

Original Article

# Determinants of Energy Consumption in Saudi Arabia and its Role in Decreasing the Misuse of Environmental Resources

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**Abstract** - Saudi Arabia has been experiencing rapid growth in population and economic activities since 1971, which has increased the demand for energy sources. The present study aims to investigate the impact of real GDP per capita as an economic growth indicator, energy prices, industrialization share in GDP, services share in GDP, and urbanization to reduce local energy consumption. Findings have contributed towards the adoption of optimal production and consumption patterns for protecting natural resources and preserving the right of an individual to lead a balanced life. Therefore, the study suggests that Saudi Arabia needs to reduce energy consumption in non-renewable energy sources by investing in renewable energy sources. Moreover, there is a need to improve the urban environment to increase energy efficiency and achieve sustainable development in the future.

**Keywords** - Consumption, Efficiency, Energy Sources, Energy, Environment, GDP, Prices.

## I. INTRODUCTION

Economic growth mainly concentrates on change in the quantity, which the society's individual gets without giving attention to quality and the internal structural distributions. The development is considered as a wide and comprehensive concept causing a series of structural changes in the economy, which guarantees the continuity of its growth in a balanced pattern [1]. This necessitates the occurrence of changes in various economic and social activities, where an economic balance between various organizational sectors depends on the development process. The developmental processes contribute towards raising the economic and social standard, especially when the nature of the country's potentials, especially the energy sources, are considered. These energy sources are considered as the determinants of the development because they cause structural changes at economic and social levels, where these sources change the relative importance of the organizational structures and production techniques [2].

This leads to the production of new commodities and services in addition to changing the structure of the labor force.

The intensive use of the energy is the most important pointer of the energy efficiency, which highlights the quantity of energy used to produce one unit of the product. The rise in the energy intensity yields the same amount of product with a less quantity of the used energy, regardless of the measurement at the level of the economy as a whole or at the level of the productive sectors [3]. According to the International Agency for Energy [4], the following countries have consumed the highest amount of energy;

- China-approximately 2000 million tons to equivalent petrol
- United States of America-approximately 1500 million tons to equivalent petrol
- Saudi Arabia Kingdom-approximately 139.6 million tons of equivalent petrol.

The energy density for each China, United States, and Saudi Arabia was as follow 0.3, 0.1, and 0.3, respectively; whereas, the quantity of used energy to produce one unit in the Saudi economy equals the quantity of the energy used to produce one unit in the Chinese economy. This approximates submits questions based on the variation in the structure of the Chinese economy as compared to the Saudi economy. Therefore, it is important to understand the pattern of the local consumption of the energy resources and identify the determinants of density to use energy in Saudi Arabia.

The importance of this study arises from the fact that the economy concentrates on studying the economic sources characterizing relative scarcity. Saudi Arabia is moving towards the adoption of a more efficient economy to use energy. The government of Saudi Arabia believed that this step would not only contribute towards preserving the natural resources but would also help in achieving persistent economic growth. Despite the exerted efforts,



the energy sector is facing several challenges that must be overcome. Therefore, this study is considered as a specialized study to identify the reality of energy in the Saudi Arabia and focus on the expected consumable pattern of energy in the light of upcoming projects. It is believed that the horizons of this study are not limited to the economic side. Rather they extend to social and environmental aspects. In particular, the present study aims to identify the determinants of the intensity of using energy in Saudi Arabia. The study also aims to identify the local consumption of the energy and define the independent variables that play a significant role in energy consumption. The research questions addressed in this study are as follows;

- What are the determinants of Energy Consumption in the Saudi Arabia?
- Does the local consumption of the energy sources characterized by optimization and is directed towards achieving the concept of energy efficiency?

The assumptions adopted by this study based on the study objectives are as follows;

- There is an association between economic growth and energy consumption
- There is an association between prices of power and energy consumption
- There is an association between the added value of the industrial sector and energy consumption
- There is an association between the added value of the services sector and energy consumption
- There is an association between the civilization expansion and energy consumption
- There is an association between carbon dioxide emissions and energy consumption

## II. METHODS

The study has adopted the descriptive-analytical method to cover the theoretical aspect, including the important concepts that are related to the study subject. Previous literature has been reviewed to identify and present it as continuity to the contribution of the previous studies. This was followed by analyzing the development pattern of the local energy consumption.

## III. REVIEW ANALYSIS

The study by Sasana and Ghazali [5] analyzed the causative relationship between the individual's share of the energy consumption, the income, and the civilization expansion using Granger between 1971 and 2014. The study concluded that a one-direction causative relationship exists between the variables, which moves between the individual's share of income and the energy consumption. Hence, the study confirmed the importance of the individual's income and the civilization expansion in defining the pattern of the energy consumption. Another study by Dehaghi et al. [6] was conducted between 1973 and 2011, which showed a direct correlation between the consumption of the energy and the added value to the industrial sector. Moreover, there exists a single directional

causative relationship, which is directed towards the energy consumption and added value of the industrial sector.

The study conducted by Li and Lin [7] was based on the data from 73 countries between 1971 and 2010. These countries were classified into four construction groups at the income level to define the nature of the relationship between the variables. The study identified the level of development that plays an important role in defining the volume of the energy consumption. In the group of low-income countries, the civilization expansion contributed towards reducing the energy consumption. In the lowest group of the average income countries and the strip of the high-income countries, the industrial sector was inversely correlated with the consumption of the energy; whereas, the civilization expansion was directly correlated to energy consumption. The industrial sector and the civilization expansion had no significant influence on the energy consumption considering the upper group of the average income countries. In Jordan, Matar [8] defined the direction of causative correlation between the individual's share of the energy consumption and the economic growth associated with the actual total domestic product between 1975 and 2011. There was no causative correlation between the economic growth and the energy consumption, which depicted that the increase in the individual's share of the total domestic product has no impact on the volume of the domestic energy consumption.

Another study conducted by Ajlouni [9] defined the impact of the energy consumption on the economic growth. The study also defined the direction of the causative relationship between energy consumption and economic growth using the time series information between 1980 and 2012. The results depicted a dual-direction positive correlation between the consumption of the energy and the economic growth, which highlighted that the adoption of policies to rationalize the consumption of the energy is likely to result in the slowdown of the economic growth. Alkhatlan and Javid [10] defined the nature of the correlation between economic growth and carbon emissions as independent variables, and energy consumption, electricity consumption, and petrol/gas consumption as dependent variables. The study concluded that long-term economic growth could be achieved by maximum energy consumption, which showed the presence of a dual relationship between energy consumption and economic growth. These results prove the significance of energy as a motor for driving the Saudi economy.

A study by Alyousef and Abu-Edit [11] in Saudi Arabia measured the size of indirect governmental support and the scope of its influence on the growth of the demand considering the total domestic product and the population growth. The study concluded that the submitted governmental advertisements are characterized by two features;

- The large value and size are estimated to be approximately 1.37 trillion Riyal.
- Accelerated and continuous growth following the rise in the international prices in return to the steadiness of the local prices where the yearly average growth was estimated at 25%.

According to the standard tests, there exists a shared integrated correlation between the indirect governmental support and the domestic demand for energy which means that the governmental support is an incentive factor for the growth of the demand. This also depicts the existence of a single-directional causative correlation that is directed to the indirect governmental support and further towards the domestic demand for the energy.

A study was performed by Danette and Seghir [12] investigated the causative relationship between the economic growth and the energy consumption for a group of the petrol exporting countries between 1990 and 2010 using the dynamic standard economy samples. The results showed the presence of one direction causative correlation moving from the economic growth to the energy consumption in the long run. However, the results showed a one-direction causative correlation moving from the consumption of the energy to the economic growth in the short run. Therefore, the study recommends the adoption of energy consumption rationalization policies, which would not have a negative impact on the economic growth.

Most of the studies stated the existence of a significant correlation between the selected variables and the intensity of using the energy. Among all the mentioned studies, Sasana and Ghazali [5] focused on civilization expansion as an influential factor and confirmed that the civilization expansion is an important determinant for the energy intensity. Most of the previous studies depicted the relationship between energy and the economic variables. However, further studies would help to understand the variation in the results is due to the variation in the economic and social structure for the selected sample in each study.

There are some aspects of deficiencies, even though most of the previous studies agreed on the importance of the energy. For instance, few of the previous studies concentrated on the actual gross domestic product as a variable influencing the energy consumption [8-10]. Here, appears the relative importance of the remaining factors like economic structure and population factor that influence the energy sector. In return, Li and Lin [7]

further studies the factors influencing the intensity and consumption of the energy; however, the study failed to reach a definite result to confirm the initial influence for each factor. This variation in the previous studies was beneficial for the researcher to identify the important changes concerned with the analysis and the explanation. In return, the aspects of deficiencies opened research horizons that contributed to overcoming the weak research gaps considering the suitable methodology.

#### A. Development of Energy Sector in the Saudi Arabia

The discovery of petrol in Saudi Arabia changed the features of the Saudi society from all the economic and social aspects. The petroleum returns have played an important role in developing the quality of life and raising the standard of the social welfare. It has also established the infrastructure in terms of the roads network, bridges, airports, ports in addition to expenditure on the education, training, and health programs, along with other development services. The petrol jump played a significant role in the demographic transformation that was based on the change in the volume and structure of the local consumption for the energy. This transformation contributed towards the continuous development of the energy sector, as discussed below.

#### B. Contribution of Economic Sectors towards the Gross domestic product (GDP)

The pre-petrol discovery stage was characterized by the complete reliance of the Saudi Kingdom on the customs duty imposed on the pilgrims. However, this was not an enough source to achieve a real economic growth until the discovery of petrol in Bahrain. This discovery gave a hope to search and drill for petrol in 1933 in Saudi Arabia. On the 4<sup>th</sup> of March 1938, petrol flew from Al-Dammam well Number (7) at the rate of 1585 Barrels, and the first tanker was loaded with a cargo of the Saudi raw oil for export in May of the same year [13]. The rise in the volume of exports increased the petroleum returns, which had a positive impact on the country's economy because of the rise in the government expenditure such as industry and the services accompanying the civilization centers. This was accompanied by the movement of the population from the bounds of the country and an increase in the number of immigrants from abroad.

*a) The Period (1970 – 1980)* During 1970-1980, the highest contribution of the petroleum sector was towards the Domestic Product as shown in Table 1, despite of the gradual expansion of the production base for the non-petroleum sector.

**Table 1. Relative Contribution in the Gross Domestic Product using the Fixed Prices for the Year 2010 according to the Organizational Sectors for the Years (1970-1980)**

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Petroleum Sector	78	80	81	82	79	72	75	75	72	74	73
Non-Petroleum Sector	21	19	18	17	20	28	24	24	27	26	26

Source: General Authority for Statistics.

**b) The Period (1981 – 1990)** The Iraqi – Iranian war in 1980, resulted in the halting of the exports and production operations. This halt resulted in reduced prices of petrol for the variations in the volume of the international production. Therefore, OPEC adopted the system of producing shares for the member countries to support the prices in 1980, and Saudi Arabia has delegated the authority to play the role of the favored producer. This means that producing shares can change according to the demand and supply in the market

as Saudi Arabia has a surplus production power. Hence, the government of Saudi Arabia reduced its petrol production until the average daily production reached 93.7 million barrels in 1985, according to data from the Saudi Arabia fund Association. Therefore, it is noticed that the relative contribution to the petroleum sector was reduced gradually until reaching to its lowest level in the 1985, as shown in table 2.

**Table 2. Relative Contribution in the Gross Domestic Product with the Fixed Prices in Year (2010) according to the organizational Sectors for years (1981-1990)**

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Petroleum Sector	71.2	61.3	52.8	50.7	45.7	56.1	53.1	57.3	56.5	61.0
Non-Petroleum Sector	28.4	38.2	46.6	48.6	53.6	43.4	46.2	41.3	42.4	38.1

Source: General Authority for Statistics.

**c) The Period (1991 – 2000):** In the Year 1991 the demand for petrol was dropped as a consequence of the economic recession that occurred in the United States of America. However, Saudi Arabia increased its petrol production from the 1989 until 1991 by approximately 5.06 million barrels in 1989, 6.41 million barrels in 1990, and 8.12 million barrels in 1991. This was because the government of Saudi Arabia believed that the demand would continue to increase from the Asian countries. However, there was a reduction in the demand after the financial crisis in 1997. The contribution of the petroleum sector to the Saudi economy went up at the beginning of the period and later dropped after 1995 (Table 3).

**Table 3. Relative Contribution in the Gross Domestic Product with the Fixed Prices in Year (2010) according to the organizational Sectors for Years (1991-2000)**

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Petroleum Sector	65.3	64.8	63.6	63.5	63.2	62.7	61.3	61.3	58.7	59.5
Non-Petroleum Sector	33.9	34.2	35.3	35.6	36.0	36.3	37.8	37.7	40.3	39.8

Source: General Authority for Statistics.

**d) The Period (2008 – 2017):** In the following years after 2008, the Saudi government gave noticeable attention to the non-petroleum sector. This contributed towards an increase in GDP, as shown in table 4.

**Table 4. Relative Contribution in the Gross Domestic Product with the Fixed Prices in Year (2010) according to the organizational Sectors for years (2008-2017)**

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Petroleum Sector	50.7	46.8	44.5	45.40	45.3	43.3	42.7	43.2	44	43
Non-Petroleum Sector	48.5	52.5	54.7	53.84	53.9	55.8	56.5	56.0	55.2	56.3

Source: General Authority for Statistics.

The trend towards the development of the non-petroleum sector is likely to promote the strength of the economy in the future. It is not possible to just rely on petrol as an essential source of income, even if it played an important role in the early foundation stages. This is because of the uncertainty that surrounds it as a commodity, where petrol is like any commodity covered by the fluctuations in the prices. Table 5 presents the fluctuations of prices of Raw Brent Oil between 2011 and 2017. At the start of 2011, the price of yearly average petrol was 111 Dollars/barrel, i.e., a daily production equals 9.3 million barrels.

**Table 5. Prices of Raw Brent oil**

<b>Petroleum Pointers</b>	<b>Distinction</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>
Brent Raw Oil (Yearly Average: Dollar/Barrel)	Yearly Average (Dollar/Barrel)	111	112	109	99	52	44	54
Production (Million Barrel/Day)	Million Barrel/Day	9.3	9.8	9.6	9.7	10.2	10.5	10

Source: Data from Ministry of Economy and Planning for Years (2011-2017)

In comparison to table 4, it can be stated that the actual contribution by the petroleum sector in 2011 was 45.4%; whereas, a relative contribution for the petroleum sector dropped by approximately 43% in 2017. This decrease took place, despite of increase in the petroleum production, where it equaled approximately 10 million barrels daily (Table 6).

**Table 6. Actual and Nominal Contribution for the Organizational Sectors in the Gross Domestic Product in 2017**

	<b>2017</b>	<b>2017</b>
	Nominal	Actual
The Petroleum Sector	28.46	43
The Non-Petroleum Sector	70.63	56.27

Source: Data from General Institute for Statistics for Year (2017).

The role of the petroleum sector plays an important role in the Saudi economy through the growth averages related to the actual GDP. For example, during 2000 – 2010 and 2011-2017, the average growth of the economic activities was high because of the increased income on petroleum as they provide the source of funding (Table 7). In the second period, the economic activities grew with low growth averages because of a reduction in the petroleum incomes.

**Table 7. Real GDP Growth Rate According to the Type of Economic Activity**

<b>The economic activity</b>	<b>Growth rate (2001-2010)</b>	<b>Growth rate (2011-2017)</b>
Agriculture - forestry - and fish	24%	11%
Mining and quarrying	8%	9%
A) Crude oil and natural gas	8%	9%
B) Other mining and quarrying activities	165%	18%
Transformative Industries	82%	31%
A) Oil refining	16%	54%
B) other industries	139%	23%
Electricity, gas and water	89%	23%
Construction	78%	18%
Wholesale and retail trade, restaurants and hotels	180%	22%
Transport, storage, and communication	263%	32%
And business services	83%	33%
A) Home ownership	46%	45%
B) other	140%	21%
Group, social and personal services	49%	25%
Calculated banking services	24%	6%

Source: General Authority for Statistics data

The growth of economic activities means an increase in the number of productive units, which require a large amount of energy consumption. During 2000 – 2010, the volume of domestic energy consumption grew by about 90%, as the total final consumption in 2000 reached approximately 63518 a kiloton to equivalent oil. In 2010, the volume of consumption doubled to reach 120654 a kilo to equivalent oil.

### C. Energy sources and Growth Rate of Domestic Consumption

Historical data indicated the importance of the energy sector, including oil and natural gas, towards the structure of the Saudi economy, either directly or indirectly, through its mutual relationship with other economic sectors. Therefore, it will always remain a commodity with an increase in demand locally and globally, which may affect the position of Saudi Arabia across the world. While examining the demand, primary energy supply is considered because it reflects the country's need for energy sources, before converting it to secondary energy sources. For Saudi Arabia, the apparent feature is the increase in the values of primary energy supplies during the last period as it has been on a continuous rise since 1990 to keep pace with the local demand for final energy sources, whether by individuals or industrial and commercial establishments (IEA data for the years (1990-2016)).

It is shown that the final consumption volume has grown from 1990 to 2016 continuously, by comparing the size of the total final consumption according to the energy sources. Most of the consumption was in favor of oil derivatives because it is considered the basis of the production processes. The continuous growth is an indication of Saudi Arabia's concern to fulfill the requirements of local demand and enhance opportunities to integrate the energy sector with other sectors, and diversify the production base within the economy.

According to reports issued by the International Energy Agency, Saudi Arabia ranks ahead in the volume of domestic consumption. For instance, in 2017, Saudi Arabia was ranked sixth in consuming oil products. This is an indication that the pattern of domestic consumption, in general, is not rational and has low inefficiency. This is

confirmed by the upward trend in per capita total energy consumption during the previous decades. The present study has reviewed the primary and final energy supplies to indicate the total volume of domestic consumption for each source.

**a) Oil and Petroleum Products:** Saudi Arabia is experiencing continuous development of economic and social projects, which contribute towards an increase in domestic consumption of oil derivatives over decades. The years from 2010 to 2012 witnessed an increased consumption that exceeded production levels and had a negative impact on oil exports. In 2013, exports decreased at their lowest level with a low-level production. The increase in the volume of consumption and demand at a higher rate of production emphasizes the importance of a balance between production and consumption rates so that the negative economy is not affected.

The domestic demand was accommodated through the opening of two new refineries, the Yasrif Refinery and Satorb Refinery. The total production capacity of both the refineries was 800,000 barrels per day; therefore, it is noted that growth has occurred at a decreasing rate considering the total consumption of approximately 6.53 and 4.59 in 2014 and 2015, respectively. As domestic demand was met by approximately 1,516,804 million barrels, compared to about 1,423,796 million barrels in 2013 CE, the growth rate decreased from the previous one in 2016 and 17 as it reached 0.24% and 1.23%. This might be due to the increase in energy prices, which negatively affected the level of consumption. As gasoline and diesel prices were raised, a decrease in the growth rate was observed by about 2.96, due to a decrease in consumption of refined products by local consumption from all sectors (Table 8).

**Table 8. Domestic Consumption of Refined Products, Crude Oil, and Natural Gas by Sectors**

Year	LPG consumption		Natural gas consumption		Consumption of other refined products		Total summation	Percentage change
	To the public	For the oil industry	To the public	For the oil industry	To the public	For the oil industry	Grand	% Change
2010	13,148	280	405,190	116,594	689,885	33,832	1,258,929	9.35
2011	15,838	2,454	437,210	113,492	721,667	30,750	1,321,411	4.96
2012	13,740	2,616	484,615	113,357	760,296	33,966	1,408,590	6.6
2013	12,266	2,993	496,436	100,799	776,022	35,280	1,423,796	1.08
2014	11,483	3,705	504,087	110,540	837,941	49,048	1,516,804	6.53
2015	12,597	3,530	506,065	121,611	892,061	50,634	1,586,498	4.59
2016	13,396	4,581	557,437	106,022	854,887	53,977	1,590,300	0.24
2017	12,867	4,385	573,780	121,481	843,080	54,346	1,609,939	1.23
2018	13,229	3,912	581,356	127,314	780,134	56,329	1,562,274	-2.96

Source: Saudi Arabian Monetary Agency for the years 2010 -2018

When comparing the consumption of the public between 2017 and 2018, it was noted that the consumption of premium gasoline decreased by approximately (6.5%) from the previous year. Moreover, for diesel it decreased by 12.1%, fuel oil by

About 3.52%, and crude oil decreased by about 10.53%. This decrease may return to the current policy pursued by the Saudi Arabia for adopting the use of natural gas with higher efficiency instead of diesel in several sectors such as electricity generation and water desalination (Table 9).

**Table 9. Public Consumption of Refined Products, Crude Oil, And Natural Gas**

The product	2017	2018	Change percentage (%)
Liquefied petroleum gas	12.87	13.23	2.82%
Excellent gasoline	208.00	194.49	-6.50%
Jet fuel and Kerosene	36.14	37.88	4.81%
Diesel	207.91	182.75	-12.10%
Fuel oil	180.29	173.96	-3.52%
Crude oil	167.37	149.74	-10.53%
Asphalt	20.36	20.73	1.83%
Lubricating oil	1.34	1.51	12.86%
Natural gas	573.78	581.36	1.32%

*Source: SAMA data for the years 2017-2108 (researcher preparation 2019)*

**b) Natural Gas:** Natural gas is considered one of the most important primary energy sources necessary for the chemical industry. It is considered as an efficient source of oil derivatives, because of its high production efficiency versus its low cost. It is used with its various products, as raw material for

Most important industrial activities besides its importance as a source to produce electrical energy. Table 10 presents the quantities of consumption, production, and reserves of natural gas for the years 2005 and 2015. It is noted that at the end of the period, natural gas was nearly twice of what was consumed in the 2005.

**Table 10. Production, Consumption, and Reserves of Natural Gas**

	2005	2010	2015
Reserves (billion standard cubic feet)	243648	283,057	303,251
Natural gas production (billion cubic meters)	81.35	97.03	119.83
Natural gas consumption (thousand barrels)	340,753	521,784	627,676

*Source: Ministry of Energy, Industry and Mineral Resources for the years 2005 -2015*

Saudi Arabia plans to increase its dependence on natural gas as a generator for electric energy and water desalination to raise energy efficiency and fulfill the expected domestic demand in the coming years. The trend towards increasing dependence on natural gas will contribute to providing 71 dollars per barrel of crude oil that are replaced with an equivalent barrel of gas in electricity generation; Aramco aims to raise the level of natural gas production to reach (23) billion cubic feet [14]. The contribution of natural gas as a generator of electric energy exceeded the contribution of oil, which confirms the orientation of Saudi Arabia towards the adoption of the best and most efficient option.

**c) Electric power:** Electrical energy is among the most important final energy sources as it secures the basic needs of individuals, such as providing water and air conditioning facilities. This has rapidly increased the growth of the consumption of electrical energy. According to the

authority, 40% of licensed fuel consumption goes in favor of seawater desalination and dual production, and the remaining 60% is in favor of generating electricity. By reviewing the total sales of electric energy according to the consumer categories between 2010 and 2017, it can be stated that the highest consumption was in the housing sector, followed by the industrial sector and then the commercial and government sectors. This continuous growth has pressurized the energy sources in Saudi Arabia, especially in the summer months. According to the joint data of the oil-exporting countries (JODI- Joint Organizations Data Initiative), the amount of oil used to generate electric energy reached more than 700,000 barrels per day from 2014 and 2016. These quantities of direct burning of oil amounted to 12% in 2015 that was 9.5% in 2011 [15].

The energy in its various sources plays an important role in the development process, and it is credited with making a pivotal shift in the Saudi economy. However,

numerous challenges are created due to rapid growth in domestic demand, which make it difficult to harmonize, especially in the recent time. Energy consumption is expected to increase at high rates of growth in conjunction with the aspirations of Saudi Arabia for industrial, urban, and service progress considering development plans and programs of Vision 2030.

### C. Determinants of the Intensity Use of Energy

Several factors affecting the behavior of the sector are noted, while considering the energy sector. These factors themselves constitute challenges that must be dealt with accurately to achieve the desired goal of energy. GDP is at the top of these factors that are directly associated with total energy consumption.

**a) Size and Structure of Population:** The size and structure of the population affect the volume of energy consumption based on the following characteristics;

- **Quantitative Fissure:** It is the population that is directly related to the total energy consumption. In Saudi Arabia, the population in 1971 reached approximately 6 million people, according to data from the World Bank. During the past decades, the population increased with an increasing growth rate till it exceeded 33 million in 2018. This, in turn, brought about several structural transformations at the social level. For instance, a great number of experienced and competent people were drawn to participate in the establishment of a development project. At the same time, the Saudi government encouraged its citizens to get enrolled in education and training schools and institutes. Financial support was provided along with the development of services and their concentration in the main cities. There was the establishment of different industrial cities, such as Yanbu and Jubail, which began the process of migration from rural to urban centers. This migration gradually increased till 2018 and reached approximately 83% of the total population from 48% in 1970. The increase in population necessitated the production of more goods and services, which in turn necessitated more energy consumption for the production process.
- **Relative fissure (per capita energy consumption):** It is also directly correlated with energy consumption, as the higher the per capita income, it coincides with the rise in the share of energy consumption. Therefore the per capita share of energy consumption is an important indicator that reflects some of the indications. One of the indications is the state's ability to supply energy, and the extent of the ability to meet the basic needs of the necessary energy [16]. The per capita primary energy supply has grown by approximately 84% between 1990

and 2016. In 1990, per capita, primary energy supply was 3.55 tons to oil equivalent, which increased to 6.52 tons to oil equivalent in 2016. On the contrary, there was a decrease in the population growth rate from 3.56% to 2.25%, which reflected the increased demand for energy in accordance with the rise in per capita income. According to data from the World Bank, per capita income increased from 26981 riyals in 1990 to approximately 75,107 riyals in the year 2016. This increase depicts that both indicators are consistent in direction. Moreover, the increase in energy demand was to secure the requirements of the development process that affected the individuals and their desires.

**b) Energy-Consumption in Economic Sectors:** There is variation in the consumption of productive sectors of based on the nature of the sector in accordance with the data of the International Energy Agency. Considering the total energy consumption, the transportation sector was considered among the most consumed sectors (41%), followed by the industrial sector (38%), residential sector (13%), commercial and public service sector (8%).

- **The transport sector –** The divergent nature of the Saudi Arabia's geography has created the need to link its cities with each other that has reached more than eighty thousand kilometers. This helped in achieving the rate of transport sector consumption, i.e., 41% of the total energy consumption, as the size of the vehicle fleet reached 12,000,000 vehicles in 2017. This increase in the number of vehicles represented 82% of the average daily consumption of gasoline and diesel, i.e., approximately 811,000 barrels. It is expected that the fleet of vehicles will reach more than 26 million vehicles by 2030, and the daily consumption rate will rise to about 1,860,000 barrels of gasoline and diesel. The Saudi Energy Efficiency Program concluded that the main reason for the high rate of consumption in the transportation sector is the low rate of vehicle fuel economy. It is equivalent to 12 kilometers per liter of fuel, compared to about 13 kilometers per liter of fuel in the United States of America, and 18 kilometers per liter of fuel in Europe [17].
- **The industrial sector –** According to the International Energy Agency, the industrial sector consumed about 38% of the primary energy in Saudi Arabia in 2016. Iron, steel, petrochemical, and cement industries accounted for most of the energy consumption in this sector, where the consumption rate reached (65%) of the total consumption of the sector Industrial in 2016 (Table 11).



**Table 11. The Ratio of Consumption of Different Industries to the Total Industrial Sector**

Industry	Number of companies	Consumption ratio Of the total sector
Cement	14	10%
Iron and Solid	3	5%
Petrochemicals	23	50%
Total	40	65%

Source: Saudi Energy Efficiency Center data for 2016.

In the year 2017, the General Authority for Statistics calculated the total purchases of industrial establishments from water, electricity, and fuel by economic activity (in thousands of riyals). The analysis revealed that the coke and refined petroleum products industry was the most purchased, as shown in table 12.

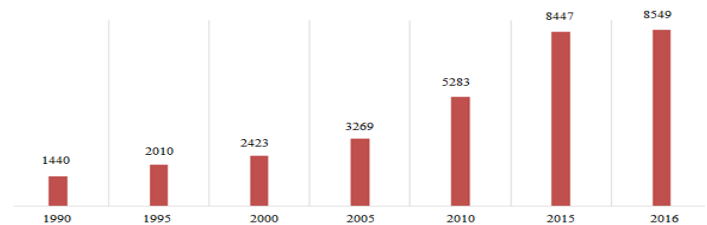
**Table 12. Total Purchases of Industrial Establishments From Water, Electricity, and Fuel by Economic Activity (In Thousands of Riyals)**

The economic activity	Electricity	Water	Fuel
Manufacture of coke and refined petroleum products	2961284	640257	14235062
Electricity, gas, steam, and air conditioning delivery	773636	288547	5683297
Manufacture of food products	1524988	319039	3516076
Manufacture of chemicals and chemical products	748905	121714	3558768
Manufacture of other non-metallic mineral products	403662	92035	3909436
Making base metals	455620	42477	1601657
Coal mining, lignite, crude oil, and natural gas extraction	58209	19241	1403090
Making drinks and making tobacco products	345910	49618	788820
Manufacture of computers, electronic and optical products, and electrical equipment	306109	28114	715766

Source: Statistics Authority data for the year 2017 AD.

Few of the most prominent challenges to raise energy efficiency in the industrial sector are as follows [17];

- Existing factories suffer from worsening energy consumption due to the absence of targets related to raising the level of energy efficiency.
- Lack of data to assess the previous situation of production quantities and energy consumption.
- Lack of attention to energy efficiency when purchasing industrial equipment and devices due to the low level of prices.
- Scarcity of experience and skills training in the field of energy efficiency due to lack of focus in the past.
- Many existing old factories still adopt low-efficiency technologies.
- Scarcity of internal policies for energy efficiency in factories.
- Services Sector – The services sector includes retail stores, hotels, educational institutions, health care, government, and private hospitals. There has been an increase in the level of consumption in the services sector over the years; although, the level of consumption is considered small compared to other sectors. Figure 1 shows the energy consumption from the commercial and public services sector for the years 1990 and 2016.



**Fig. 1 Energy Consumption From The Commercial And Public Services Sector (KTOE). (Source: IEA Data For The Years 1990-2016 (Researcher Preparation 2019))**

- Building Sector – The building, either residential, government, or commercial, consume a large percentage of the total energy. The total energy consumption has reached 23%, with total electrical energy reaching 75% and an annual growth rate of up to 7%. This is due to low energy efficiency in the electrical appliances used and lacking of thermal insulation in the majority of the buildings (The Saudi Energy Efficiency, 2019).

**c) Energy Prices:** Low level of prices is among the factors contributing to the growth of energy consumption locally. The cost of this decrease is borne by the producing companies represented by Aramco, oil refineries, and the

Saudi Electricity Company. Saudi Arabia has launched a program to achieve financial to encourage optimal consumption of energy sources and correct energy prices. This approach is likely to enhance fiscal revenues by linking energy products to reference prices that will be gradually completed by 2025 [18]. Table 9 shows a decline in the level of public consumption in 2018 in several energy products, which means that price adjustments have

achieved something of the desired goal. It is worth noting that the energy price correction initiative considered low and middle incomes, and financial support was provided to mitigate the effects of price increases through the “citizen account” program. Table 13 shows the change in retail prices of petroleum derivatives (riyals/liter) for the years 2010 -2019.

**Table 13. Retail Prices of Petroleum Derivatives**

Products	2010	2015	2018	The second quarter of 2019
Penryn 91	0.45	0.75	1.37	1.44
Gasoline 95	0.6	0.9	2.04	2.1
diesel	0.25	0.45	0.47	0.47
Kerosene	0.43	0.6	0.64	0.64
liquefied petroleum gas	0.72	0.72	0.75	0.75
<i>Source: Ministry of Energy, Industry and Mineral Resources data, Saudi Aramco for the years 2010 -2019 (researcher preparation 2019)</i>				

### C. National strategy for the energy sources in the (2030 Vision)

The above discussion has clarified that the energy sector plays an effective role in advancing developments in Saudi Arabia. The developments resulted in several structural changes that had a significant impact on the overall structure of domestic energy consumption. It remained in a state of continuous growth over the years, and the level of consumption is expected to rise with what it aspires. Saudi Arabia is likely to undergo industrial and urban progress in the upcoming years. This ambition requires extensive infrastructure and real estate facilities; therefore, Saudi Arabia is seeking to take advantage of the environmental and investment potentials to raise the efficiency of local energy consumption based on the National Industrial Development and Logistics Services program. Among the strategies for the energy sector, the most important is to rationalize consumption and encourage energy efficiency by developing and legislating energy efficiency standards such as defining the energy efficiency standard for all air conditioning units and continuing with programs to reduce loads during peak hours. There is also a need to control the adaptation loads of the major subscribers in addition to the energy mix. It is important to get surety about no conflict between the various economic sectors, rather that they are integrated, and that the resources are managed in a sound and more efficient manner. Therefore, the vision 2030 included a thesis on renewable energy connected with the infrastructure to achieve sustainable development at the economic and environmental levels. It is expected that the total domestic consumption of energy will decrease, by between 5.1 to 2 million barrels per day to oil equivalent by 2030. The second phase aims to apply a renewable energy plan to generate more than 25 gigawatts of solar and wind energy during the next five years, with up to the generation of 60 gigawatts over the next decade. This would include 40 GW of solar energy and 16 GW of wind

power. The total generating capacity of seven projects will suffice to generate energy for approximately 226,500

Households, and the volume of investments in projects are expected to reach about 1.51 billion dollars. This cost would contribute towards creating more than 4,500 billion dollars. These projects include; Al Qurayyat Project (200 MW), Al Madinah Al Munawwarah Project (50 MW), Rafha Project (45 MW), Al Faisaliah Project (600 MW), Rabigh Project (300 MW), Jeddah Project (300 MW), and Mahd Al Dahab Project (20 MW) [19].

As for the electric power sector, Saudi Arabia aims to adopt a more diversified system instead of relying on oil and gas. The government aims to replace generation capacities that depend on gas and renewable energy for liquid energy generation, so that the generation capacity reaches 40 gigawatts of solar energy PV, 16 gigawatts of wind energy, and 3 gigawatts of concentrated solar energy. This can be achieved by submitting 30% of the renewable energy targets within tenders announced by the Renewable Energy Projects Development Office, while a percentage of about 70% will be paid by the Public Investment Fund and P.O [19].

## V. CONCLUSION

This study came as a contribution to stress on the necessity of adopting optimal production and consumption patterns to protect natural resources, preserve the right of the individual to a balanced life that achieves sustainable prosperity, and a modest attempt to enrich the scientific library. The study literature was presented in the most important economic theories, in addition to the basic concepts related to the subject of energy. It presented a set of previous studies that concerned the knowledge side of the index of energy intensity and total consumption. The structure of the Saudi economy was discussed with an analysis of the contribution of the energy sector to indicate the historical development of the for both primary and final energy sources.

The pattern of domestic consumption of energy sources in Saudi Arabia was characterized by increased growth during the study period, as all the sectors coincided with economic and population growth. In addition to the contribution of government support to energy prices that allowed the formation of this pattern, Saudi Arabia was at alert to enact several reform policies to raise energy efficiency and rationalize consumption. Geographical distance and individual lifestyle, as well as city design, mainly depend on private transportation in a transportation unit. Transportation sector is considered as the most energy-intensive sector; while, the industrial sector was expected to be the most consumed as the industries in it are energy-intensive industries.

## VI. RECOMMENDATIONS AND IMPLICATIONS

The study highlights the significance of diversifying energy sources and working to attract investment for alternative and clean energy sources. It is also important to set the necessary facilities from enacting incentive laws that encourage owners of commercial and industrial facilities to rationalize energy consumption. Dissemination of a culture of awareness and good use of energy among different segments of society is possible through the establishment of seminars that explain the concept of energy efficiency, along with possible alternatives that contribute to achieving this concept. It is necessary to create an appropriate and encouraging climate for such seminars as; activating public transportation. In addition, the role of government institutions should not be satisfied. Rather the role of civil society institutions should be activated to contribute towards raising individuals 'awareness of the energy relationship with economic and social development. There is a dire need to consider the design of cities to keep pace with population growth and the rapid pace of urbanization to avoid the consequences of random expansion. The goal of Saudi Arabia should not be to reduce consumption as much as to increase energy efficiency so that the outputs are consistent with the consumer from the production process inputs.

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