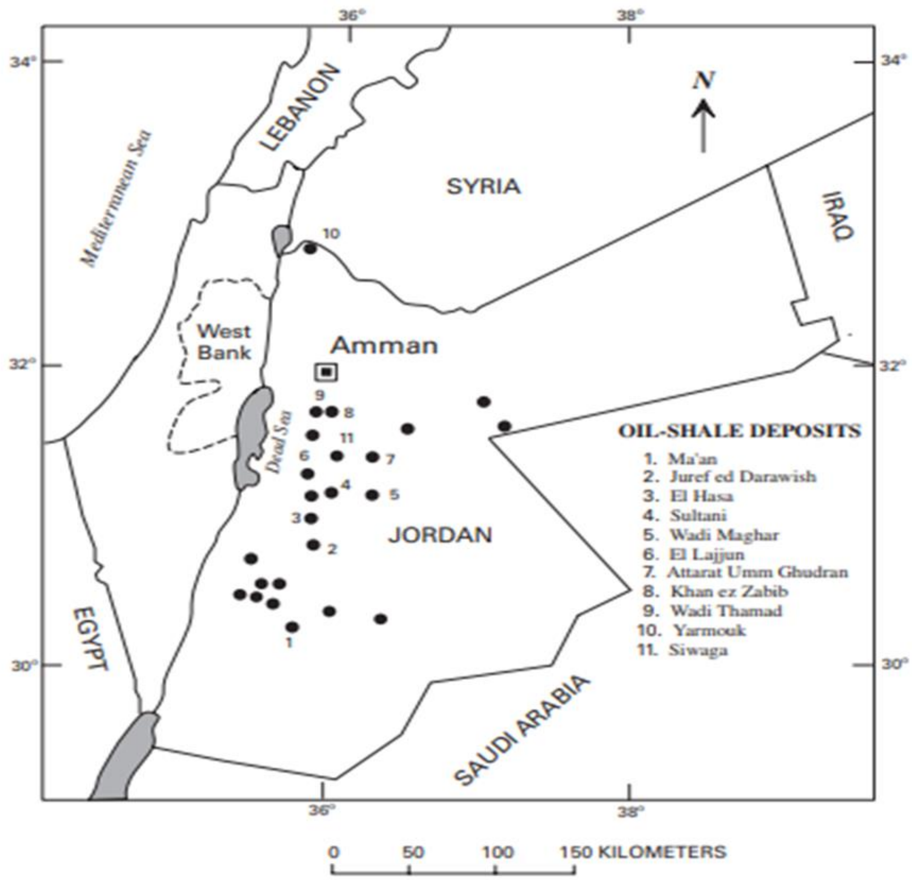

Figure 4 - Location Map of the Distribution of Shale Oil in Jordan

Renewable energy companies: These stations rely on renewable sources of electricity, including wind and solar power stations. In the last five years, electricity production has been started through solar and wind power stations in Jordan which currently account for about 6% of annual electricity production. And the various climatic environment in Jordan to the existence of many areas that are suitable for the construction of these stations and within the high productivity. Most of the Jordanian lands fall within the high horizontal radiation area, where the radiation reaching the earth's surface can be represented in different ways. Global Horizontal Irradiance (GHI) is the total amount of shortwave radiation received from above by a surface horizontal to the ground. This value is of particular interest to photovoltaic installations and includes both Direct Normal Irradiance (DNI) and Diffuse Horizontal Irradiance (DIF). DNI is solar radiation that comes in a straight line from the direction of the sun at its current position in the sky. DIF is solar radiation that does not arrive on a direct path from the sun but has been scattered by molecules and particles in the atmosphere and comes equally from all directions according to global radiation maps as indicated by the radiation map in Figure 5.

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The digital census of the rate of sunshine hours in Jordan per year is 310 days in the last ten years, and the rate of 3650 hours per square meter. With regard to wind, it is known that the amount of wind power

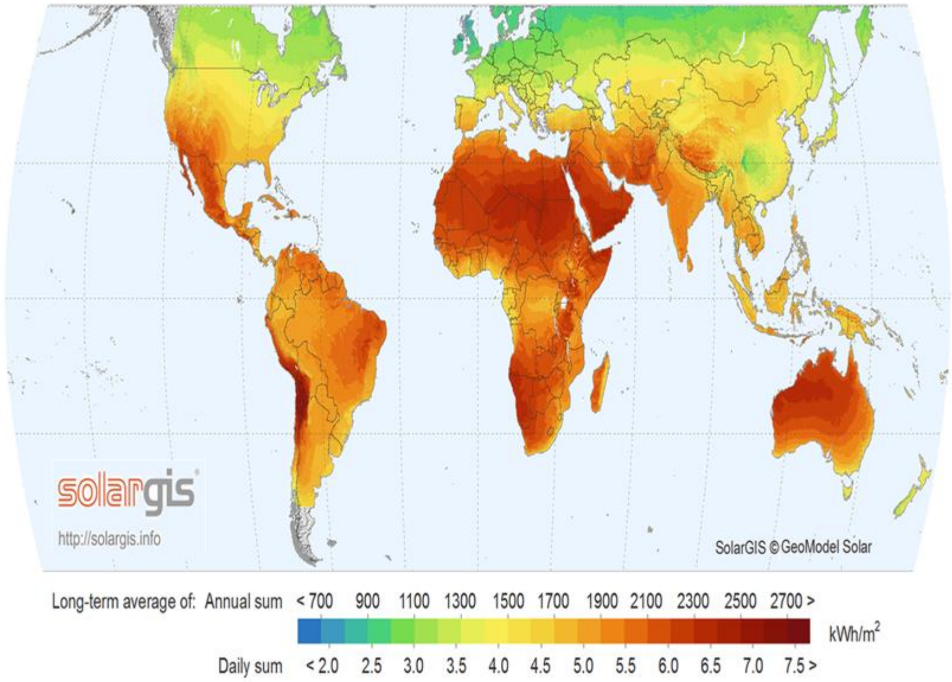

Figure 5 - Global Horizontal Irradiation

production is based on a positive relationship with wind density and speed, according to the equation

$P = \frac{1}{2} \mathrm{P} \, \mathrm{V}^3 C_P$ Where

$p =$ Power (Watt (W)), P $=$ Density $\left(kg / m^3\right)$, V = Wind Speed (m / s), C_P = Power Coefficient.

Due to mountainous areas in Jordan, the country is densely winded with an appropriate speed to generate electricity using mechanical turbines. Currently, Jordan has three main wind stations and produces about 1% of the total energy. As for the other types of nuclear power, there is a project under construction. Jordan's Ministry of Energy and Mineral Resources reports that there are large amounts of uranium ore in Jordan, which encourages the trend towards nuclear energy as a solution to the energy problems. It is possible that the tendency to produce electricity through nuclear energy is effective if it is planned and implemented within scientific standards.

Refinery Company: In Jordan there is one company specialized in the field of petroleum refineries, and this company is in the north of Jordan, and is the main source of petroleum derivatives, Asphalt (Blown and Liquid), Gasoline, Kerosene, Aviation Fuel, Diesel and Fuel Oil. At a rate of 100 thousand barrels per day. Currently, the company's production does not cover all the Kingdom's needs for oil products, and Jordan must rely on imports from other countries. The company suffers from old technology, and it needs expansion and modernization.

Fuel distribution stations: It is a companies working in handles the distribution and sale of petroleum products within various stations in the country such as (kerosene for heating, gasoline and diesel for fuel for different means of transport).

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Challenges of the Energy Sector in Jordan

There are many challenges facing the energy sector in Jordan. These challenges are geographical, political, population and economic development, these challenges will be reviewed below:
Geographical: Jordan is located in the heart of the Middle East lying between 29° and 34° north latitudes and 35° and 39° east longitudes, sharing borders with Syria to the north, Iraq to the East, Saudi Arabia to the south and Palestine to the west. The total area of Jordan 88,780 km2 and the percentage of agricultural land is about 11% of the total area according to World Bank documents for 2017. The topography of Jordan is mostly a desert plateau, and highlands in the western areas of arable land and Mediterranean evergreen forestry. Jordan has a combination of Mediterranean and arid desert climates with Mediterranean prevailing in the north and west of the country, while most of the country is desert. Generally, the country has hot, dry summers and mild, wet winters with annual average temperatures ranging from 12 to 25 ºC and summertime highs reaching above 40º C. This location and geographic nature explain the high rate of solar radiation in Jordan. This moderate rate of temperature and solar radiation is suitable for the expansion of solar and wind power plants. Thus, Jordan's geographic challenge within the expansion of solar and wind power production is a very limited challenge.
Population Growth: Jordan's demographic situation has changed rapidly over the last 60 years, with an estimated population of 9.5 million by mid-2015, representing a fivefold increase of the 600 thousand registered in 1952. The population density of the country is about 106 inhabitants/km2. Population growth over the past 15 years has exceeded 100%, which is one of the highest in the world. Population growth is a real challenge for most sectors, including the energy sector. Table 2 shows the population growth rate and the main reasons for this growth. This challenge can be formulated through the following system of equations: Figure 6 shows the logical relationship between population growth and services and the Figure 7 shows the traditional solutions for the case of a lack of services.

Figure 7 - Relationship between Population Growth and Services

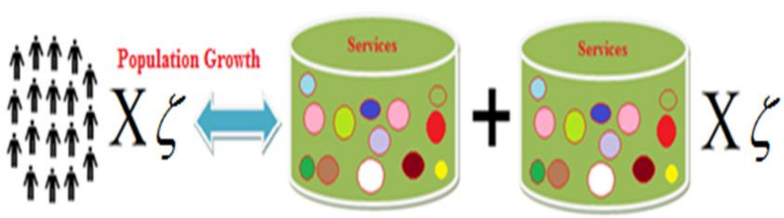

Figure 6 - Traditional Solutions

Since there is a mathematically logic for population growth, there is logic to an equation describing the need for balance of services versus the population, it could be clarified as follows:

$S_{ag} = S_{bg}(1+\zeta)$,

where

S_{ag} : Quantity of Services after growth.

S_{bg} : Quantity of Services Before growth.

ζ : Population growth rate.

This indicates that the growth in energy demand has already taken place in previous years, which requires growth in actual energy production to ensure a balance between population growth and energy demand. Population growth can therefore be described as a deep challenge to the energy sector in Jordan because of the turbulent population growth due to conflict-induced migration in the surrounding region. This challenge has a wide negative impact on the services sector in general and on the national economy.

Table 2 - Population Growth in Jordan from 1952-2015

Statistical Year	Population	Growth Rate / 10 years	Factors	World Population Prospects The 2006 Revision	World Population Prospects The 2015 Revision	Added Burden
1952	586200		Normal Growth + Emigration from Palestine			
1961	900800	0.537	Normal Growth + Emigration from Palestine			
1979	2133000	0.684	Normal Growth + Emigration from Palestine			
1994	4139500	0.631	Normal Growth + Emigration from Iraq			
2004	5100000	0.232	Normal Growth			
2015	9531712	0.869	Normal Growth + Emigration from Iraq and Syria	6 923000	7 595000 (0.468)	0.401

Economy: The Jordanian economy is one of the emerging economies that is suffering from several problems. Jordanian Gross Domestic Product (GDP) is estimated to be around $38 billion for the year 2018. The Jordanian economy is suffering from a high indebtedness of around 100% of the GDP. The energy sector represents about 20% of the value of GDP. The importation of oil derivatives is the main factor of economic vinegar in Jordan. This is a cumulative result due to negligence in the development of the energy and mining sector.

Politics: Jordan is located within a politically unstable area. The Middle East is the center of global conflicts in all forms, military wars, economic wars, sectarian conflicts, all of which reflect negatively on the Jordanian energy sector in terms of prices, securing the movement of oil as well as international relations and forced migration and its relationship with high population growth and increasing pressure on the services sector in Jordan.

Model Alternatives for Jordan Energy Sector Situation

Based on the above sections, it is clear that improving the energy sector in Jordan is subjected to an interrelated set of factors (policy (C1), economy (C2), geography (C3), and population growth (C4)). These factors are fundamental criteria in determining the appropriate decision-making mechanism to determine the most appropriate alternative to implement a comprehensive reform in the energy sector in Jordan. While the alternatives available are all that can achieve an improvement in energy production levels which can be illustrated by Table 3.

Table 3 - Available Alternatives to Improve Energy Production Levels in Jordan

Code	Alternative	Reason
A1	Development and modernization of existing stations.	The operational efficiency of thermal stations is up to 40% according to operational performance indicators.
A2	Construction of new thermal plants.	Where statistical data indicate the need for growth in total energy production up to 12% per year to cope with population growth, services and industry.
A3	Improving the transmission and distribution network	Where the data in the transport companies for the loss of up to 2% and loss of up to 14% in the distribution companies.
A4	Improving and developing the mechanism for transporting oil materials.	Where the data and reports of the Ministry of Energy to the loss of up to 0.6% due to poor handling.
A5	Improvement and development of oil refinery.	Where reports indicate a weakness in the values of conversion of oil derivatives compared to modern refineries, and this weakness causes a high loss
A6	Establishment of a modern oil refinery.	Whereas relying on one refinery is not enough to cover the rapid growth in the need for oil products.
A7	Expansion of oil exploration.	Jordan is located in the middle of a geographical environment for countries rich in oil and gas, there is likely to be an oil reserve in Jordanian territory, and continued reliance on oil imports burdens the national economy.
A8	Exploitation of oil shale.	Survey reports from Ministry of Energy and many national research centers to the oil shale stocks in Jordan are huge and estimated at 40 billion tons.
A9	Exploitation of uranium	Survey reports from Ministry of Energy and many national research centers to the oil shale stocks in Jordan are huge.
A10	Expansion of solar power plants and Expansion of wind power plants.	The calculations of direct and indirect solar radiation indicate that the Jordanian territories are an encouraging environment for the expansion of electricity production through solar panels technology. Where geographical and climatic data indicate that there are many mountain areas in Jordan suitable for expansion in the production of electricity through wind power plants.
A11	Establishment of nuclear power plants	Nuclear power plants are a solution to expanding power production in countries where oil and gas are not available.
A12	Establishment of uranium enrichment centers	The uranium enrichment process is very important in the civil and military trade system in the world, which is highly economical and does not require highly developed technology in its implementation.

AHP is one of the most popular methods used in the process of trade-offs between alternatives and depending on the above we can build a hierarchical analysis model which can be consulted in the decision-making process in determining the priorities of alternatives available as shown in the Figure 8

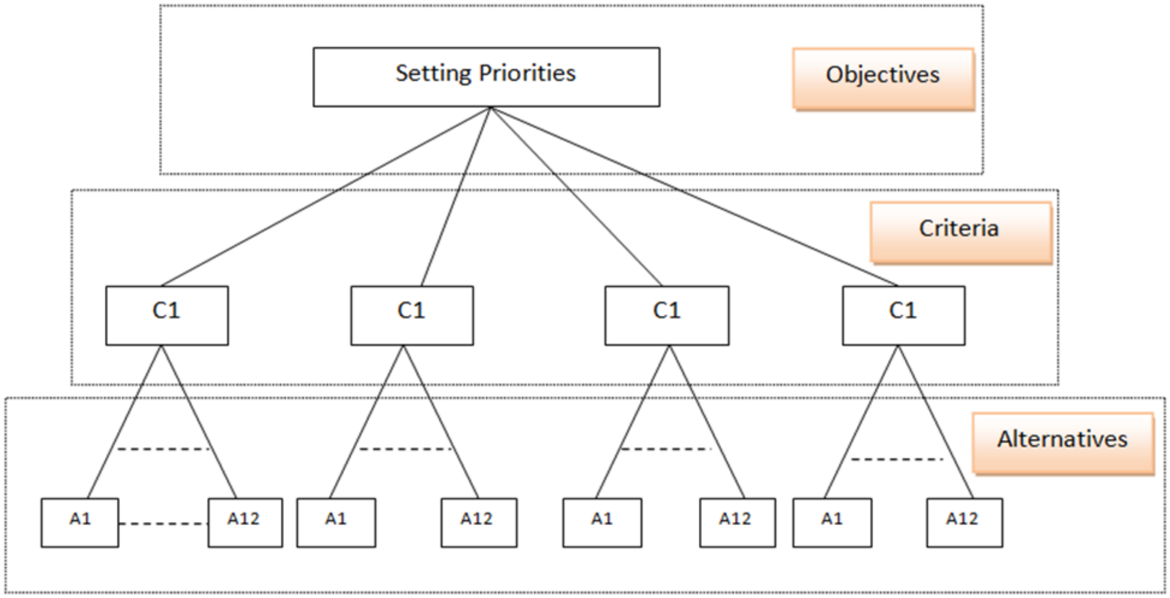

Figure 8 - AHP Model to Determine Priorities of Decisions in The Process of Improving the Energy Sector in Jordan

Based on the above model shown in Table 4, Digital data has been collected through a sample of specialists in the field of energy and economics. The following Tables 4-13 illustrate these data.

Table 4 - Identified Alternative of Criteria for Energy Sector

Criteria	Criteria	More Important	Intensity
C1	C2		
C1	C3		
C1	C4		
C2	C3		
C2	C4		
C3	C4		

Table 5 - Data Collection by Table 4

C	C1	C2	C3	C4
C1	0.07	0.06	0.10	0.08
C2	0.5	0.43	0.50	0.40
C3	0.07	0.08	0.10	0.13
C4	0.36	0.43	0.30	0.40

By analyzing the
Table 5, the results were as shown in the following matrix:

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$$M_0 = \begin{pmatrix} 0.08 \\ 0.46 \\ 0.10 \\ 0.36 \end{pmatrix}$$

Table 6 - Effect the C1 on All Alternative

Criteria	Criteria	More Important	Intensity	Criteria	Criteria	More Important	Intensity
A1	A2			A4	A8		
A1	A3			A4	A9		
A1	A4			A4	A10		
A1	A5			A4	A11		
A1	A6			A4	A12		
A1	A7			A5	A5		
A1	A8			A5	A6		
A1	A9			A5	A7		
A1	A10			A5	A8		
A1	A11			A5	A9		
A1	A12			A5	A10		
A2	A3			A5	A11		
A2	A4			A6	A6		
A2	A5			A6	A7		
A2	A6			A6	A8		
A2	A7			A6	A9		
A2	A8			A6	A10		
A2	A9			A6	A11		
A2	A10			A7	A7		
A2	A11			A7	A8		
A2	A12			A7	A9		
A3	A4			A7	A10		
A3	A5			A7	A11		
A3	A6			A8	A8		
A3	A7			A8	A9		
A3	A8			A8	A10		
A3	A9			A8	A11		
A3	A10			A9	A9		
A3	A11			A9	A10		
A3	A12			A9	A11		
A4	A5			A10	A9		
A4	A6			A10	A10		
A4	A7			A11	A12		

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Table 7 - Data Collection by Table 6

A	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
A1	1	0.25	4	1	3	3	4	4	1	1	4	3
A2	4	1	0.33	0.33	0.2	0.2	0.2	0.33	0.2	1	3	3
A3	0.2	3	1	0.33	1	1	0.33	1	3	1	3	1
A4	1	3	3	1	1	1	1	0.33	3	1	3	3
A5	0.33	5	1	1	1	1	1	1	3	1	3	5
A6	0.33	5	1	1	1	1	3	3	3	1	3	3
A7	0.25	5	3	1	1	0.33	1	1	3	1	3	3
A8	0.25	3	1	3	1	0.33	1	1	3	1	3	3
A9	1	5	0.33	0.33	0.33	0.33	0.33	0.33	1	0.2	1	1
A10	1	1	1	1	1	1	1	1	5	1	3	3
A11	0.25	0.33	0.33	0.33	0.33	0.33	0.33	0.33	1	0.33	1	1
A12	0.33	0.33	0.33	0.33	0.2	0.2	0.33	0.33	1	0.33	1	1
S	9.94	31.9	16.32	10.56	11.06	9.72	13.56	13.52	27.2	9.86	31	30
A/S	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
A1	0.101	0.007	0.245	0.095	0.271	0.308	0.294	0.295	0.037	0.101	0.129	0.100
A2	0.402	0.032	0.020	0.031	0.018	0.020	0.015	0.021	0.007	0.101	0.097	0.100
A3	0.02	0.097	0.061	0.031	0.090	0.102	0.024	0.073	0.110	0.101	0.097	0.033
A4	0.101	0.097	0.184	0.095	0.090	0.102	0.074	0.024	0.110	0.101	0.097	0.100
A5	0.033	0.161	0.061	0.095	0.090	0.102	0.074	0.073	0.110	0.101	0.097	0.166
A6	0.033	0.161	0.061	0.095	0.090	0.102	0.221	0.222	0.110	0.101	0.097	0.100
A7	0.025	0.161	0.184	0.095	0.090	0.033	0.074	0.073	0.110	0.101	0.097	0.100
A8	0.025	0.097	0.061	0.284	0.090	0.033	0.074	0.073	0.110	0.101	0.097	0.100
A9	0.101	0.161	0.020	0.031	0.030	0.033	0.024	0.021	0.037	0.020	0.032	0.033
A10	0.101	0.010	0.061	0.095	0.090	0.102	0.074	0.073	0.184	0.101	0.097	0.100
A11	0.025	0.010	0.020	0.031	0.030	0.033	0.024	0.021	0.037	0.033	0.032	0.033
A12	0.025	0.010	0.020	0.031	0.018	0.020	0.024	0.021	0.037	0.033	0.032	0.033

By analyzing the Table 7, the results were as shown in the following matrix:

$$M_1 = \begin{pmatrix} 0.16525 \\ 0.072 \\ 0.069917 \\ 0.097917 \\ 0.096917 \\ 0.116083 \\ 0.09525 \\ 0.095417 \\ 0.04525 \\ 0.090667 \\ 0.027417 \\ 0.025333 \end{pmatrix}$$

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Table 8 - Effect the C2 on All Alternative

Criteria	Criteria	More Important	Intensity	Criteria	Criteria	More Important	Intensity
A1	A2			A4	A8		
A1	A3			A4	A9		
A1	A4			A4	A10		
A1	A5			A4	A11		
A1	A6			A4	A12		
A1	A7			A5	A5		
A1	A8			A5	A6		
A1	A9			A5	A7		
A1	A10			A5	A8		
A1	A11			A5	A9		
A1	A12			A5	A10		
A2	A3			A5	A11		
A2	A4			A6	A6		
A2	A5			A6	A7		
A2	A6			A6	A8		
A2	A7			A6	A9		
A2	A8			A6	A10		
A2	A9			A6	A11		
A2	A10			A7	A7		
A2	A11			A7	A8		
A2	A12			A7	A9		
A3	A4			A7	A10		
A3	A5			A7	A11		
A3	A6			A8	A8		
A3	A7			A8	A9		
A3	A8			A8	A10		
A3	A9			A8	A11		
A3	A10			A9	A9		
A3	A11			A9	A10		
A3	A12			A9	A11		
A4	A5			A10	A9		
A4	A6			A10	A10		
A4	A7			A11	A12		

Table 9 - Data Collection by Table 8

A	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
A1	1	0.2	4	1	5	5	5	4	1	1	5	0.2
A2	5	1	0.33	0.33	0.2	0.2	0.2	0.33	0.2	0.2	5	0.2
A3	0.25	3	1	0.33	1	1	0.33	1	3	0.2	5	0.2
A4	1	3	3	1	1	1	1	0.33	3	1	5	0.2
A5	0.2	5	1	1	1	1	1	1	3	1	5	0.2
A6	0.2	5	1	1	1	1	3	3	3	1	5	0.33
A7	0.2	5	3	1	1	0.33	1	1	3	0.2	5	0.33
A8	0.25	3	1	3	1	0.33	1	1	3	0.2	5	0.33
A9	1	5	0.33	0.33	0.33	0.33	0.33	0.33	1	0.2	5	0.2
A10	1	5	5	1	1	1	5	5	5	1	5	0.2
A11	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.33	1	0.2
A12	5	5	5	5	5	3	3	3	5	5	5	1
S	15.3	40.4	24.86	15.19	17.73	14.39	21.06	20.19	30.4	11.33	56	3.59
A/S	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
A1	0.065	0.005	0.161	0.066	0.282	0.347	0.237	0.198	0.032	0.091	0.089	0.056
A2	0.327	0.025	0.013	0.022	0.011	0.014	0.009	0.016	0.006	0.018	0.089	0.056
A3	0.016	0.074	0.040	0.022	0.056	0.069	0.016	0.049	0.099	0.018	0.089	0.056
A4	0.065	0.074	0.121	0.066	0.056	0.069	0.047	0.016	0.099	0.088	0.089	0.056
A5	0.013	0.123	0.040	0.066	0.056	0.069	0.047	0.049	0.099	0.088	0.089	0.056
A6	0.013	0.123	0.040	0.066	0.056	0.069	0.142	0.148	0.099	0.088	0.089	0.056
A7	0.013	0.123	0.121	0.066	0.056	0.023	0.047	0.049	0.099	0.018	0.089	0.092
A8	0.016	0.074	0.040	0.197	0.056	0.023	0.047	0.049	0.099	0.018	0.089	0.092
A9	0.065	0.123	0.013	0.022	0.0186	0.023	0.016	0.016	0.032	0.018	0.089	0.092
A10	0.065	0.123	0.201	0.066	0.056	0.069	0.237	0.247	0.164	0.088	0.089	0.056
A11	0.013	0.005	0.008	0.0132	0.011	0.014	0.009	0.009	0.006	0.029	0.017	0.056
A12	0.326	0.123	0.201	0.329	0.282	0.208	0.142	0.148	0.164	0.441	0.089	0.278

By analyzing the Table 9, the results were as shown in the following matrix:

$$M_2 = \begin{pmatrix} 0.13575 \\ 0.0505 \\ 0.050333 \\ 0.0705 \\ 0.06625 \\ 0.082417 \\ 0.066333 \\ 0.066667 \\ 0.043967 \\ 0.12175 \\ 0.01585 \\ 0.227583 \end{pmatrix}$$

Table 10 - Effect the C3 on All Alternative

Criteria	Criteria	More Important	Intensity	Criteria	Criteria	More Important	Intensity
A1	A2			A4	A8		
A1	A3			A4	A9		
A1	A4			A4	A10		
A1	A5			A4	A11		
A1	A6			A4	A12		
A1	A7			A5	A5		
A1	A8			A5	A6		
A1	A9			A5	A7		
A1	A10			A5	A8		
A1	A11			A5	A9		
A1	A12			A5	A10		
A2	A3			A5	A11		
A2	A4			A6	A6		
A2	A5			A6	A7		
A2	A6			A6	A8		
A2	A7			A6	A9		
A2	A8			A6	A10		
A2	A9			A6	A11		
A2	A10			A7	A7		
A2	A11			A7	A8		
A2	A12			A7	A9		
A3	A4			A7	A10		
A3	A5			A7	A11		
A3	A6			A8	A8		
A3	A7			A8	A9		
A3	A8			A8	A10		
A3	A9			A8	A11		
A3	A10			A9	A9		
A3	A11			A9	A10		
A3	A12			A9	A11		
A4	A5			A10	A9		
A4	A6			A10	A10		
A4	A7			A11	A12		

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Table 11 - Data Collection by Table 10

A	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
A1	1	0.33	5	3	5	5	5	5	5	0.14	5	0.2
A2	3	1	0.33	0.33	0.2	0.2	0.2	0.33	0.2	0.2	5	0.2
A3	0.2	3	1	0.33	1	1	0.33	1	3	0.2	5	0.2
A4	0.33	3	3	1	1	1	1	0.33	3	0.14	5	0.2
A5	0.2	5	1	1	1	1	1	1	3	0.14	5	0.2
A6	0.2	5	1	1	1	1	3	3	3	0.14	5	0.2
A7	0.2	5	3	1	1	0.33	1	1	3	0.2	5	0.2
A8	0.2	3	1	3	1	0.33	1	1	3	0.2	5	0.33
A9	0.2	5	0.33	0.33	0.33	0.33	0.33	0.33	1	0.2	5	0.2
A10	7	5	5	7	7	7	5	5	5	1	5	0.2
A11	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.33	1	0.2
A12	5	5	5	5	5	5	5	3	5	5	5	1
S	17.73	40.53	25.86	23.19	23.73	22.39	23.06	21.19	34.4	7.89	56	3.33
A/S	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
A1	0.056	0.008	0.193	0.129	0.210	0.223	0.217	0.236	0.145	0.018	0.089	0.060
A2	0.169	0.025	0.013	0.014	0.008	0.009	0.009	0.016	0.006	0.025	0.089	0.060
A3	0.011	0.074	0.039	0.014	0.042	0.045	0.014	0.047	0.087	0.025	0.089	0.060
A4	0.019	0.074	0.116	0.043	0.042	0.045	0.043	0.016	0.087	0.018	0.089	0.060
A5	0.011	0.123	0.039	0.043	0.042	0.045	0.043	0.047	0.087	0.018	0.089	0.060
A6	0.011	0.123	0.039	0.043	0.042	0.045	0.130	0.142	0.087	0.018	0.089	0.060
A7	0.011	0.123	0.116	0.043	0.042	0.015	0.043	0.047	0.087	0.025	0.089	0.060
A8	0.011	0.074	0.039	0.129	0.042	0.015	0.043	0.047	0.087	0.025	0.089	0.099
A9	0.011	0.123	0.013	0.014	0.014	0.015	0.014	0.016	0.029	0.025	0.089	0.060
A10	0.395	0.123	0.193	0.302	0.295	0.313	0.217	0.236	0.145	0.127	0.089	0.060
A11	0.011	0.005	0.007	0.009	0.008	0.009	0.009	0.009	0.006	0.042	0.018	0.060
A12	0.282	0.123	0.193	0.216	0.210	0.223	0.217	0.142	0.145	0.634	0.089	0.300

By analyzing the Table 11, the results were as shown in the following matrix:

$$M_3 = \begin{pmatrix} 0.132 \\ 0.036917 \\ 0.045583 \\ 0.054333 \\ 0.053917 \\ 0.069083 \\ 0.058417 \\ 0.058333 \\ 0.03525 \\ 0.207917 \\ 0.016083 \\ 0.231167 \end{pmatrix}$$

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Table 12 - Effect the C4 on All Alternative

Criteria	Criteria	More Important	Intensity	Criteria	Criteria	More Important	Intensity
A1	A2			A4	A8		
A1	A3			A4	A9		
A1	A4			A4	A10		
A1	A5			A4	A11		
A1	A6			A4	A12		
A1	A7			A5	A5		
A1	A8			A5	A6		
A1	A9			A5	A7		
A1	A10			A5	A8		
A1	A11			A5	A9		
A1	A12			A5	A10		
A2	A3			A5	A11		
A2	A4			A6	A6		
A2	A5			A6	A7		
A2	A6			A6	A8		
A2	A7			A6	A9		
A2	A8			A6	A10		
A2	A9			A6	A11		
A2	A10			A7	A7		
A2	A11			A7	A8		
A2	A12			A7	A9		
A3	A4			A7	A10		
A3	A5			A7	A11		
A3	A6			A8	A8		
A3	A7			A8	A9		
A3	A8			A8	A10		
A3	A9			A8	A11		
A3	A10			A9	A9		
A3	A11			A9	A10		
A3	A12			A9	A11		
A4	A5			A10	A9		
A4	A6			A10	A10		
A4	A7			A11	A12		

Table 13 - Data Collection by Table 12

A	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
A1	1	1	5	1	5	5	5	5	5	0.14	3	0.33
A2	1	1	0.33	0.33	0.2	0.2	0.2	0.33	0.2	0.14	3	0.33
A3	0.2	3	1	0.33	1	1	0.33	1	3	0.14	3	0.2
A4	1	3	3	1	1	1	1	0.33	3	1	3	0.2
A5	0.2	5	1	1	1	1	1	1	3	1	3	0.2
A6	0.2	5	1	1	1	1	3	3	3	1	3	0.2
A7	0.2	5	3	1	1	0.33	1	1	3	0.2	5	0.2
A8	0.2	3	1	3	1	0.33	1	1	3	0.14	5	0.33
A9	0.2	5	0.33	0.33	0.33	0.33	0.33	0.33	1	0.14	5	0.2
A10	7	7	7	1	1	1	5	7	7	1	5	0.2
A11	0.33	0.33	0.33	0.33	0.33	0.33	0.2	0.2	0.2	0.14	1	0.2
A12	3	3	5	5	5	5	5	3	5	5	5	1
S	14.53	41.33	27.99	15.32	17.86	16.52	23.06	23.19	36.4	10.04	44	3.59
A/S	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
A1	0.069	0.024	0.179	0.065	0.280	0.302	0.217	0.216	0.137	0.014	0.068	0.092
A2	0.069	0.024	0.012	0.022	0.011	0.012	0.009	0.014	0.005	0.014	0.068	0.092
A3	0.014	0.073	0.036	0.022	0.056	0.061	0.014	0.043	0.082	0.014	0.068	0.056
A4	0.069	0.073	0.107	0.065	0.056	0.061	0.043	0.014	0.082	0.100	0.068	0.056
A5	0.014	0.121	0.036	0.065	0.056	0.061	0.043	0.043	0.082	0.100	0.068	0.056
A6	0.014	0.121	0.036	0.065	0.056	0.061	0.128	0.129	0.082	0.100	0.068	0.056
A7	0.014	0.121	0.107	0.065	0.056	0.020	0.043	0.043	0.082	0.020	0.114	0.056
A8	0.014	0.073	0.036	0.196	0.056	0.020	0.043	0.043	0.082	0.014	0.114	0.092
A9	0.014	0.121	0.012	0.022	0.018	0.020	0.014	0.014	0.027	0.014	0.114	0.056
A10	0.482	0.169	0.250	0.065	0.056	0.061	0.217	0.302	0.192	0.100	0.114	0.056
A11	0.023	0.008	0.012	0.022	0.018	0.020	0.009	0.009	0.005	0.014	0.023	0.056
A12	0.206	0.073	0.179	0.326	0.280	0.302	0.217	0.129	0.137	0.500	0.114	0.278

By analyzing the previous Table 13, the results were as shown in the following matrix:

$$M_4 = \begin{pmatrix} 0.138583 \\ 0.029333 \\ 0.044917 \\ 0.066167 \\ 0.062083 \\ 0.076333 \\ 0.06175 \\ 0.06525 \\ 0.037167 \\ 0.172 \\ 0.01825 \\ 0.228417 \end{pmatrix}$$

Through the implementation of AHP steps the output of analytical processes is as follows:

Insert matrix | Restore matrix

	A_1	A_2	A_3	A_4
1	0.165	0.136	0.132	0.139
2	0.072	0.050	0.037	0.029
3	0.070	0.050	0.046	0.045
4	0.098	0.071	0.054	0.066
5	0.097	0.066	0.054	0.062
6	0.116	0.082	0.070	0.076
7	0.095	0.066	0.058	0.061
8	0.095	0.066	0.058	0.065
9	0.045	0.044	0.035	0.037
10	0.091	0.122	0.208	0.172
11	0.027	0.016	0.016	0.018
12	0.025	0.228	0.231	0.228

X

Insert matrix | Restore matrix

Complex numbers (more)

Decimal

	B_1
1	0.08
2	0.46
3	0.10
4	0.360..

=

	C_1
1	0.139
2	0.0429
3	0.049400000000000006
4	0.06966
5	0.06584000000000001
6	0.08136
7	0.06572
8	0.06716
9	0.04066
10	0.14612
11	0.0176
12	0.21206000000000003

Through the above results, the most important alternatives available are:

- Exploitation of Uranium mining through the establishment of uranium enrichment centers.
- Expansion of the construction of solar power plants.
- Maintenance and modernization of existing thermal power stations and upgrading of production efficiency.
- Construction of new refineries.
- While the establishment of nuclear power plants was the last of all alternatives.

Conclusion

Through what has been reviewed in the previous sections it is clear that the energy sector in Jordan faces several challenges that have a negative impact on the economy. These challenges are summarized as follows:

- Increase in energy demand.
- Unavailability of domestic energy sources.
- The cost of importing oil and natural gas.
- Conflict in neighboring countries, a great risk for ways of energy supply and import of gas and oil.

- Financial losses in the energy sector in Jordan due to poor planning and management of the energy sector.
- The instability of the surrounding countries has contributed to the increasing challenges in the Jordanian energy sector, where security challenges have increased as well as increasing population growth.
- The absence of a clear vision for planning in the energy sector and relying on immediate solutions has contributed to the increasing volatility in the Jordanian energy sector.
- Default solutions:

The results indicate that there is an urgent need to modernize the existing power plants as well as to expand the construction of alternative power plants. There is also the possibility of expanding the process of mining oil shale. There is also an urgent need for the establishment of new refineries. Isotopes of uranium and their exploitation in support of the Jordanian economy. The diversity of sources of challenges in the energy sector and the convergence of the impact resulting from these challenges, as indicated by the hierarchical analysis makes the decision-making process very difficult and needs to plan clearly and accurately. There is ambiguity in the nuclear program in Jordan, which explains the low rate of the ranking of (Establishment of nuclear power plants (A11)) in the list of available alternatives.

Acknowledgements

We extend our thanks and appreciation for all those who contributed to the completion of this research and submitted the requested data. We also thank the staff of the Information Service at the Ministry of Energy and Mineral Resources of Jordan.

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