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The Contribution of Coal Resources to Electrical Energy Production in Afghanistan

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Abstract

This study investigates the impact of coal reserves in Afghanistan on the country's electricity generation. To conduct this study, the secondary data collected by reliable sources was used. For the analysis of data, a quantitative approach with descriptive methods is used. The analysis showed a massive impact of electricity-from-coal with a 4.94 times increase in generation making 93% of the overall energy consumption of the country. It has been concluded that sustainable usage of coal in electricity production could reduce the annual imports to zero making the country self-sufficient. However, there are several limitations in the data collected including fewer data for the types and quality of the coal in the country and no previous research in the field.

Keywords: Energy, Electricity, Coal, Afghanistan

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1. Introduction

Afghanistan, is a country rich in mineral mines and energy resources especially fossil fuels like coal, natural gas, and oil. Afghanistan's minerals mines are estimated to be worth over $1 trillion. Due to everlasting political and economic crisis, not enough research have been conducted in the area of energy resources to find the potential capacity of each source for electricity production. [1]

A large percentage of electricity production in Afghanistan is of non-renewable energy resources, renewable resources makes small percentages. [2] [3] While the country has total electricity production capacity of 5.55 billion kWh, yet consumes most of its electricity from imported power mainly from Tajikistan and Uzbekistan. [4]

With high capacity of electrical energy production from fossil fuels in Afghanistan, unfortunately it has only oil power plants currently active in several locations of the country and zero coal and gas power plants. [5]

Coal plays a significant role in energy production in most countries and is the largest single resource for electricity production making 36% of total electrical energy produced as of 2019 in the world. It may be an efficient energy source in Afghanistan due to the large reservoirs that the country possesses. [6]

Initial researches estimated the total amount of coal to be 100-400 million tons. However, recent studies by the United States Geological Survey showed that the amount of proven and economic available coal reservoirs in Afghanistan seems to be less than that is mainly located in the north and south areas of the country. [7]

Annual coal production and consumption in the country is equal. Making Afghanistan 45^{th} for production in world rankings and 61^{st} for consumption in rankings. Either all the coal, which is being produced annually, is consumed for domestic use or as a thermal energy source in factories and a portion of it is being exported to foreign countries. [8] [2]

In this study, with the data collected about the coal status in Afghanistan and using Quantitative approach and data analysis methods, this study aims to estimate the contribution of coal resources in electrical power generation in the country.

2. Literature review

Afghanistan is one of the countries that uses non-refined materials such as wood, animal excrement and waste materials in the winter season for heating homes. This causes various diseases mainly due to the lack of electricity and its high prices. In general, in the winter season, the household energy consumption in this country is 40% from wood, 40% from coal, 10% from natural gas and 10% from electricity. [9]

Energy is an important necessity for humankind. Hence, the level of progress and development of a country is directly related to its energy consumption. Coal, which is the primary cause of the industrial revolution in the world, with the reduction of oil and gas reserves, it is one of the main alternatives to meet the world's energy needs. [10]

Global coal production in 2018 showed an increase of 4.3%, which was much higher than the 10-year average of 1.3%. China accounted for half of this global growth and Indonesia had an increase of 51 million tons. Coal consumption in 2018 shows an increase of 1.4%, which is the fastest growth since 2013. Globally, coal still accounts for 38.0% of electricity production, which is the continuation of the trend of the past two decades. Coal is still mainly used for 66.5% of commercial electricity and heat generation. The above statistics show the value of coal in electricity production. [11]

Despite the advances in renewable energy, the role of fossil resources in electricity production is still unshakable. Coal makes up about 40% of electricity production in the world and the reason is its cheapness and availability. [11]

The distribution of coal is much fairer than other fossil energy sources such as oil and natural gas, which is concentrated in the Middle East, for example, Turkey, which does not have much capacity in terms of other fossil energy sources, but in terms of coal, it has 2% of all coal in the world. After 1973 with the energy crisis in the world, it turned to using coal resources inside the country for electricity production. [10]

In order to achieve the purpose of the research, the data were collected and filtered outliers out according to our needs. The results of this study are presented below.

2.1. Electricity production, consumption, and import

Table below shows the data provided by the US Energy Information Administration about the energy generation, consumption and import in 2019. [4] [12]

Table 1 Total amount of electrical energy consumption, production and import of Afghanistan in 2019

Electricity	Total	per capita
Own consumption	5.9 bn kWh	138.72 kWh
Production	1.1 bn kWh	30.40 kWh
Import	4.9 bn kWh	110.45 kWh

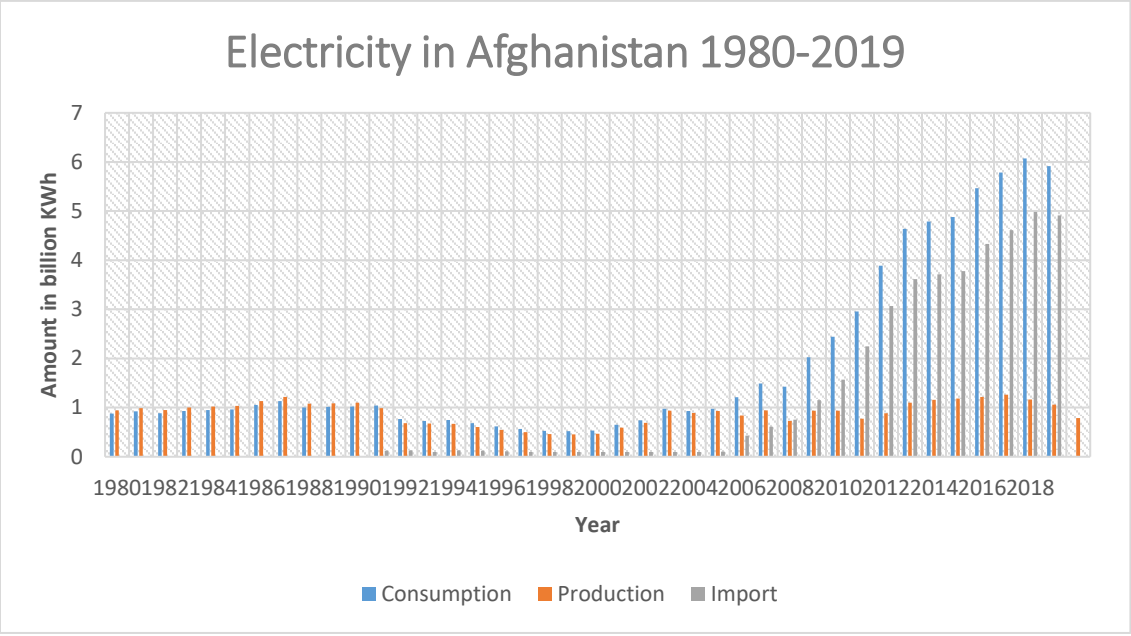


Figure 1 Electricity generation, consumption and import level of Afghanistan between the years 1980-2019(Source: US Energy Information Administration)

According to the United Nations Statistical Division total household electrical consumption in the year of 2020 is estimated to be 3.4 GWh. [13]

2.2. Potential electricity generation capacity by source

Table below shows the potential capacity of electricity generation by source. The theoretical value of the production capacities for electric energy is only possible under ideal conditions. They are measuring the amount of energy that would be generated if permanent and full use of all capacities of all power plants. In practice, this is not possible, because e.g. solar collectors are less efficient under clouds. In addition, wind- and water-power plants are not always operating under full load. All these values are only useful in relation to other energy sources or countries. [4] according to McGinely of UK, From each tone of coal in average 0.00246 GWh (that is equal to 2.46 MWh) electrical energy could be generated. [14]

Table 2 Source based electricity generation potential of Afghanistan

Energy source	Total	Percentage	per capita
Fossil fuels	2.50 bn kWh	45.0 %	62.75 kWh
Nuclear power	0.00 kWh	0.0 %	0.00 kWh
Water power	2.89 bn kWh	52.0 %	72.51 kWh
Renewable energy	222.19 m kWh	4.0 %	5.58 kWh
Total production capacity	5.55 bn kWh	-	139.44 kWh
Actual total production	1.21 bn kWh	21.8 %	30.40 kWh

2.3. Share of renewable and non-renewable sources in electricity generation

Table below shows data of renewable and non-renewable share of electricity generation in Afghanistan according to a research conducted by International Renewable Energy Agency (IRENA) in 2020. [15]

Table 3 Current domestic electricity generation by source in Afghanistan 2020

Generation in 2020	GWh	%
Non-renewable	135	12
Renewable	995	88
Hydro and marine	933	83
Solar	63	6
Wind	0	0
Bioenergy	0	0
Geothermal	0	0
Total	1128	100

2.4. Coal reserves and annual production

According to a report from ministry of mines and industry of Afghanistan in 2002, coalmines estimated to be 440 million tons with annual production rate of 150000 ton in which only 40000 tons of it was from governmental controlled mines. [8]

Recent studies with developed mechanism showed the proven coal reserves in Afghanistan to be about 73 million tones. Bituminous and Anthracite are the two types making the majority of reserves in the country. [16] Figure below shows the production rate of coal from the year 1980 to 2021 in Afghanistan:

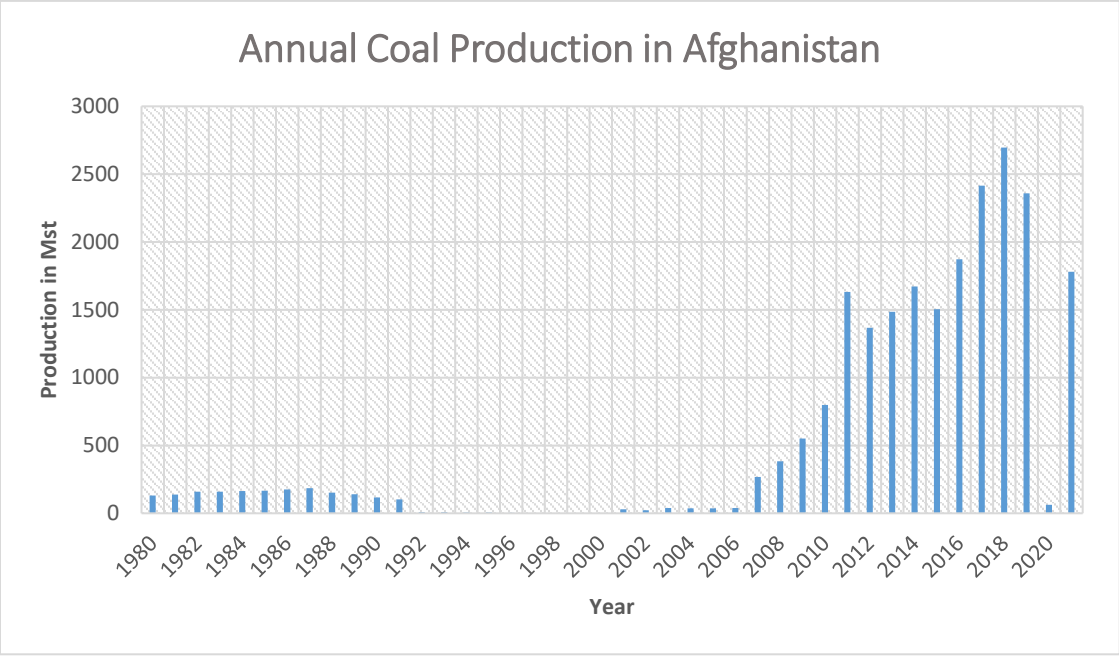


Figure 2 Annual Coal production in Afghanistan from years 1980 to 2021(Source: US EIA)

Coal plants require enormous amounts of coal. Shockingly: a 1000 MWe coal plant uses 9000 tons of coal per day, equivalent to an entire trainload (90 cars with 100 tons in each!). [17]

3. Methodology

Through this study, the electricity generation capacity of coal in kWh was analyzed and compared with other sources currently used in Afghanistan and the amount of electricity imported from foreign countries.

The data used were primarily collected through laboratory tests, field investigations, surveys and interviews conducted by various national and international organizations. The data used in this research is secondary data collected and compiled from reliable sources. With deep literature review of other researches, the amount of coal and it's types were determined. Then from laboratory experiments of international energy laboratories, the potential electrical capacity of each ton of coal in GWh was found. Furthermore, the data for total electricity consumption for that last decade collected and its sources was determined to be further compared with coal power.

To carry out this research, quantitative methods are used to analyze and evaluate the collected data and present the results and calculations with the help of formulas and tables. To complete this review paper, descriptive analysis is used to organize and categorize data collected from sources with the help of Microsoft Excel. In addition, inheritance analysis will be used to interpret and analyze the data of the results to achieve the purpose of this study.

4. Results and analysis

4.1. Potential electricity generation capacity of coal reserves

From each tone of coal in average 0.00266 GWh (that is equal to 2.66 MWh) electrical energy could be generated. With the amount of coal exist in Afghanistan (73 Million tons), about 194,180 GWh electricity could be generated in total. By considering the electricity consumption in Afghanistan, which is shown in Figure below, the country could achieve it's electricity demand for 43.7 years with only using electricity generated from coal reserves.

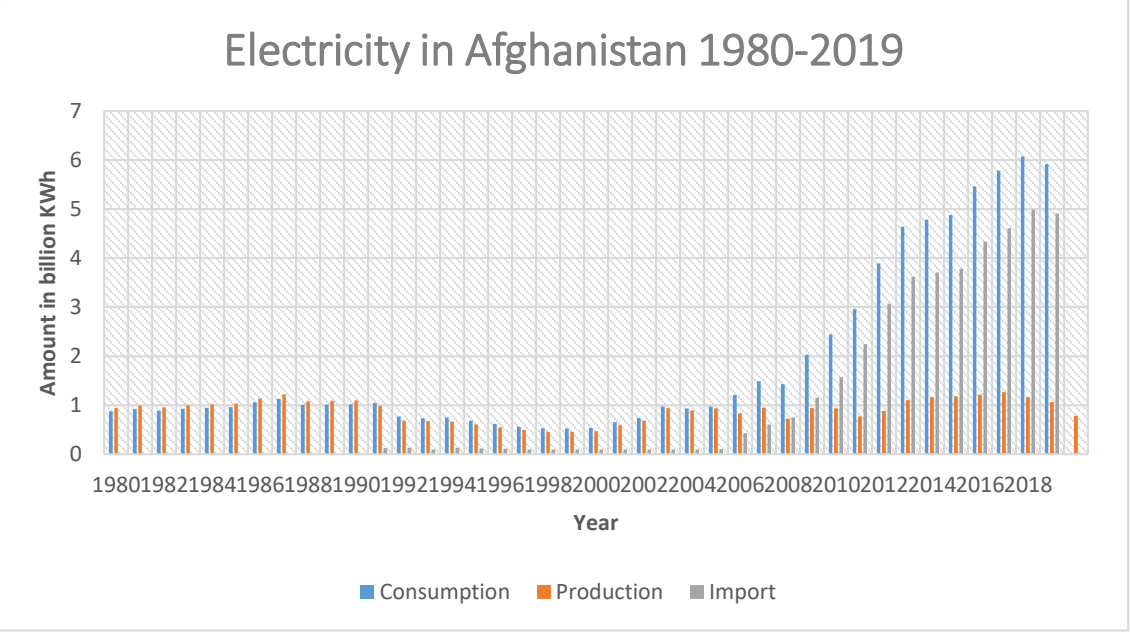


Figure 3 Electricity generation, consumption and import level of Afghanistan between the years 1980-2019

Calculations:

Potential Electricity Generation Capacity= (Conversion factor GWh/metric tone)(total reserves in tone)

Potential Electricity Generation Capacity= 0.00226GWh/tone x 73 Mt= 194,180 GWh

Total Years for a single source to meet the annual electricity demand = (Electrical capacity of the source)/(Annual Energy Consumption)= (194,180 GWh/year) /(4442 GWh)=43.7 years

4.2. Contribution of coal generated electricity to electricity consumption and generation

Based on our calculations we found that the average annual production of coal in last decade (2011-2021) is 1713.004 Mst (thousand short tons). This is equivalent to 1.5 Million tones (1,554,011 tones). By considering the assumption of using annual coal production to generate electricity, there will be 4133.669 GWh electrical energy generation per year.

Using descriptive analysis, we can find that the average electricity production in the past decade (2010-2020) is 1.047 bn kWh that is equivalent to 1047 GWh. With addition of the amount energy generated from coal, annual electricity generation of the country will become 5180.669 GWh, which shows 4.94 times increase in total electrical energy generation from interior sources.

Analysis shows that with annual production rate and annual potential electricity generation capacity of coal, it secures 93% of total electricity consumption per year. Since with the help of descriptive analysis, the average electricity consumption of the country is 4442 GWh from 2009 to 2019.

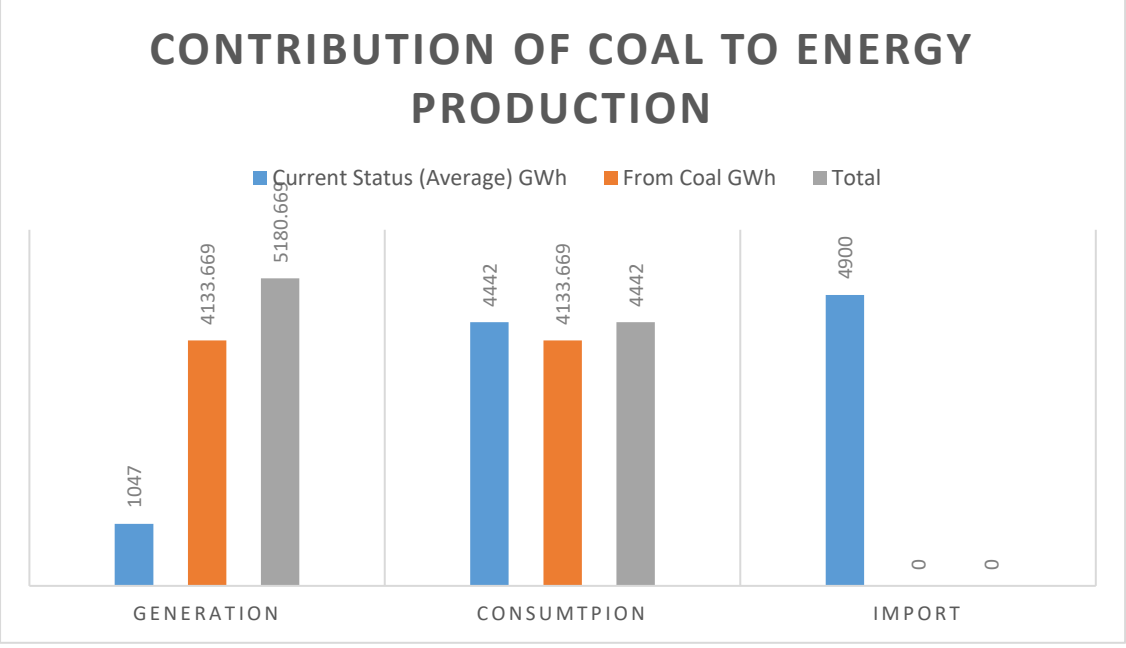


Figure 4 The contribution of coal reservoirs to Electrical energy production in Afghanistan

5. Conclusion

Because electricity is such an essential part of everyone's life, especially in the age of technology and computers, it is important to understand the potential of every available resource. Coal, the world's main source of energy, is plentiful in Afghanistan with vast amounts. The country is still not using its coal reserves for electricity generation and there is no coal-fired power plant. It is crucial to understand the overall electrical energy potential capacity of these reserves and its impact on all aspects of energy production, consumption and imports. With the results presented, the use of coal as an energy source could be very effective in reducing imports and saving the country’s financial resources.

A total of 194,180 GWh electricity could be produced in coal-burning power plants. This amount of electricity will increase Afghanistan's energy production by 4.94 times, making the country self-sufficient in the energy sector and reducing foreign energy imports to zero. Annual electricity produced from coal accounts for 93 percent of the country's total electricity consumption, leaving little room for the use of other sources. The total generated electrical power could meet the electricity demand of country for up to 43 years. However, calculating how a hybrid system can improve its life cycle is a remarkable feat.

In the future, studies can be conducted on financial difficulties and technical obstacles that may prevent the realization of the results of this study. It is also the duty of researchers to investigate methods aiming to establish a national sustainable energy production plan for sustainable utilization and life cycle extension of energy resources.

6. Discussion

The study demonstrates a correlation between the electrical energy that could be generated from coal reserves in Afghanistan and its impact on total electricity generation and import. However, due to the lack of data on types of reserves in Afghanistan with their respective percentages, the results may not fit well with implications in practice. Investment costs of building power plants, Carbon Dioxide emissions and relevant limitations in conversion processes should be also taken into consideration. Avenues for future research include accurate investigations to find percentage and qualitative values for each type of coal available and its impact on sustainable energy and economic development.

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