Interdisciplinary Publication
REPA PROCEEDING SERIES

Vol 1 (1): Pages 1-12 (2020)
DOI 10.37357/1068/SODC2019.1.1.01
ISSN 2435-7308

International Conference on
Sustainability Outreach in Developing Countries (SODC 2019)
16-19 November 2019, Kabul, Afghanistan

Afghanistan fuel market prediction

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Conference Proceeding
Open Access
Published

Keywords
- Fuel market
- Gross domestic product (GDP)
- Prediction scenarios
- Afghanistan energy
- Afghanistan fuel trade
- Fossil fuel

ABSTRACT

Afghanistan is an underdeveloped country with a good rebuilding and developing potential. It is obvious that the amount of energy consumption of each country directly affects its economy and GDP. All economic activities are directly or indirectly linked to the energy sector. That is why the energy sector is considered a backbone of the countries development as well as means of achieving sustainable economic development. Accurate evaluation and studying of the energy market and prediction of the future's energy market is significant to taking proper decisions, making effective and applicable energy policies and goals regarding energy policies. Consequently, it will have a huge influence on the economic and political future of a country. Fossil fuel has a huge share among the energy consumption sources, as well as playing the main role to run the power sector, transportation sector, and industrial sectors. Exports of fossil fuel are also somehow linked to a proper analysis of the internal demand and production rate as well as capacity in the future. In this research, we present Afghanistan's fuel demand and its future situation prediction by 2032, based on three scenarios. It has been the first time that such research is performed in Afghanistan and will enable energy and fossil fuel sectors to use, analyze, and explore the findings of this research for the purpose of strategic planning, export and import predictions.

Received: January 17, 2020; Revised: March 17, 2020; Accepted: March 20, 2020; Published: June 12, 2020

1. Introduction

The huge amount of energy demand in Afghanistan is met by traditional fuels such as wood, animal dung, and agricultural waste, and for the higher scale of energy demand, imported power, hydropower, gas, and petroleum products are used. Petrol, diesel, and liquid petroleum gas (LPG) make up most of Afghanistan's petroleum product use. This research paper focuses on evacuation and prediction of the market for coal, petrol, diesel, and liquid petroleum gas (LPG) in Afghanistan. All of these are produced from crude petroleum oil and rock coal and are used in internal combustion engines, thermal power plants, and heating technologies. Diesel engines are generally preferred over petrol engines for commercial and heavy-duty vehicles and are also more readily available for a wide range of uses, such as diesel generator sets for homes, electricity utilities, and businesses. Diesel use in Afghanistan is much higher than petrol use. Most of the country's heavy vehicles, including trucks and buses, have diesel engines. Afghanistan has very low vehicle ownership per capita, about 29.29 vehicles per 1000 people in 2011 [1]. The use of private diesel-powered generators for urban domestic electricity and for factories and businesses is widespread. In addition to the consumption of diesel by private generators, a substantial proportion of electricity supplied by the national grid to Kabul, and all of the emergency electricity currently supplied to Kandahar, Qalat, and Lashkar Gah, is produced by diesel-powered turbines and generators.

Fuel reserves, exports, and imports are the main criteria of the fuel market and need to be studied for evaluation of the fuel market. Afghanistan is a landlocked country which is located in the center of Asia with a huge amount of coal, oil, and natural gas reserves. Currently, most of the research on gas and oil in Afghanistan have been carried out in five oil and gas fields, two fields in the northern part of Amu, one field in Helmand, one in Herat, and one in the Katouz province of Paktika. However, beyond the five fields

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mentioned above, the results of a NASA survey indicate that there are more than 100 oil and gas fields in Afghanistan that will be available after further research. Afghanistan has 1.908 billion barrel crude oil and 59 trillion cubic feet natural gas discovered reserves. In addition, the coal reserves of Afghanistan are estimated to be 73 million tons. However, the US Geological Survey states: "very little is known about the character of the Afghan coal resource, and much of the existing data is not readily available to potential users." Today coal is produced by artisanal miners and delivered by road to the consumer. It is used by kilns for brick production, a cement factory, and domestic consumers. The coal production of Afghanistan is estimated to be 35,000 metric tonnes per year as per 2008. The prewar coal production of Afghanistan peaked in 1987 at 167,000 metric tonnes per year [2]. Today fuel is imported into Afghanistan from Central Asia in the north, Iran in the west, and Pakistan in the south and east. The routes for importing fuel into Afghanistan have been, and continue to be, tied up with Afghanistan's geopolitics. Fuel is imported to Afghanistan by eight ports (Shir Khan, Heiratan, Akina, Turgundi, Islam Qala, Zaranj, Spenboldak, and Turkham). In 2016, Afghanistan imported 566873 tonnes of petrol, 951910 tonnes of diesel, and 623257 tonnes of LPG from Central Asia and Iran [3].

As has been mentioned before, the energy sector has an essential role in the economy of the country. Therefore, the study and evaluation of the energy market is an important step to manage the economy of the country. Fuel, as the primary energy consumption resource, has the most share among the world energy consumption. However, unfortunately, the shortage of data and studies regarding the Afghanistan fuel market results in not having a clear perspective of the energy market. It also results in having unsecured and unsustainable energy market, which has destructive effects on the GDP and economy of the country.

To predict the amount of fuel demand in Afghanistan, firstly, we need to find the amount of fuel consumption for the current status, and to find the amount of fuel demand, it is suggested to divide the fuel demand based on consumer sectors. These are the power sector, transportation sector, and residential and industrial sectors. The fuel demand prediction mechanism is described in Figure.1.

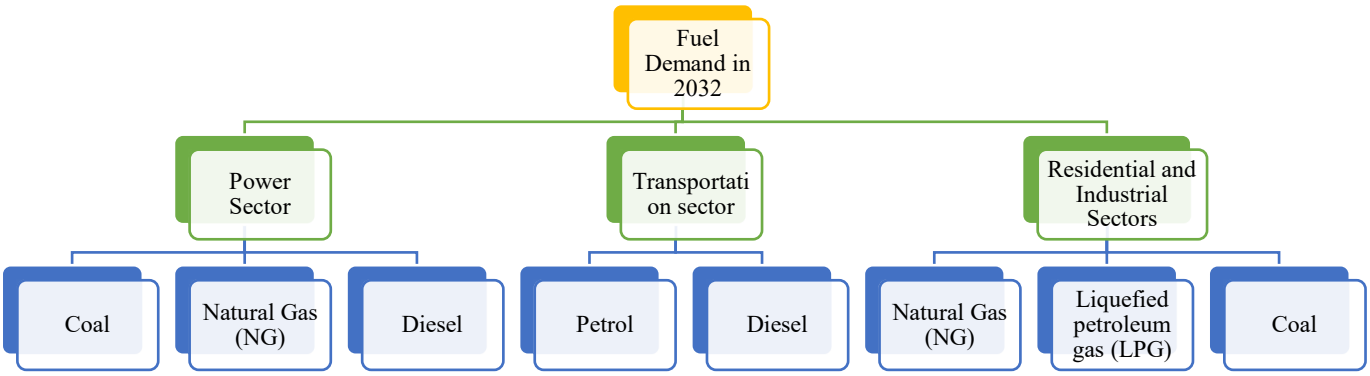

Figure 1. The fuel prediction mechanism chart.

2. Current situation

As it has been mentioned before, for the prediction of fuel demand, all demanded fuel has been divided into power, transportation, industrial, and residential sectors. For improving the accuracy of prediction, three scenarios (high case, base case, and low case) have been considered, and each sector is described below.

1.1. Power sector

To predict the amount of fuel consumption in the power sector, it needs to evaluate scenarios and expresses the various usage factors for thermal power plants. These scenarios are dependent on the same parameters, which will be described in the next section. After studying and investigating the usage factor for thermal power plants in various countries, several usage factors have been selected for each scenario. By using power generation capacity of the planned thermal power plants and usage factors, it is possible to predict the amount of annual thermal

power generation, so it makes us able to find the amount of annual fuel consumption in the power sector by using annual thermal power generation, plant efficiency, and fuel calorific value.

2.1. Transportation sector

A huge amount of fuel has been consumed by the transportation sector. Petrol and diesel are two major consumed fuels by the transportation sector in Afghanistan, although LPG (as hybrid fuel) has a minor share of consumed fuel in the transportation sector, consumption of LPG in the transportation sector is always limited, and it is related to fuel affordability. For predicting the amount of required fuel for the transportation sector, firstly, we need to find the amount of required fuel for transportation in the current status and, in the second step, predict the amount of required fuel for the transportation sector. To find the amount of required fuel for the transportation sector, we need to find the number of vehicles in the country, the fuel economy of vehicles, and the average annual traveled distance, and for predicting the amount of required fuel for the transportation sector, we need to consider the proliferation of vehicles and increase fuel economy and efficiency of vehicles. By using these parameters, the amount of required fuel for the transportation sector could be calculated.

2.2. Residential and industrial sectors

Most of the consumed fuel in the residential and industrial sectors is for heating and power generating from small standalone power generators. A shortage of data for finding the amount of consumed fuel for electrification by small standalone generators and also the improvement of electricity reliability by expanding the national grid will cause a decrease in power generation by a small off-grid generator. For these issues, the amount of consumed fuel for electrification by small off-grid generators has been ignored. Coal, natural gas (NG), and liquefied petroleum gas (LPG) are used for heating in residential and industrial sectors. It is assumed that all produced and imported coal, natural gas (NG), and liquefied petroleum gas (LPG) are consumed for heating in residential and industrial sectors.

3. Results and discussion

As the method described before, to find and predict fuel demand, we need to divide the fuel demand to several sectors, and by using available data, the fuel demand could be predicted. The result of each sector has been mentioned below.

3.1. Power sector

Total installed generation capacity (domestic and imports) available to Afghanistan is approximately 1504.6 MW, of which 60% is imported. Domestic operating capacity stands at approximately 83.5% of installed capacity. Total installed generation capacity (domestic and imports) available to Afghanistan is approximately 1504.6 MW, of which 60% is imported. Domestic operating capacity stands at approximately 83.5% of installed capacity. Domestic generation in 2016 stands at 1046 million KWh, which was a 6% decrease over the previous year (Afghanistan electricity production and import chart is shown in Figure 2) [4].

Table 1: The amount of annual consumed diesel in the power sector.

Year	Thermal [GWh]	Tonne
2010	101	23653.392
2011	39	9133.488
2012	55	12880.56
2013	20	4683.84
2014	137	32084.304
2015	76	17798.592
2016	40	9367.68

Domestic installed capacity stands at 604 MW, of which the majority is from hydropower and thermal sources. All the existing thermal power plants of Afghanistan are fired by imported diesel fuel. Nearly all of this thermal generation comes from reciprocating engines except for the Kabul NE power plant, which consists of two diesel-fired gas turbines. The amount of annual fuel consumption is found by calculations of annual thermal power generation in GWh, power plants efficiency in %, and fuel heating values. The heating value of diesel is 12.2 kWh/kg and the efficiency of existing thermal plants is between 32% and 39%, so 35 % is selected as an average efficiency for thermal power plants (the amount of consumed diesel is mentioned in Table 1).

The growth of fuel consumption in the power sector directly depends on the amount of planned thermal power generation capacity (as shown in Table 2) and the total hours which a power plant has to operate in a year. The ratio between operating hours of a power plant to whole hours of a year is called usage factor. By increasing the usage factor, the fuel consumption will increase, and by decreasing the usage factor, the fuel consumption will decrease.

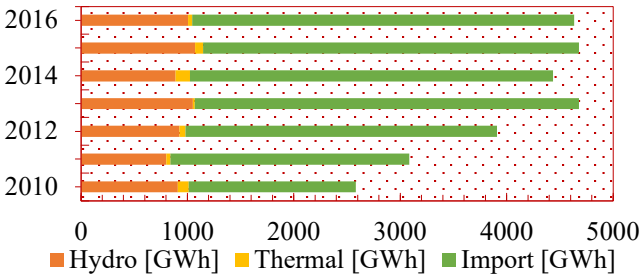

Figure 2. Afghanistan electricity production and imports chart [4].

Table 2: The existing and planned thermal power plants [5].

TPP	Grid Segment	Capacity	Fuel	Efficiency	Operating Hour	OPEX	General Availability
Unit		MW		%	hr/yr	1000 M$	
Sheberghan TPP	NEPS_TKM	400.0	Natural Gas	45	8000	9.5	2025-2032
Ishpushta TPP	NEPS_AFG	400.0	Coal	32.5	6000	25.5	2027-2032
DraSuf TPP	NEPS_AFG	800.0	Coal	32,5	6000	25.5	2029-2032
Balkh TPP	NEPS_UZB	48.0	Diesel	33	8000	17.0	2016-2032
Tarakhil TPP	NEPS_AFG	105.0	Diesel	39	8000	9.0	2016-2032
Kabul GT3.4 TPP	NEPS_AFG	44.8	Diesel	24	8000	9.0	2016-2032
Nangarhar TPP	NEPS_AFG	2.7	Diesel	39	8000	9.0	2016-2032
SEPS TPP	SEPS	56.5	Diesel	39	8000	9.0	2016-2032

There are several parameters that have an influence on the growth of fuel consumption in the power sector; by increasing and decreasing them, the growth of fuel consumption in the power sector will change. The major parameters are mentioned below.

- Availability and affordability of fuel in the market: The availability and affordability of fuel in the market play the main role in the growth of fuel consumption. Fuels availability and affordability could be provided by fuel extraction, international sustainable fuel trade, and fuel transit projects. The extraction of fuel mines is a basic solution for improving the availability and affordability of fuel in the market. As we mentioned in the previous section, Afghanistan has a huge amount of fuel reserves, and by extracting them, it could provide electricity for several decades. The abundance of fuel on the market can increase the usage factor of domestic thermal power plants. Therefore, the fuel consumption in the power sector will rapidly increase.
- Energy demand: By increasing the power demand and shortage of electricity, we need to compensate for the power demand with domestic power generation. Hydropower plants, thermal power plants, and solar power plants are the main domestic power generation technologies that could compensate for growing power demand in the future. Domestic power generation could cause improvement to the energy security of the country and provide sustainability and reliability for the energy sector. Beside them, domestic power generation increases self-sufficiency. Increasing power demand and leakage of electricity causes an increase in the usage factor of thermal power plants, which will increase fuel consumption.
- Environmental concerns: The thermal power generation plants and energy infrastructure projects always have high concerns related to emissions and pollution of air, raw water use and possible water pollution, noise pollution, loss of fauna and flora habitats, and disturbance of the landscape. Fossil fueled thermal power plants produce a large part of human-made CO_2 emissions to the atmosphere, and efforts to reduce these are varied and widespread. Environmental policies and concerns could affect the usage factor of thermal power plants. By increasing environmental concerns, the government will have to decrease the use of thermal power plants and reduce fuel consumption.
- Alternative power generation projects: Alternative energy generation technologies use any energy source instead of fossil fuel. These alternatives are intended to address concerns about fossil fuels,

such as its high carbon dioxide emissions and being an important factor in global warming. Hydropower plants and solar power plants are the main alternative to thermal power plants. By the implementation of renewable energy projects, the usage factor of thermal power plants will decrease. The amount of fuel consumption will be varying by variation of the mentioned parameters. Moreover, it makes three scenarios: base case scenario, high case scenario, and low case scenario. Each scenario shows a state of growing fuel consumption and is described below.

1- Fuel demand prediction for the power sector in high case scenario:

This case indicates the rapid growth of the thermal power plant's usage factor. It means each of the mentioned parameters will be in the best condition. Thus power demand will increase rapidly, and it will be 19500 GWh/yr in 2032, fuel availability and affordability will increase rapidly, and environmental concerns will not be a hot subject. After studying other fuel producers (India's large coal producer and Iran and Saudi Arabia's large gas and oil producers), we assumed some usage factors for different power plants for the high case scenario. For coal power plants, the usage factor annually grows by 3.4375 % and it will reach a 55% usage factor by 2032. For Natural Gas power plants, the usage factor annually grows by 3.125 % and it will reach a 50% usage factor by the mentioned date. The usage factor of diesel power plants will grow annually by 2.7 % to reach a 45 % usage factor by the end of 2032. By this scenario, 8111 GWh/yr (41.6 %) of power demand will be fed by thermal power plants. The amount of Annual Fuel Consumption is calculated by annual thermal power generation, power plant efficiency, and fuel heating values.

Table 3: Predicted amount of consumed fuel for power sector in high case scenario.

Year	Existing Diesel Fired TPPs			Sheberghan 400 MW NG Fired TPP			Ishpushta 400 MW Coal Fired TPP			Drasuf 800 MW Coal Fired TPP		
Unit	(%)	(GWh)	(Tonne)	(%)	(GWh)	(Tonne)	(%)	(GWh)	(Tonne)	(%)	(GWh)	(GWh)
2016	1.8	40.4127	9,464.339	0	0	0	0	0	0	0	0	0
2018	7.2	161.65	37,857.36	6.25	0	0	6.875	0	0	6.875	0	0
2020	12.6	282.889	66,250.38	12.5	0	0	13.75	0	0	13.75	0	0
2022	18	404.127	94,643.39	18.75	0	0	20.625	0	0	20.625	0	0
2024	23.4	525.365	123,036.4	25	0	0	27.5	0	0	27.5	0	0
2026	28.8	646.603	151,429.4	31.25	1,092	174,720	34.375	0	0	34.375	0	0
2028	34.2	767.841	179,822.4	37.5	1,310.4	209,664	41.25	1,441.44	997,476	41.25	0	0
2030	39.6	889.08	208,215.5	43.75	1,528.8	244,608	48.125	1,681.68	1,163,722	48.125	3,363.3	2,327,445
2032	45	1,010.31	236,608.5	50	1,747.2	279,552	55	1,921.92	132,996,8	55	3,843.8	2,659,937

2- Fuel demand prediction for the power sector in base case scenario:

In this case the amount of the usage factor of thermal power plants will normally grow. It means each of the mentioned parameters will be in normal condition. Power demand will normally increase and it will be 16000 GWh/yr in 2032. Fuel availability and affordability will normally increase and environmental concerns will be in normal condition. By this condition, usage factor for coal power plants will grow annually by 2.8125 % and it will reach 45% usage factor up by 2032. For Natural Gas power plants, the usage factor will grow annually by 2.1875 % and it will reach a 35% usage factor by the mentioned date. The usage factor of diesel power plants will grow annually by 1.7625 % to reach a 30 % usage factor by the end 2032. By this scenario, 6614 GWh/yr (41.3 %) of power demand will be fed by thermal power plants. The amount of annual fuel consumption is calculated by annual thermal power generation, power plant efficiency, and the fuel heating value.

Table 4: The predicted amount of consumed fuel for the power sector in the base case scenario.

Year	Existing Diesel Fired TPPs			Sheberghan 400 MW NG Fired TPP			Ishpushta 400 MW Coal Fired TPP			Drasuf 800 MW Coal Fired TPP		
Unit	(%)	(GWh)	(Tonne)	(%)	(GWh)	(Tonne)	(%)	(GWh)	(Tonne)	(%)	(GWh)	(GWh)
2016	1.8	40.41	9,464.339	0	0	0	0	0	0	0	0	0

2018	5.325	119.55	27,998.67	4.375	0	0	5.625	0	0	5.625	0	0
2020	8.85	198.69	46,533	8.75	0	0	11.250	0	0	11.250	0	0
2022	12.375	277.83	65,067.33	13.125	0	0	16.875	0	0	16.875	0	0
2024	15.9	356.97	83,601.67	17.5	0	0	22.500	0	0	22.500	0	0
2026	19.425	436.12	102,136	21.875	764.4	122,304	28.125	0	0	28.125	0	0
2028	22.95	515.26	120,670.3	26.25	917.2	146,764	33.75	1,179.36	816,117	33.75	0	0
2030	26.475	594.40	139,204.7	30.625	1070.1	171,225	39.375	1,375.92	952,136	39.375	2,751.84	1,904,273
2032	30	673.54	157,739	35	1,223.0	195,686	45	1,572.48	1,088,156	45	3,144.96	2,176,312

3- Fuel demand prediction for power sector in low case scenario

In this case the amount of usage factor of thermal power plants will slowly grow. It means each of the mentioned parameters will be in the worst condition. Power demand will increase slowly and it will be 12000 GWh/yr by 2032. Fuel availability and affordability will slowly increase and environmental concerns will be a hot subject. In this condition, the usage factor will annually grow for coal power plants by 2.1875 % and it will reach a 35% usage factor by 2032. For Natural Gas power plants, the usage factor will grow annually by 1.25 % and it will reach a 20 % usage factor by the mentioned date and the usage factor of diesel power plants will grow annually by 0.825 % to reach 15 % usage factor by the end 2032. By this scenario, 4704 GWh/yr (39.2 %) of power demand will be fed by thermal power plants. The amount of annual fuel consumption is calculated by annual thermal power generation, power plant efficiency, and fuel heating values. The amount of Annual Fuel Consumption is calculated by annual thermal power generation, power plant efficiency, and the fuel heating values.

Table 5: Predicted amount of consumed fuel for power sector in low case scenario.

Year	Existing Diesel Fired TPPs			Sheberghan 400 MW NG Fired TPP			Ishpushta 400 MW Coal Fired TPP			Drasuf 800 MW Coal Fired TPP		
Unit	(%)	(GWh)	(Tonne)	(%)	(GWh)	(Tonne)	(%)	(GWh)	(Tonne)	(%)	(GWh)	(GWh)
2016	1.8	40.41	9,464.33	0	0	0	0	0	0	0	0	0
2018	3.45	77.45	18,139.98	2.5	0	0	4.375	0	0	4.375	0	0
2020	5.1	114.50	26,815.62	5	0	0	8.75	0	0	8.75	0	0
2022	6.75	151.54	35,491.27	7.5	0	0	13.125	0	0	13.125	0	0
2024	8.4	188.59	44,166.91	10	0	0	17.5	0	0	17.5	0	0
2026	10.05	225.63	52,842.56	12.5	436.8	69,888	21.875	0	0	21.875	0	0
2028	11.7	262.68	61,518.20	15	524.16	83,865.6	26.25	917.28	634,757	26.25	0	0
2030	13.35	299.72	70,193.85	17.5	611.52	97,843.2	30.625	1,070.16	740,550	30.625	2,140.32	1,481,101
2032	15	336.77	78,869.49	20	698.88	111,820	35	1,223.04	846,343	35	2,446.08	1,692,687

4. Transportation sector

As is mentioned before, the number of vehicles, fuel economy or fuel efficiency, and annual traveled distance per vehicle are three main parameters that are required to find the amount of fuel demand in Afghanistan. Each of them is described below.

4.1. The number of vehicles in Afghanistan

The number of vehicles in Afghanistan is mentioned in the world Bank report, but for finding the types of vehicles, Kabul transportation statistics are received from Kabul Traffic Department as a sample to find types of existing vehicles in Afghanistan. The number of existing vehicles in Afghanistan is mentioned in Table 6.

Table 6: The number of vehicles in Afghanistan and Kabul [6].

Year	Amount of Vehicles in Afghanistan	Amount of Vehicles in Kabul
2007	638250	330858
2008	707481	364577
2009	787580	415741
2010	771606	483514
2011	831396	526583
2012	842889	554024
2013	851752	566347
2014	872340	572764
2015	904571	576394
2016	955000	583535

After finding the number of vehicles in Afghanistan, Kabul vehicles' annual statistic report is used as a sample to determine the types of vehicles in Afghanistan. Types of vehicles in Kabul are mentioned in Figure 3.

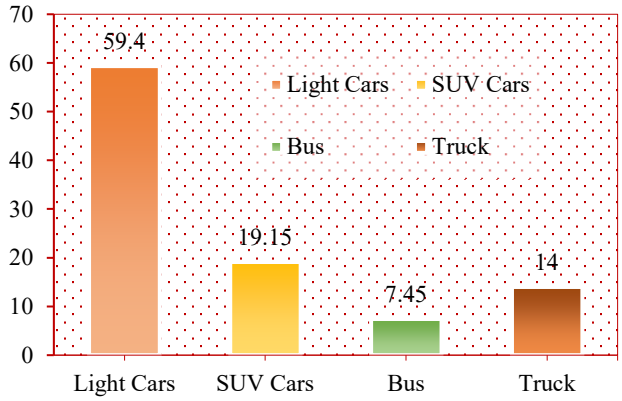

Figure 3. Types of existing vehicles in Kabul.

4.2. Fuel Economy

Fuel economy or fuel efficiency is an important parameter to calculate the amount of fuel demand for the transportation sector. Fuel economy presents how much distance a vehicle can travel on a specific amount of fuel. For estimating the fuel economy of vehicles, some cars are selected to assume fuel economy (MPG) of vehicles. The following samples are mentioned for MPG assumption. After evaluating the MPG values of samples, some MPG values are selected for each type of vehicle. Diesel vehicles have 20% more MPG value at the same power than petrol vehicles. The selected MPG values are mentioned below.

Table 7: Fuel economy of vehicles [7].

Types of Vehicles	Petrol			Diesel		
	MPG min	MPG max	Share	MPG min	MPG max	Share
2016	25	29	80	30	35	20
2018	13	17	90	15	20	10
2020	15	20	50	5	7	50
2022	0	0	0	8	12	100
2032	0	0	0	4	8	100

4.3. Annual Mileage

Annual mileage or annual traveled distance plays an important role in finding the amount of fuel demand for the transportation sector. In each country, the annual vehicle's mileage is recorded by transportation and traffic departments, but unfortunately, in Afghanistan, it has not been recorded. To solve this problem, a survey questionnaire has been conducted. The he survey results is shown in Figure 4.

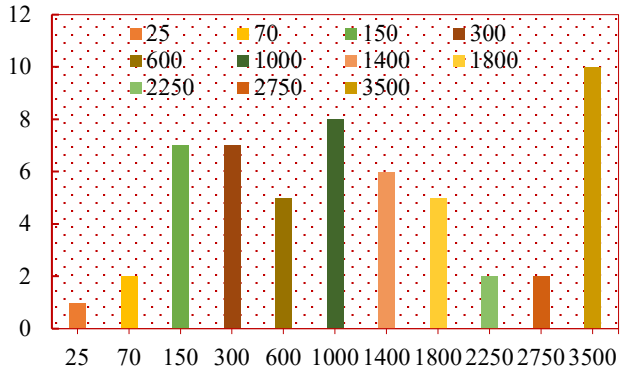

Figure 4. The survey results regarding the average traveled distance.

After the evaluation of the survey, the average traveled distance has been found. The average monthly traveled distance is 1394 km/month which means 10253 miles/year. The annual average traveled distance in India is 10455 miles/year, and in the U.S., it is 13476 miles/year. By comparison of found results with U.S. average annual traveled distance, it is possible to assume an annual traveled distance of any type of vehicle for Afghanistan. The value of the average annual traveled distance is selected and mentioned in Table 8.

Table 8: Average annual traveled distance.

Type of Vehicles	Average Annual Vehicles Traveled Miles
Light vehicles	10293.76
SUV	10293.76
Bus	20000
Delivery Truck	12000
Class 8 Truck	52000

By using the number of vehicles in Afghanistan, their fuel economies, and vehicle mileage, the amount of consumed fuel for the transportation sector has been found, and the results are shown in Table 9.

Table 9: Estimated amount of fuel consumption in the transportation sector.

	Light Car		SUV Car	L.Bus	H.Bus	D.Truck	8.Truck	SUV Car		
Year	Petrol	Diesel	Petrol	Diesel	Petrol	Diesel	Diesel	Diesel	Total Petrol	Total Diesel
2010	405270	93240	270046	28557	97911	318693	283616	725712	773228	1449821
2011	429426	98733	282220	29777	102095	330431	291704	729562	813742	1480210
2012	428254	98401	277768	29245	100272	322818	282879	712757	806295	1446103
2013	425805	97779	272726	28657	98256	314768	273944	680040	796789	1395190
2014	429203	98500	271613	28487	97672	311448	269343	644763	798488	1352545
2015	438134	100492	274087	28695	98387	312368	268554	610684	810609	1320796
2016	455471	104411	281802	29454	100987	319314	273025	583904	838261	1310110

The growth of fuel demand in the transportation sector is dependent on the growth of the number of vehicles, fuel economy, and annual traveled distance. The growth of each parameter depends on some sub-parameters. The growth in the number of vehicles depends on the growth of the population and the GDP of the country. The fuel economy growth depends on technological improvements, and the growth of annual average traveled distance depends on the improvement of facilities and utilization and affordability of fuel. The fuel demand prediction for the transportation sector has been described by three scenarios which are mentioned below.

4- Fuel demand prediction for the transportation sector in low case scenario:

In this case, each of the mentioned parameters grows slowly. Firstly the number of vehicles is predicted by FORECAST.ETS-FORECAST.ETS.CONFINT formula by MS Excel software [8]. For the low case scenario, the amount of annual traveled distance will grow by 10 % by the end of 2032. The variation of each parameter for the low case is shown in Figure 5.

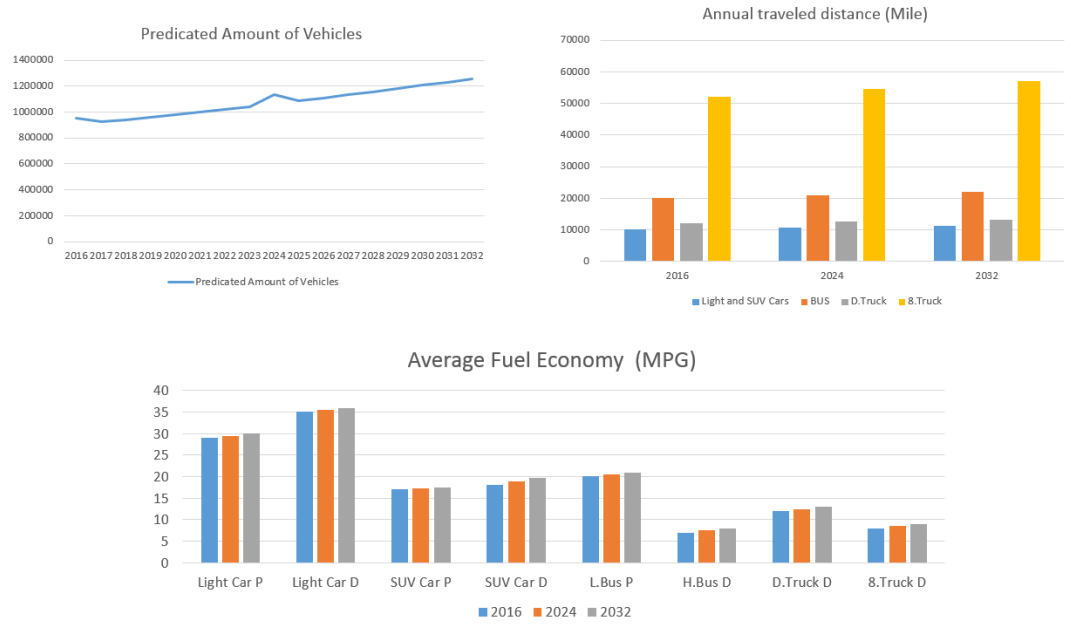

Figure 5. Variation of each parameter for low case scenario.

By using the predicted number of vehicles in Afghanistan, their fuel economies, and vehicle mileage, the amount of fuel demand for the transportation sector has been predicted for low case scenario and is shown in Table 10.

Table 10: The amount of predicted fuel consumption in the transportation sector for the low case scenario.

	Light Car		SUV Car		L.Bus	H.Bus	D.Truck	8.Truck		
Year	Petrol	Diesel	Petrol	Diesel	Petrol	Diesel	Diesel	Diesel	Total Petrol	Total Diesel
2016	455471	104411	281802	29454	100987	319314	273025	583904	838261	1310110
2018	452008	103694	279837	32024	100337	312665	269308	937746	832183	1655439
2020	473973	108812	293618	33325	105012	323594	280717	972586	872604	1719035
2022	498236	114465	308841	34768	110179	335828	293359	1011434	917257	1789856
2024	558748	128459	346564	38704	123329	371919	327089	1122367	1028643	1988540
2026	550781	126718	341831	37875	121345	362139	320590	1094963	1013958	1942286
2028	578488	133187	359245	39496	127215	375806	334828	1138416	1064950	2021733
2030	606959	139840	377153	41148	133234	389678	349362	1182584	1117347	2102614
2032	636107	146658	395502	42825	139381	403699	364141	1227293	1170991	2184618

5- Fuel demand prediction for the transportation sector in the base case scenario:

In this case, each of the mentioned parameters grows normally. Firstly the number of vehicles is predicted by FORECAST.ETS formula by MS Excel software. For the base case scenario, the amount of annual traveled distance will grow by 25 % by the end of 2032. The variation of each parameter for the base case is shown in Figure 6.

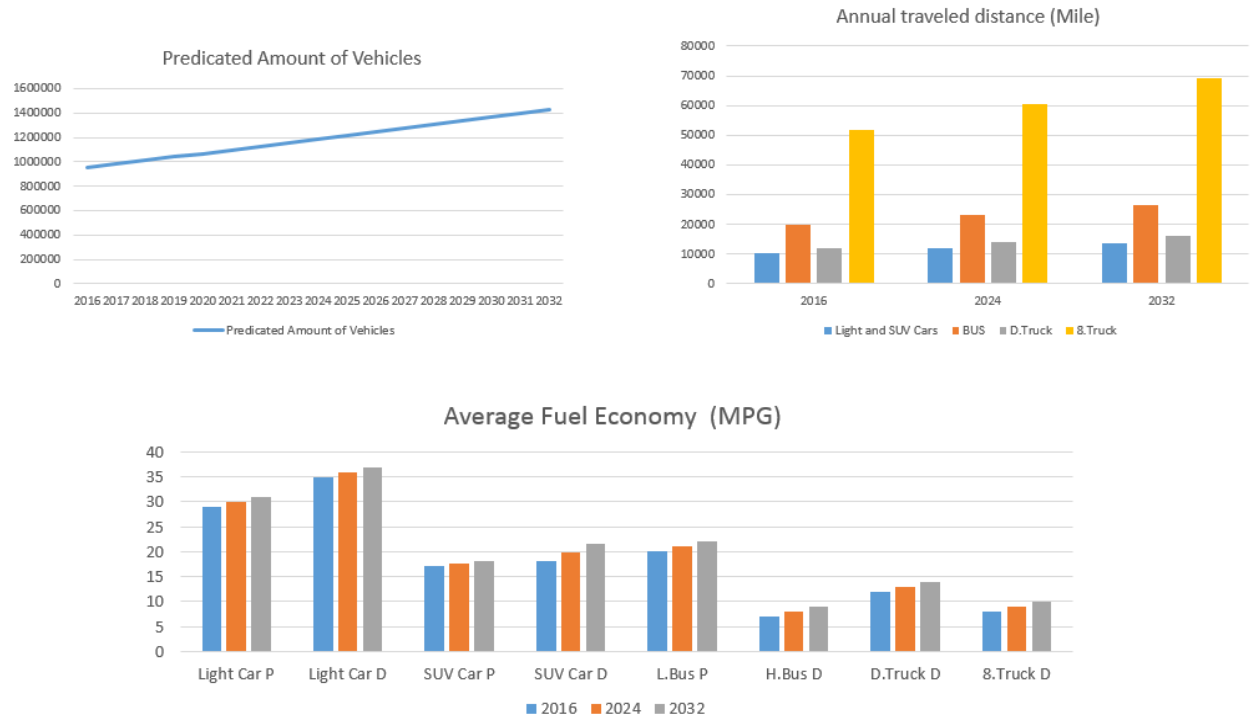

Figure 6. Variation of each parameter for the base case scenario.

By using the predicted number of vehicles in Afghanistan, their fuel economies, and vehicle mileage, the amount of fuel demand for the transportation sector has been predicted for the base case scenario and is shown in Table 11.

Table 11: The amount of predicted fuel consumption in the transportation sector for the base case scenario.

	Light Car		SUV Car		L.Bus	H.Bus	D.Truck	8.Truck		
Year	Petrol	Diesel	Petrol	Diesel	Petrol	Diesel	Diesel	Diesel	Total Petrol	Total Diesel
2016	455471	104411	281802	29454	100987	319314	273025	583904	838261	1310110
2018	497239	114153	308031	34471	110505	339468	294488	1020297	915776	1802879
2020	543010	124841	336802	37111	120215	361422	317857	1090688	1000029	1931920
2022	590319	135911	366593	39788	130199	383459	341646	1161599	1087113	2062404
2024	639130	147355	397381	42501	140447	405571	365831	1232986	1176959	2194246
2026	689404	159165	429146	45248	150949	427752	390388	1304812	1269500	2327366
2028	741105	171334	461866	48026	161697	449995	415298	1377041	1364670	2461695
2030	794199	183854	495522	50833	172682	472295	440540	1449643	1462405	2597168
2032	848652	196719	530095	53668	183896	494648	466098	1522589	1562645	2733724

6- Fuel demand prediction for the transportation sector in high case scenario:

In this case, each of the mentioned parameters grows rapidly. Firstly the number of vehicles is predicted by FORECAST.ETS+FORECAST.ETS.CONFINT formula by MS Excel software. For the high case scenario, the amount of annual traveled distance will grow by 50 % by the end of 2032. The variation of each parameter for the high case is shown in Figure 7.

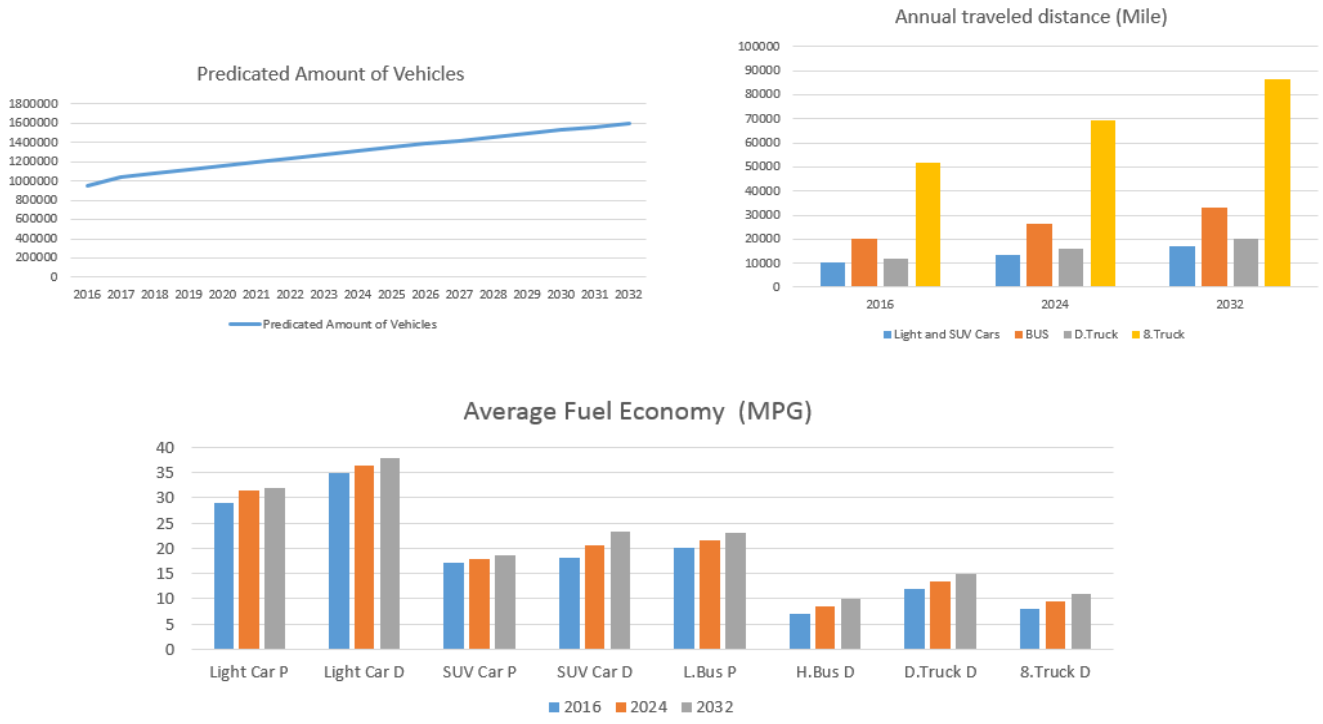

Figure 7. Variation of each parameter for the high case scenario.

By using the predicted number of vehicles in Afghanistan, their fuel economies, and vehicle mileage, the amount of fuel demand for the transportation sector has been predicted for the high case scenario and is shown in Table 12.

Table 12: The amount of predicted fuel consumption in the transportation sector for the high case scenario.

	Light Car		SUV Car		L.Bus	H.Bus	D.Truck	8.Truck		
Year	Petrol	Diesel	Petrol	Diesel	Petrol	Diesel	Diesel	Diesel	Total Petrol	Total Diesel
2016	455471	104411	281802	29454	100987	319314	273025	583904	838261	1310110
2018	550314	126429	341123	37150	122444	370915	324020	1117131	1013882	1975647
2020	629258	144876	390774	41670	139211	408757	364206	1238276	1159244	2197787
2022	710058	163821	441743	46154	156218	445503	404274	1356770	1308020	2416524
2024	793254	183390	494366	50644	173586	481668	444573	1474055	1461207	2634332
2026	878994	203618	548739	55152	191347	517465	485215	1590697	1619082	2852149
2028	967299	224513	604878	59683	209506	553003	526233	1706964	1781684	3070398
2030	1058137	246066	662764	64240	228055	588343	567631	1822996	1948957	3289278
2032	1151450	268267	722367	68822	246982	623527	609397	1938872	2120800	3508887

5. Fuel Demand Prediction for Residential and Industrial Sectors

Most of the fuel consumed in residential and industrial sectors is for heating and power generating from small standalone power generators. Coal, natural gas (NG), and liquefied petroleum gas (LPG) are used for heating in residential and industrial sectors. It is assumed that all of the produced and imported coal, natural gas (NG), and liquefied petroleum gas (LPG) are consumed for heating in residential and industrial sectors. The growth of fuel consumption in residential and industrial sectors depends on the availability and affordability of fuel in the market and environmental concerns. Availability and affordability of fuel in the market play the main role in the growth of fuel consumption. The amount of fuel demand for residential and industrial sectors is predicted in three scenarios for coal, LPG, and NG. Each scenario has been calculated by MS Excel forecasting formulas; FORECAST.ETS for the base case, FORECAST.ETS+FORECAST.ETS.CONFINT for the high case, and FORECAST.ETSFORECAST.ETS.CONFINT for the low case.

The predicted fuel demand for residential and industrial sectors is shown in Figure 8 and Figure 9.

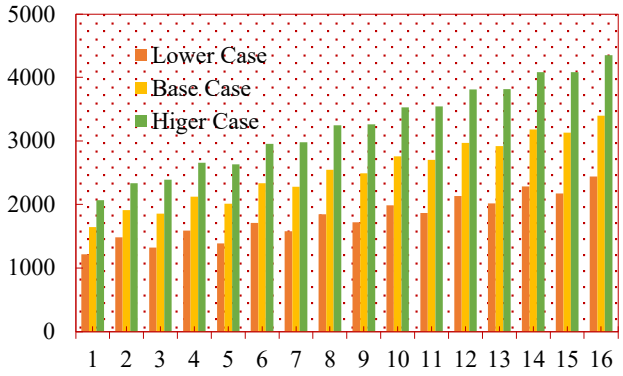

Figure 8. Predicted coal demand for residential and industrial sectors.

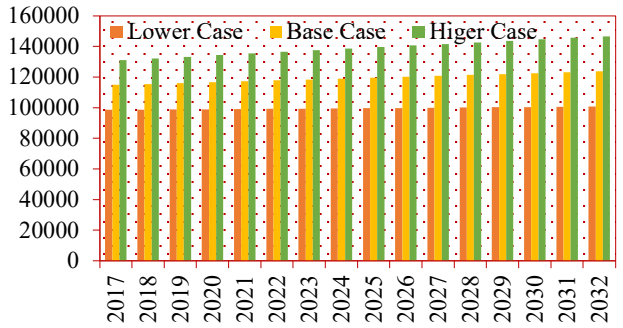

Figure 9. Predicted natural gas demand for residential and industrial sectors.

6. Conclusion

Investigation and evaluation of the energy market, especially the fuel market, is the basic approach to manage economic infrastructure because of the fuel market direct and indirect roles in the economy of the country. The objective of this paper is to estimate and predict the amount of required fuel for the current status and for the future. For improving the accuracy of prediction, three scenarios are used for

three sectors. After evaluation, analysis, and calculation, the amount of demanded fuel and consumption share of each sector has been found and they are summarized in Figure 10.

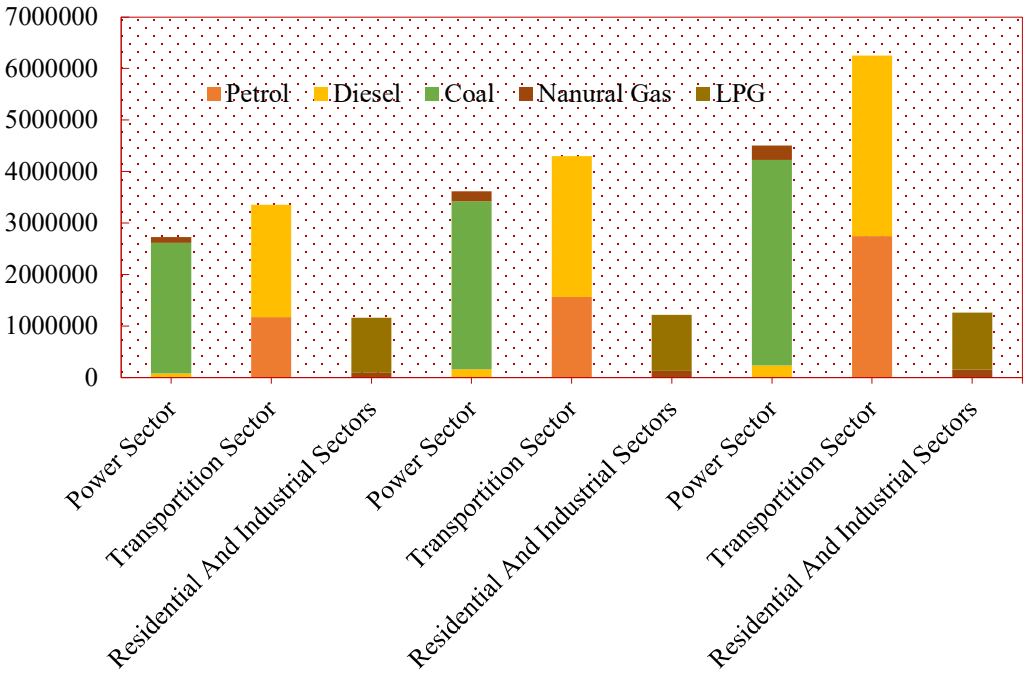

Figure 10. Fuel demand prediction up to 2032.

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