# Energy Consumption Trends in Energy Scarce and Rich Countries: Comparative Study for Pakistan and Saudi Arabia

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## Abstract

Energy crisis is raising serious concerns throughout the world. There has been constant rise in energy consumption corresponding to the increase in global population. This sector affects the other pillars of national economy including industries and transportation. Because of these reasons, the traditional fossil-based energy sources are depleting rapidly, resulting in high and unstable energy prices. Saudi Arabia and Pakistan, although different from each other in terms of their economic stability and political systems, still rely heavily on the traditional fossil fuels. This paper presents the comparison of these two countries in terms of their energy consumption and factors affecting it. These factors include, but not limited to, economic development, and growth in population and other sectors such as; industries, transportation, etc. The comparison is also made with the regional and global energy consumption trends and these countries. Moreover, regression models were built to predict energy consumption till 2040 and compare the growth in this sector and share in global energy demand. Energy consumption in oil-rich countries (Saudi Arabia) has been driven through its economic development, while for energy insecure country (Pakistan) it is mainly because of population growth. It was also found that in the next two decades the share of Pakistan in the global energy demand will increase. This concludes that population growth will have more impact on energy consumption than economic growth. It could mean that the shift in energy sector would shift towards sustenance instead of using energy for commercial or industrial usage.

**Keywords:** Energy consumption; Saudi Arabia, Pakistan, Statistical comparison

**Conference Track:** Policy and Finance and Strategies

## 1. Introduction

Energy refers to "the ability to do work. It can be found in many forms including sound, vibration, electrical, mechanical, thermal, chemical, etc. The sources for production of energy can be categorized in three major categories, namely; fossil, renewable and fissile. Fossil sources include coal, petroleum and natural gas, while renewable sources include hydro, wind and solar. Lastly, fissile sources are generated through chemical processes with radioactive elements such as uranium and thorium [1]. Industrial sector has been found to be the largest consumption of energy, followed by household and transportation sector [2, 3].

Until now, the reliance for energy source has been mainly on fossil fuels with marginal investment on renewable energy sources. This trend has given rise to the crisis in this sector. It had resulted in severe impacts on economies of developing countries which are now facing issues of energy insecurity. Approximately 40% of the world energy consumption is in developing countries [4]. Economic development, urbanization and population growth have been found as the major contributors to the energy consumption sector [5, 6]. These factors have been escalating in developing countries, consequently, giving rise to energy consumption.

In spite of the current energy crisis, developing countries like Pakistan and Saudi Arabia continue to focus resources on exploration of fossil based energy sources. The differences between these countries are the facts that these countries have different scales of economies and

indigenous resources have some impact. The reasons for selecting these countries was to investigate if there can be a common parameter affecting energy demand in these vastly different developing countries. In this paper, we have tried to study the trends of these countries in terms of factors affecting energy consumption. Moreover, comparison has also been made between them and global and regional trends for energy consumption. It is expected that the outcomes of this research will help to understand the scenario of energy consumption in developing countries as these countries represent the extremes of the developing world.

## 2. Methodology

The research was initiated with the study of global trends in the energy sector with reference to total energy consumption and alternative sources. It was followed by observing the trends of total energy consumption in Pakistan and Saudi Arabia. At this stage, the factors which have been found in the previous literature to affect the energy consumption were tested for their correlation in the scenario of these countries.

Regression models were also developed for predicting total energy consumption for both countries. These models were used to predict the energy parameters for future and compare the results with globally predicted energy growth rate. The data for this research was obtained from the online resources of World Bank (http://data.worldbank.org/data-catalog/world-development-indicators) for the years 1960 onwards. The factors affecting energy consumption were predicted using average annual growth rate estimated using the time series data. These predicted factors were used in the regression model for predicting energy consumption trend.

## 3. World Energy Consumption Trend

Bilgen [7] presented a comprehensive review of energy consumption trends for different countries and the global scenario. The trend and forecasted value for energy consumption in global scenario are given in Figure 1. It can be observed from this figure that the energy consumption trends in the regions of interest (Asia and Middle East) are same as that for global scenario.
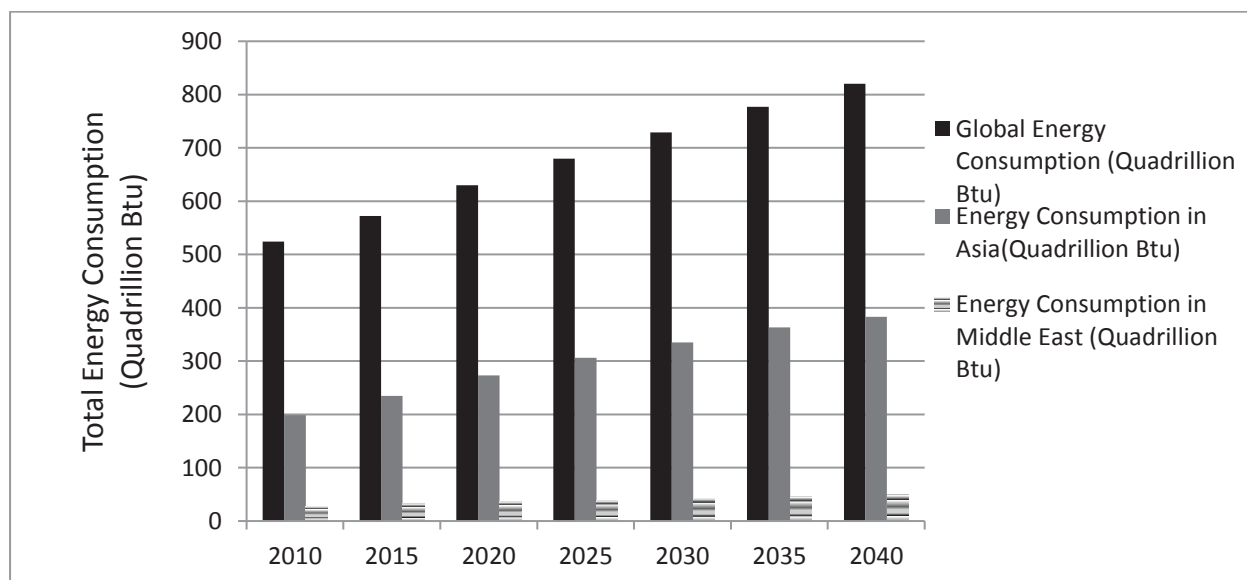


**Figure 1: Global Total Energy Consumption**

Table 1 shows the trend for the use of alternative energy resources for present as well as for future predictions. It can be observed that the fossilized sources will continue to be single largest contributor to the world energy needs at least in the next two decades as well.

**Table 1. Alternative Energy Global Consumption Trend**

| Year | 2011 | 2012 | 2025 | 2040 |
|---|---|---|---|---|
| Petroleum (Quadrillion btu) | 36.56 | 35.87 | 36.28 | 35.35 |
| Natural Gas (Quadrillion btu) | 24.91 | 26.20 | 28.97 | 32.32 |
| Coal (Quadrillion btu) | 19.62 | 17.34 | 19.03 | 17.35 |
| Nuclear (Quadrillion btu) | 8.26 | 8.05 | 8.15 | 8.49 |
| Hydropower (Quadrillion btu) | 3.11 | 2.67 | 2.84 | 2.90 |
| Biomass (Quadrillion btu) | 2.60 | 2.53 | 3.74 | 4.26 |
| Other renewable energy (Quadrillion btu) | 1.70 | 1.97 | 3.09 | 3.89 |

**4. Energy Consumption Trend in Saudi Arabia**

Saudi Arabia is among the high income countries of Middle East [8]. It has the 2nd largest proven oil reserves in the world and has been involved in highest production of fossilized fuel (as per 2012). It is the largest exporter of oil and 6th largest consumer of oil. It has been reported to over-use fossilized energy sources for its own consumption [9, 10]. This fact is obvious from figure 2 which shows the growth in per-capita GDP and energy consumption for the last four (04) decades. It shows that the growth in economy has been lagging that of energy consumption for most of the time.
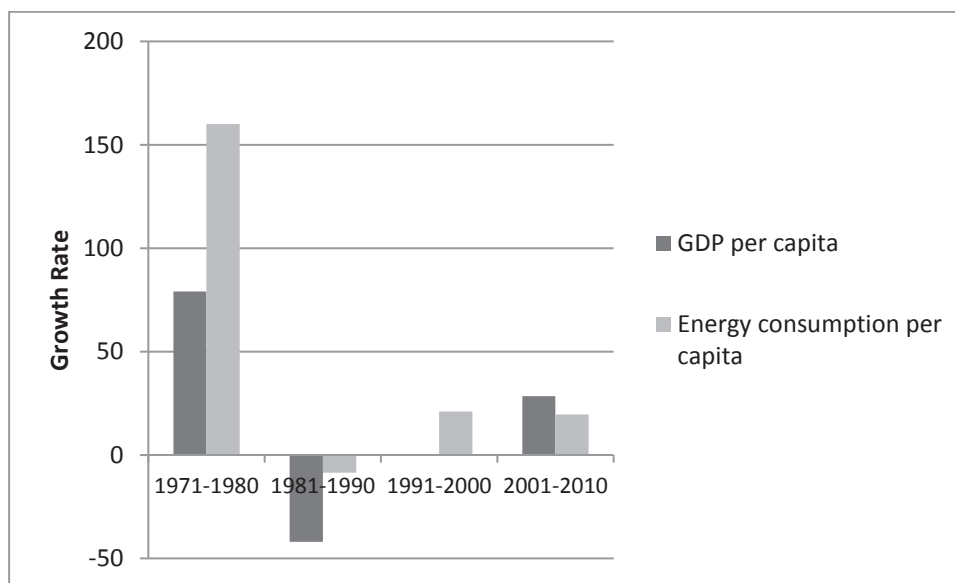


**Figure 2: Growth Rate of Per Capita GDP and Energy Consumption in Saudi Arabia**

Oil and liquid petroleum have been the main source of energy for Saudi Arabia. Natural gas has also become another dominant energy source for this country. The use of natural gas was started in the middle of 1970s and since then it has increased to cater for 50% of electricity production in the country. Figure 3 illustrates this fact; in addition, it also shows that the contribution of renewable energy sources in its electricity production is non-existent.
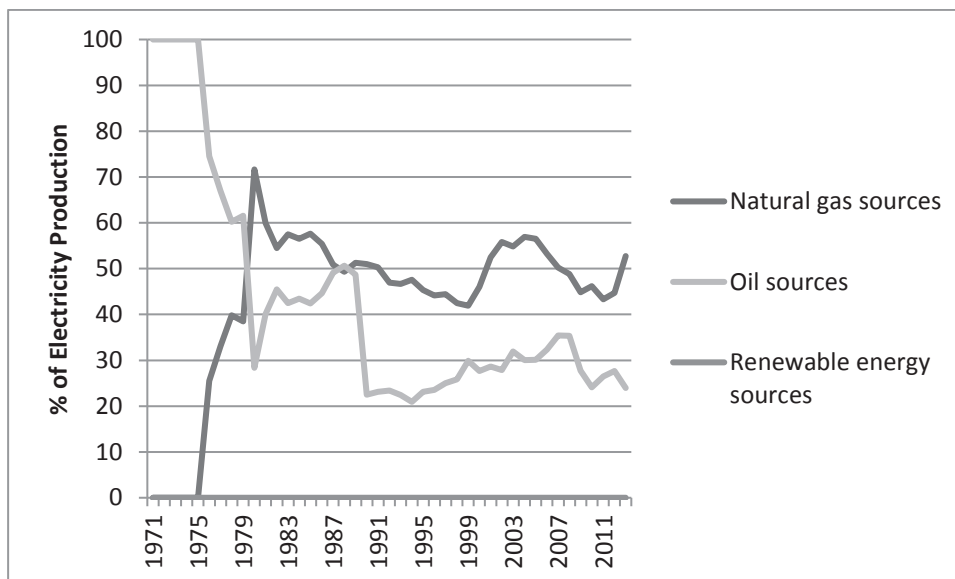
**Figure 3: Alternative Energy Sources for Saudi Arabia**

As population can be a major contributor to energy consumption, the energy consumption trend was compared with population growth. The comparison is shown in figure 4. It shows that the population has been growing at a consistent rate in Saudi Arabia while the energy consumption has been less robust in the previous decades. It can also be seen that the increase or decline in energy consumption does not show any cyclic behavior and shows more variability in the recent times.
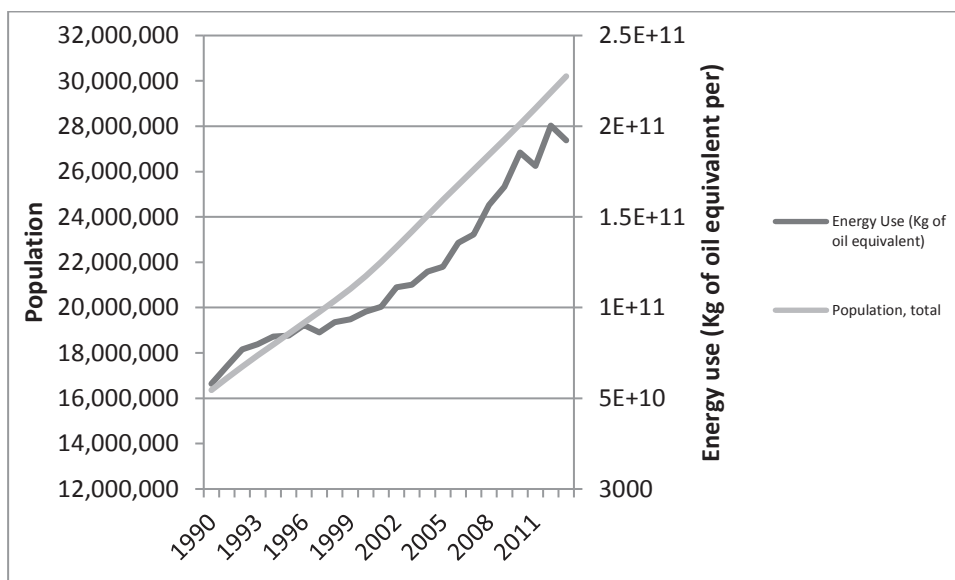


**Figure 4: Trend of Growth in Population and Energy Consumption for Saudi Arabia**

To further investigate the factors affecting energy consumption in Saudi Arabia, a regression model was developed. At this stage; population, GDP, industrial sector value, urban population and agricultural sector value were considered as the predictor variables. However, only GDP and

industrial sector were found to be affecting the model statistical significance. At this point, the correlation between GDP and industrial sector value was calculated and found to be close to 1. Hence, GDP was selected for the model to predict the energy consumption as the model with this variable was giving better R-square value. The final regression model is given in table 2.

**Table 2. Regression Model for Energy Consumption for Saudi Arabia**

| Variable | Coefficients | Standard Error | t Stat | P-value |
|---|---|---|---|---|
| Intercept | 2.42E+10 | 5.28E+09 | 4.591795 | 4.13E-05 |
| GDP (current US$) | 0.268521 | 0.019023 | 14.11559 | 2.45E-17 |
| R-square | | 0.83 | | |

## 5. Energy Consumption Trend in Pakistan

Pakistan is considered among the lower middle income countries of South Asia [11]. Energy requirements are rapidly increasing in Pakistan. It is evident from the fact that energy requirements in Pakistan have increased by more than 80 percent in the last one and a half decade. Conventional sources of nonrenewable energy satisfy more than 80% of the energy requirements in Pakistan [12]. This can be observed from figure 5 which shows high contributions of nonrenewable sources.
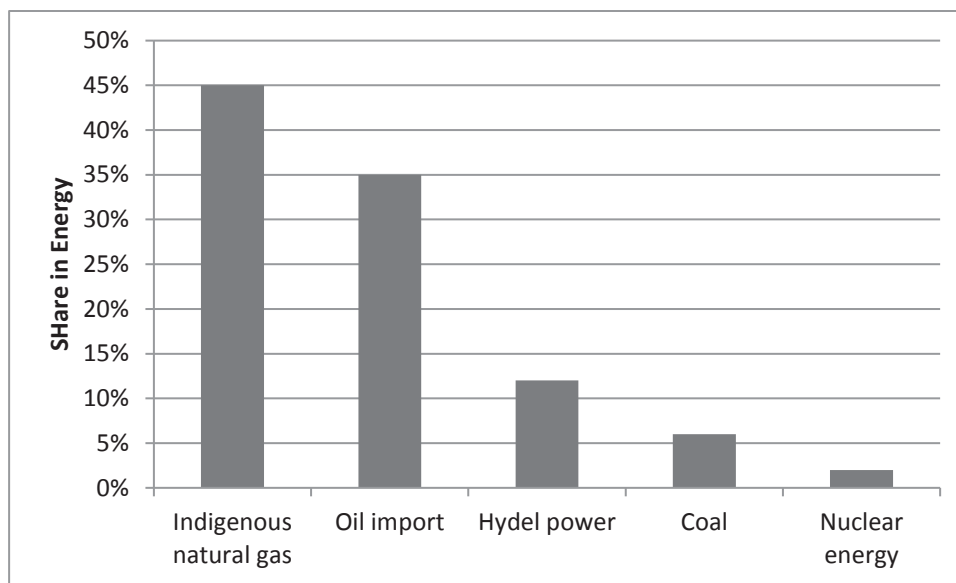


**Figure 5: Share of Energy Sources in Pakistan (2010)**

The energy sources used in Pakistan for electricity production mainly include hydroelectric, natural gas and nuclear power. Among which, the share of natural gas has increased in 1990s while that of hydroelectric has decreased. This situation is reversed from the perspective of sustainability as nonrenewable energy source have been more utilized. This has resulted in rapid depletion of natural gas reservoirs as shown in recent decline in its use (see figure 6). Figure 7 shows the comparison of energy consumption and population for Pakistan. The data shows that both parameters are growing with similar pattern i.e. consistent growth.
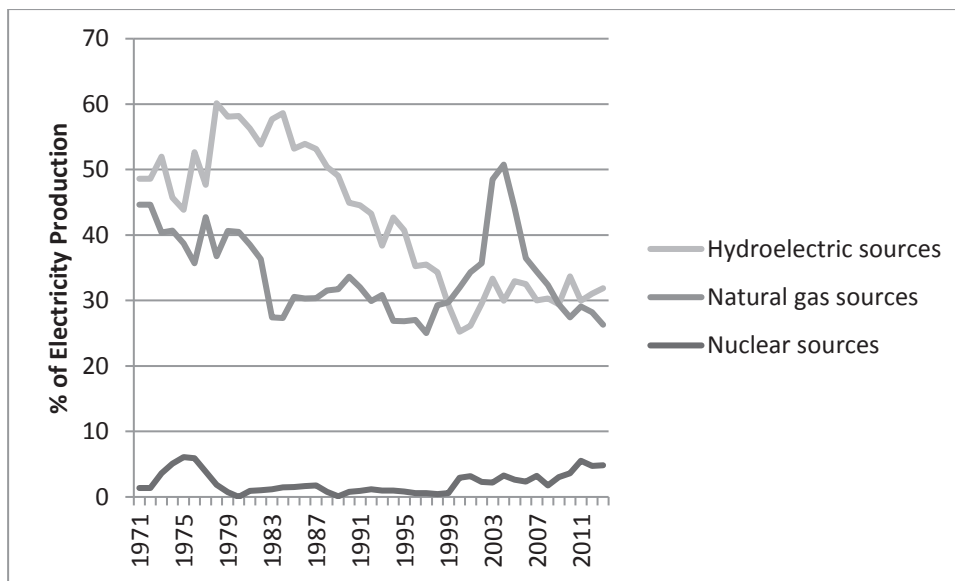
**Figure 6: Share in Electricity Production of Alternative Energy Sources for Pakistan**
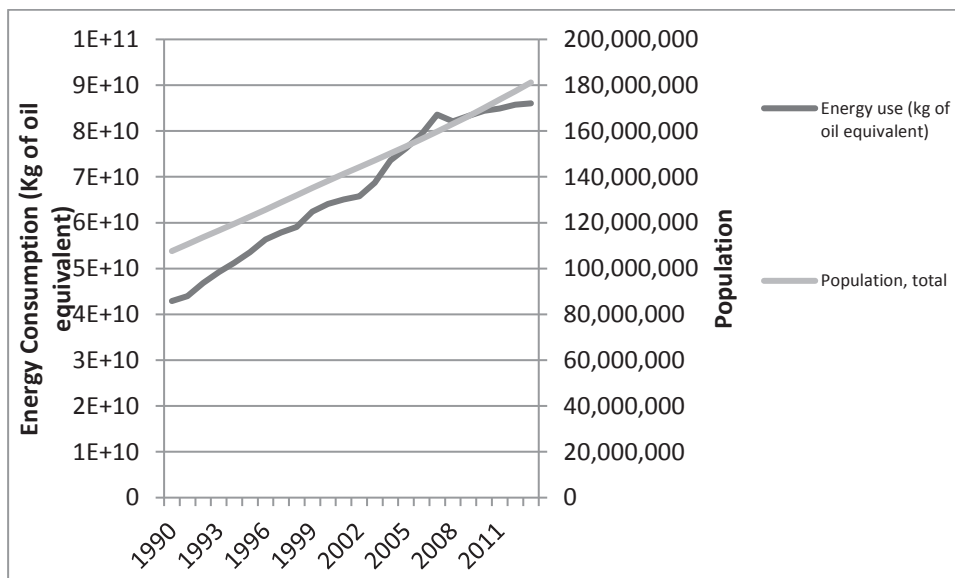


**Figure 6: Trend of Growth in Population and Energy Consumption for Pakistan**

The regression model was developed for Pakistan using the variables mentioned for Saudi Arabia. Population and urban population were found to be significantly affecting the energy consumption. However, the correlation for these factors was found to be close to 1, hence, population was used for predicting energy consumption as the model with population resulted in better R-square value. The final regression model is shown in table 3.

**Table 3: Regression Model for Predicting Energy Consumption for Pakistan**

| Variable | Coefficients | Standard Error | t Stat | P-value |
|---|---|---|---|---|
| Intercept | -2.4E+10 | 1.07E+09 | -22.2523 | 1.66E-24 |
| Population, Pakistan | 632.3549 | 8.822506 | 71.6752 | 1.04E-44 |
| R-square | | 0.99 | | |

## 6. Comparison of Energy Consumption

Table 4 presents the comparison of future energy consumption for Pakistan and Saudi Arabia. The data in this table shows that currently Pakistan is lagging behind in energy consumption with more than half of that of Saudi Arabia. However, the rate of increase in Pakistan is much higher than Saudi Arabia which could result in higher energy consumption demand in Pakistan in future.

Both countries are showing higher growth rate in energy consumption in comparison with the global trends as well as those in their specific regions. The data for the global and regional predictions was taken from Bilgen (2014). The share of Pakistan in global energy consumption is also increasing in the period 2020-2040, while that for Saudi Arabia is approximately at the same level.

**Table 4: Future Energy Consumption Trend Comparison**

| Year | Pakistan | | Saudi Arabia | | Global | Asia | Middle East |
|---|---|---|---|---|---|---|---|
| | Energy Consumption (Kg of Oil Equivalent | Share in global Market | Energy Consumption (Kg of Oil Equivalent | Share in global Market | | | |
| 2020 | 1.18E+11 | 7.4E-03 | 2.48E+11 | 1.6E-02 | 1.59E+13 | 6.88E+12 | 9.33E+11 |
| 2025 | 1.55E+11 | 9.0E-03 | 2.76E+11 | 1.6E-02 | 1.71E+13 | 7.72E+12 | 9.84E+11 |
| 2030 | 2.01E+11 | 1.1E-02 | 3.08E+11 | 1.7E-02 | 1.84E+13 | 8.45E+12 | 1.08E+12 |
| 2035 | 2.59E+11 | 1.3E-02 | 3.44E+11 | 1.8E-02 | 1.96E+13 | 9.41E+12 | 1.16E+12 |
| 2040 | 3.32E+11 | 1.6E-02 | 3.84E+11 | 1.9E-02 | 2.07E+13 | 9.66E+12 | 1.24E+12 |
| Growth (2020-2040) | 9.1 | | 2.7 | | 1.5 | 2.0 | 1.6 |

## 7. Conclusions

This research was focused on determining and comparing the trends in energy consumption of Pakistan and Saudi Arabia in global and regional context. The objective was to study the factors affecting energy consumption in the developing countries having different levels of economy, population and indigenous resources.

It was found that energy consumption in Saudi Arabia was mainly driven by the economic development, while that for Pakistan was contributed by the growth in population. This could also point out to the fact that energy scarce countries like Pakistan are hampered in their economic growth due to energy insecurity. In spite of this fact, Pakistan relies heavily on nonrenewable energy resources as does Saudi Arabia. The predictions for the year 2040 show

that Pakistan's energy consumption growth rate will be higher than Saudi Arabia and global and regional rates. On the other hand, its share in global energy consumption will also be increasing. Hence, it can be said that population growth will become a major factor to increase the global energy consumption as the economic growth may be halted due to energy insecurities.

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