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An Overview of Most Important Sources of Unconventional Energy *

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* This paper is a translation from Arabic.

An Overview of Most Important Sources of Unconventional Energy *

Abstract

The term "unconventional energy" encompasses oil and natural gas that are produced by unconventional methods, including shale oil, oil sand, shale gas, etc. In general, the production of conventional energy is both easier and cheaper than unconventional energy, given that the standards of evaluating unconventional energy sources are unstable and changing in the course of time depending on the availability of exploration and production technology, economic environment and other factors.

Many analysts have noticed the major prospective role that unconventional energy sources would play as an important source of energy in many parts around the globe. Even so, the International Energy Agency (IEA) indicates that what undermines the growth of global unconventional energy is that the exploitation methods of these resources lack required social acceptance in most places due to environmental reasons. For example, shale oil production in the state of New York has been banned for six years because of the lack of scientific evidence affirming the safety of such operations.

As a result of projections and facts regarding the depletion of conventional oil in addition to the increase in its price, developed countries - led by the United States - resorted to unconventional oil and gas sources, having managed to develop drilling techniques and refinement technology. This has enabled them to produce oil and gas from unconventional sources, like processing very heavy oil, oil sands (bitumen), shale oil and gas. In addition, modern technology has managed to turn gas into liquid that can be easily transported and extract oil from limestone coal.

Keywords: energy, oil, gas, production, consumption.

JEL Classifications: Q41, Q42, Q43, Q47.

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First: Most Important Sources of Unconventional Energy

Shale Oil and Shale Gas

The U.S. has witnessed in the latest years a revolution in the area of shale oil production, also named 'tight oil', and shale gas. It used to import a portion of its need for gas, and it has built storage tanks for this purpose. In 2007, the ratio of U.S. gas imports stood at over 15.0 percent of gross domestic consumption. Nowadays, however, due to horizontal drilling techniques and innovative processing technology, the U.S. have managed to produce shale gas. This source now accommodates a large portion of domestic consumption demand in the U.S., and it may be sufficient enough to enable it to do without importing of gas altogether in the foreseeable future. The U.S. imports of gas declined from 4.6 trillion cubic feet (ft^3) in 2007 to 2.7 trillion ft^3 in 2014. Moreover, its shale oil production rose from less than 0.5 million barrels per day (b/d) in 2007 to more than 4.0 million b/d at the end of 2014, according to data of the U.S. Energy Information Administration (EIA). Table 1 and Charts 1 and 2 demonstrate the oil production and imports of the U.S., and Chart 3 shows the EIA projections of the U.S. production of oil up to 2040. Production of shale oil is projected to peak at 4.8 million b/d in 2018 and to continue to remain unchanged in 2020, and then start falling down to 3.2 million b/d in 2040 due to prospective depletion in some oil fields.

International petroleum and gas companies in Canada, Norway, France, Britain and Australia have realized this investment opportunity in the U.S.; and hence many of them have made investments in the U.S. oil fields by taking possession of some U.S. oil companies and purchasing oil fields for high prices. Additionally, a number of oil and gas companies in India, Korea and Japan have also seized that opportunity and entered the market competitively. Giant U.S. companies have also started to acquire companies operating in this area.

There are some factors that distinguish shale oil from crude oil, the most prominent of which is that shale oil, unlike crude oil, does not require drilling operations underground. Extraction is made by inserting heating pipes deep into the

ground, which release kerogen from rocks to be pumped to the surface through conventional pumps. Moreover, shale oil extraction process does not result in producing thousands of tons of drilling waste, as is the case when extracting crude oil.

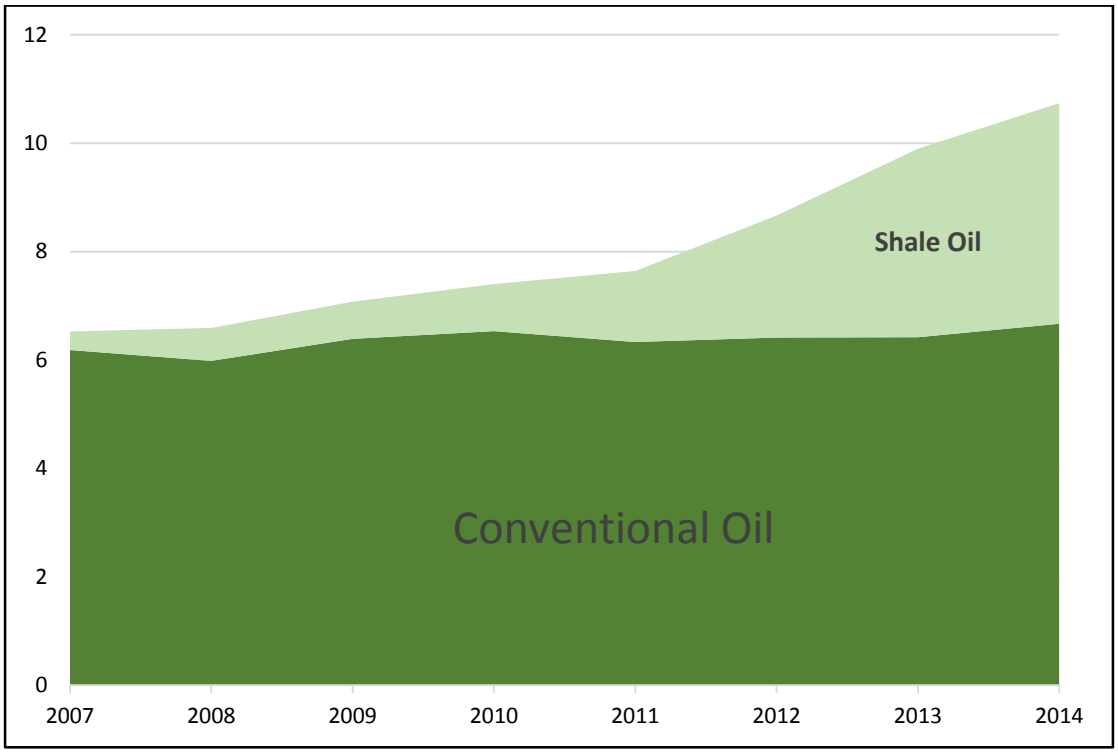
The success of the shale gas experience in the U.S. is attributable to many factors that might not be present in other countries, the most important of which are: geological factors, tax exemptions, available active service industries and trained workforce. Thus, suspicions of the possibility of replicating such conditions outside the U.S. still stand firmly, especially in European countries that do not enjoy tax exemptions. In addition, horizontal drilling- and hydraulic fracturing-related service industry in these countries is still underdeveloped compared to that in the U.S. There is also community opposition towards shale oil and shale gas drilling operations in European countries due to resultant environmental damages that accompany such operations, in particular those related to environmental pollution. The low cost of loans and the rise in oil prices in the last years have contributed to an increase in the number of companies willing to invest in shale oil drilling.

Table 1: The U.S. Production and Imports of Oil (million b/d)

	2007	2008	2009	2010	2011	2012	2013	2014
Conventional oil production	6.19	5.98	6.39	6.53	6.33	6.41	6.42	6.67
Shale oil production	0.34	0.61	0.69	0.87	1.31	2.25	3.48	4.07
Total	**6.53**	**6.59**	**7.08**	**7.40**	**7.64**	**8.66**	**9.90**	**10.74**
U.S. imports of oil	13.47	12.92	11.69	11.79	11.44	10.60	9.86	9.20
Imports of the U.S. from Saudi Arabia	1.49	1.53	1.00	1.10	1.20	1.37	1.33	1.15

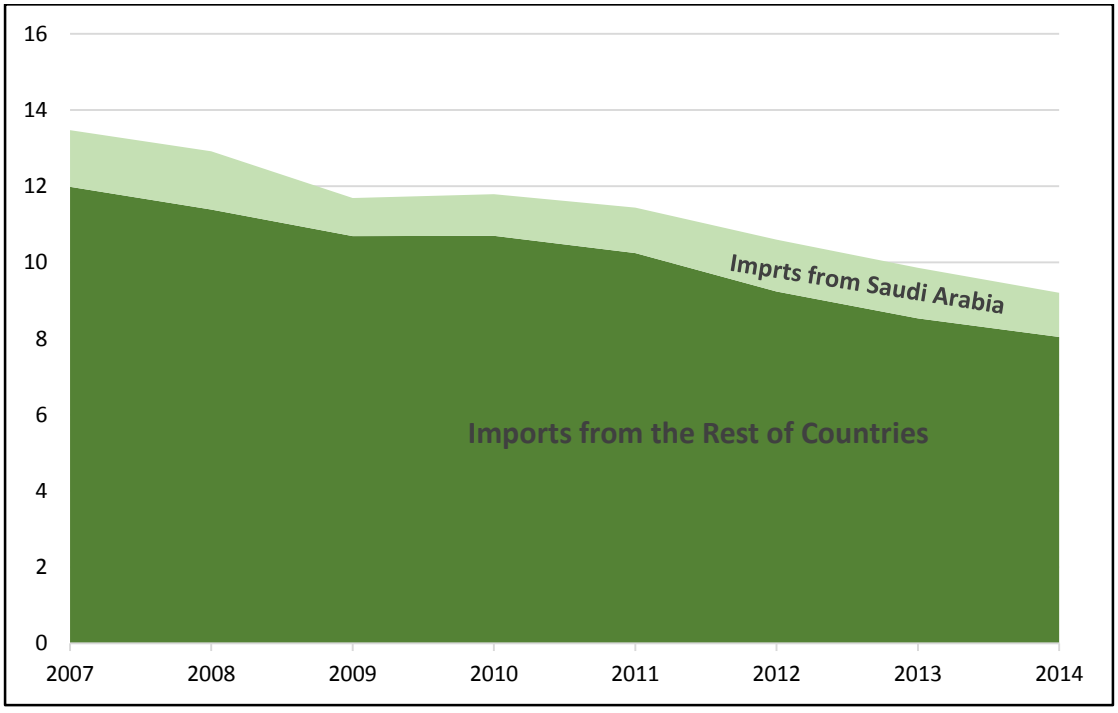
Source: the EIA.

Chart 1: The U.S. Production of Oil (million b/d)



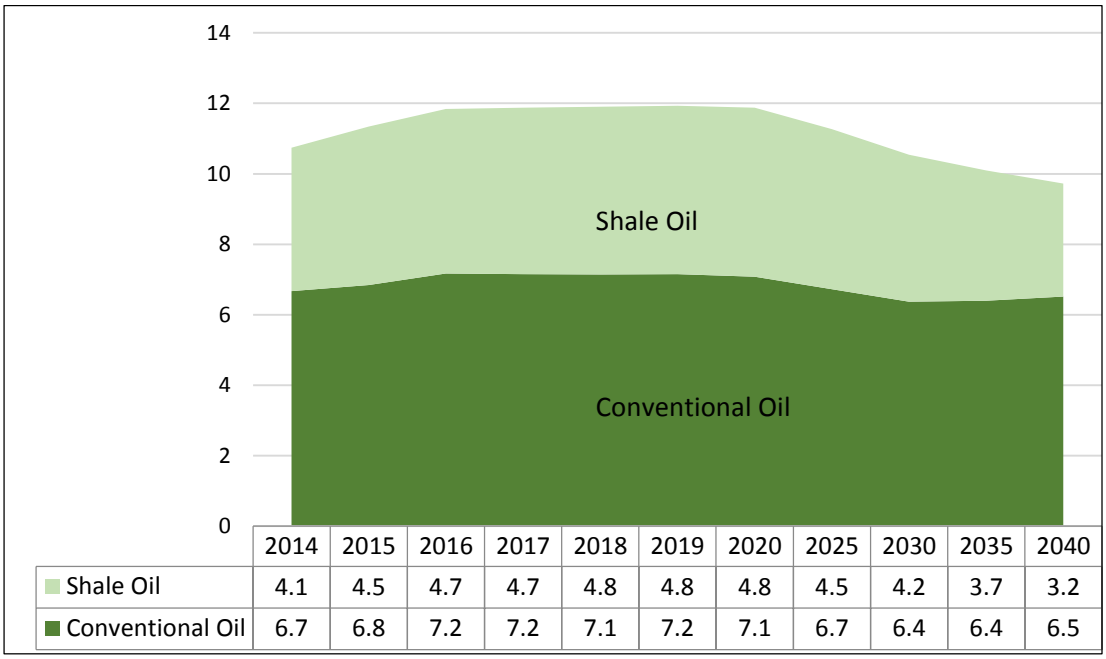
Source: the EIA.

Chart 2: The U.S. Imports of Oil (million b/d)



Source: the EIA.

Chart 3: Projections of the U.S. Production of Oil (million b/d)

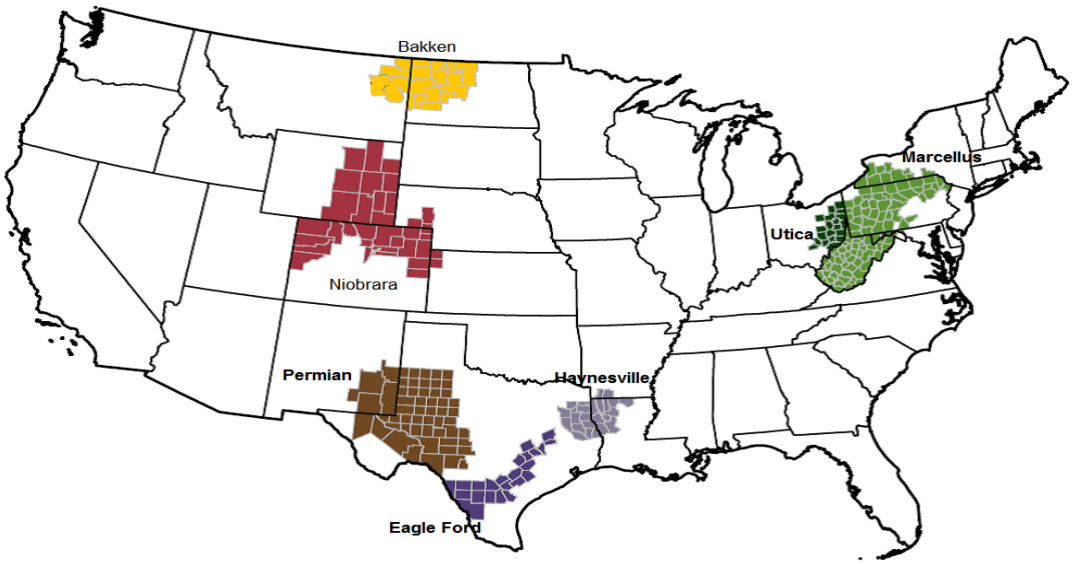


	2014	2015	2016	2017	2018	2019	2020	2025	2030	2035	2040
Shale Oil	4.1	4.5	4.7	4.7	4.8	4.8	4.8	4.5	4.2	3.7	3.2
Conventional Oil	6.7	6.8	7.2	7.2	7.1	7.2	7.1	6.7	6.4	6.4	6.5

Source: the EIA.

There are seven oil fields in the U.S. that produce shale oil and shale gas. The largest two basins are the Bakken basin, which is located in North Dakota and Montana, and the Eagle Ford basin in Texas. The productions of each exceeds one million b/d at the end of 2014.

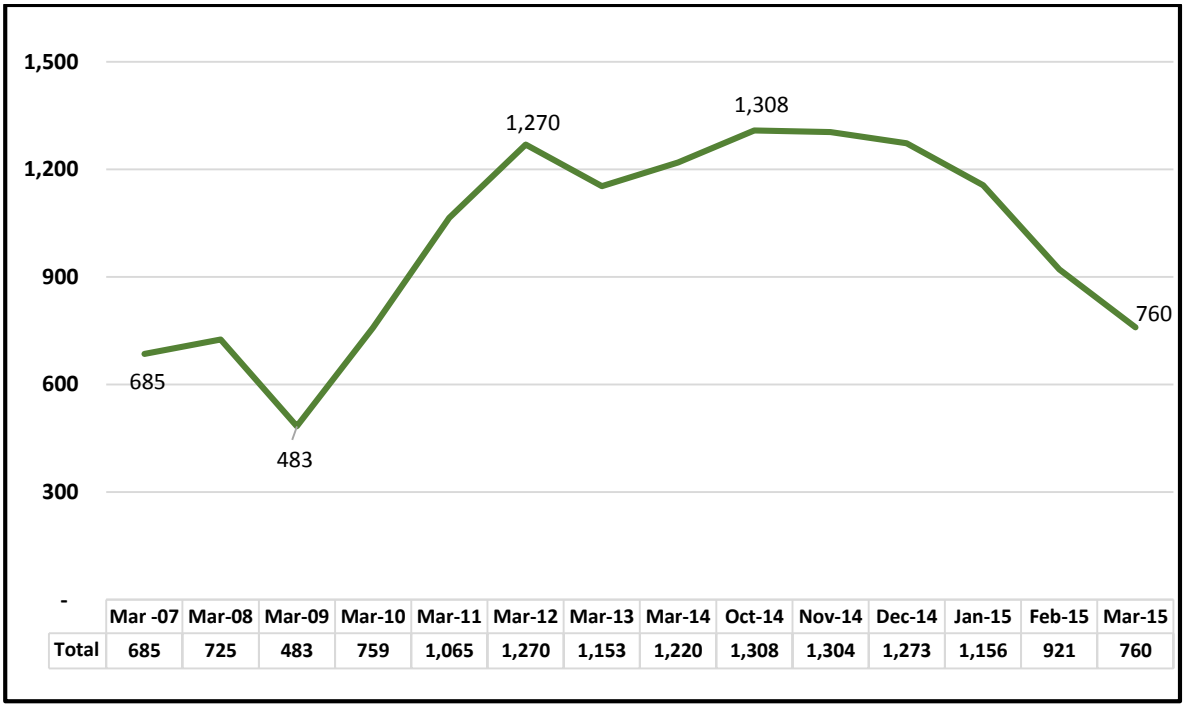
Map Illustrating the Location of Shale Oil Deposits in the U.S.



There is a contrast in the evaluation of shale oil production cost. The IEA has estimated the cost of most oil production in North Dakota formation in Bakken basin to remain profitable at $42.0 per barrel. However, other analysts including Scotiabank have estimated the breakeven price of Bakken, North Dakota to be between $60.0 and $80.0 per barrel. There are many reasons that make it difficult to establish a general cost on a single area such as Bakken where over 100 companies operate with varied costs, employing diverse drilling methods with different degrees of success.

The substantial decline in the prices of oil in the past months has resulted in a decline in demand for drilling licenses. According to latest reports, the number of drilling platforms in the U.S. declined to 1,882 in December 2014 compared to 1,925 in November 2014. Drilling rigs in the Williston basin, where Bakken shale is located, fell by 17 percent in December 2014 from its level in October 2014. Drilling rigs also fell by 16 percent and 14 percent in the Eagle Ford shale and Permian shale respectively, at the same period.

Chart 4: The Number of Shale Drilling Rigs in the U.S.



	Mar -07	Mar-08	Mar-09	Mar-10	Mar-11	Mar-12	Mar-13	Mar-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15
Total	685	725	483	759	1,065	1,270	1,153	1,220	1,308	1,304	1,273	1,156	921	760

Source: the EIA.

Several reports indicated a decline in oil prices, causing shale oil production companies to suffer financial difficulties that may eventually result in their bankruptcy. With rising pressure on shale oil producers, weak companies face a threat of dwindling investment, disruption of production, the necessity of selling assets and potential bankruptcy.

ConocoPhillips, the largest shale oil drilling and production company in the U.S., announced its plans to reduce capital spending by 20 percent to $13.5 billion in 2015, decreasing sharply compared to analysts' projections. It also stated that it will postpone shale oil drilling programs in several regions in North America.

Debts are also one of the factors that will affect the future of shale oil. The industry of shale oil has been driven by borrowing in particular, and companies have spent on drilling and completion of wells more than the achieved cash flow yield. In addition, some reports indicate that U.S. oil and gas companies have issued over $160 billion worth of high-yield bonds in the last ten years, and many of these companies have relied directly on loans to expand their investment.

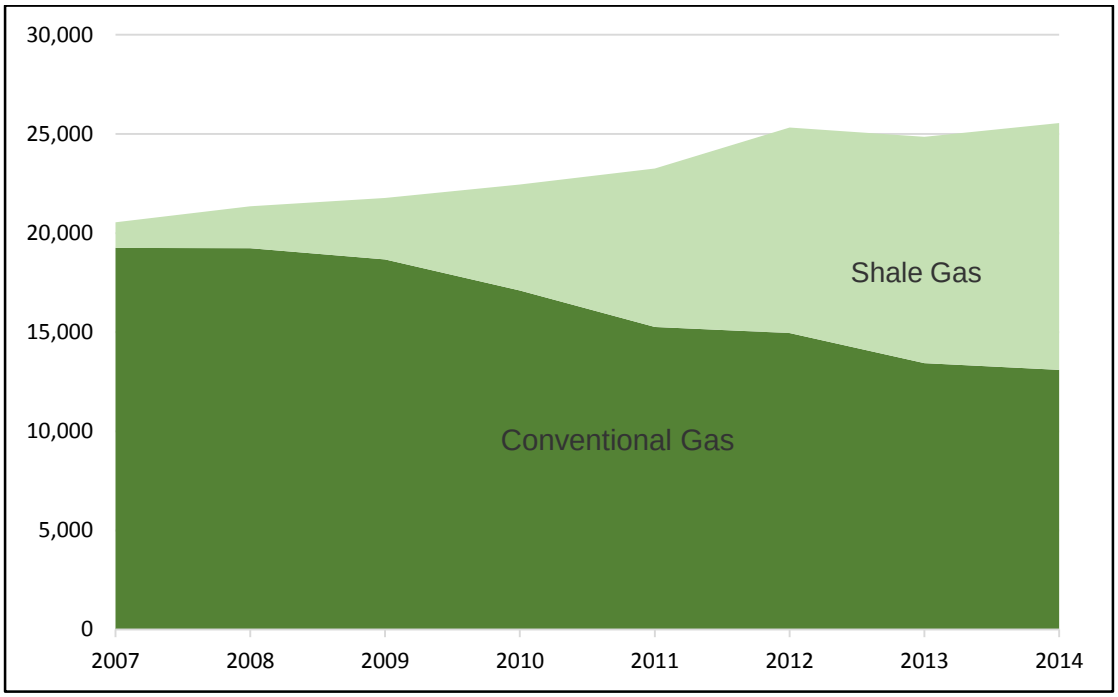
The U.S. production of shale gas constituted 48.7 percent of total American gas production in 2014, up from less than 5 percent in 2007, as indicated in Table 2 and Chart 5. Tables 3 and 4 demonstrate the top ten countries with largest reserve of shale oil and gas.

Table 2: The U.S. Production and Imports of Gas (billion ft^3)

	2007	2008	2009	2010	2011	2012	2013	2014
Conventional gas	19,244	19,233	18,666	17,112	15,266	14,955	13,444	13,102
Shale gas	1,293	2,116	3,110	5,336	7,994	10,371	11,415	12,519
Total	**20,537**	**21,349**	**21,776**	**22,448**	**23,260**	**25,326**	**24,859**	**25,621**
U.S. imports of gas	4,608	3,984	3,751	3,741	3,469	3,138	2,883	2,656

Source: the EIA.

Chart 5: The U.S. Production of Gas (billion ft^3)



Source: the EIA.

Table 3: Top Ten Countries with Largest Shale Oil Reserves (billion barrels)

		Shale	Con.
1	Russia	75	93
2	United States	48	44
3	China	32	18
4	Argentina	27	2
5	Libya	26	49
6	Australia	18	4
7	Venezuela	13	298
8	Mexico	13	11
9	Pakistan	9	-
10	Canada	9	174
11	Other	65	693
	Total	335	1688

Table 4: Top Ten Countries with Largest Shale Gas Reserves (trillion ft^3)

		Shale	Con.
1	United States	1161	330
2	China	1115	116
3	Argentina	802	11
4	Algeria	707	159
5	Canada	573	71
6	Mexico	545	12
7	Australia	437	130
8	South Africa	390	-
9	Russia	285	1104
10	Brazil	245	16
11	Other	1535	4609
	Total	7795	6558

Source: the EIA.

Map Illustrating Shale Oil and Gas Fields Worldwide

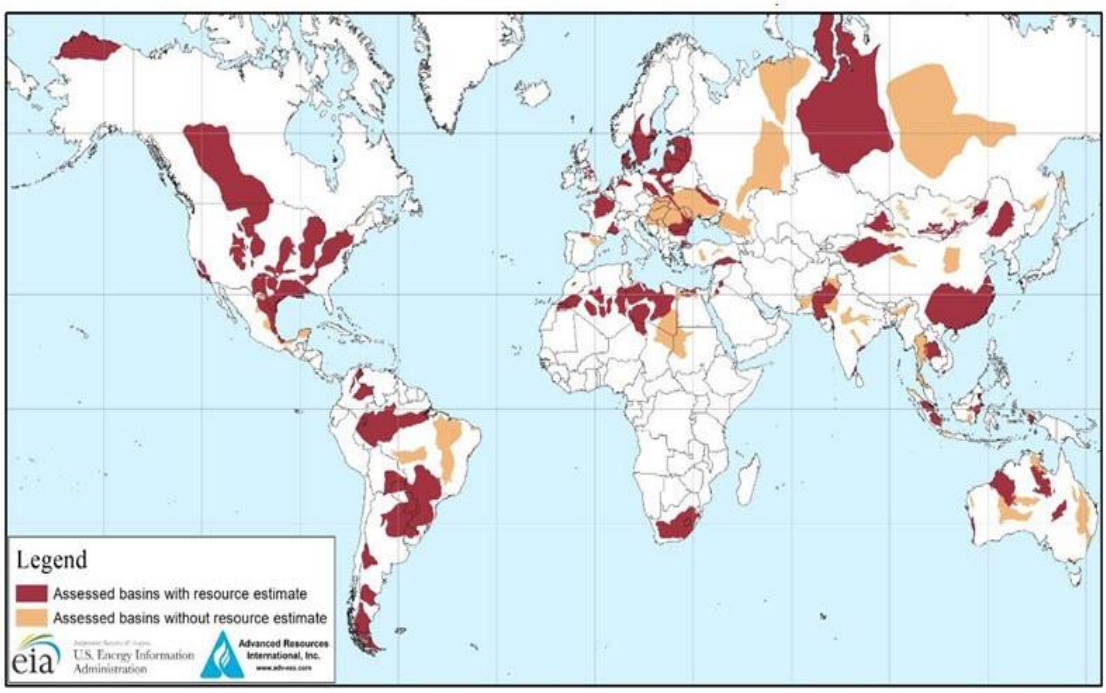


Table 5 shows shale oil and gas producing countries worldwide. Currently, only three countries produce shale oil in commercial quantities, namely, the U.S., Canada and Argentina. As for shale gas, currently only three countries produce it in commercial quantities, which are the U.S., Canada and China.

Table 5: Shale Oil and Gas Producing Countries in 2014

	Shale Oil **Million b/d**	**Shale Gas** **Billion ft^3 per day**
The United States	4.07	34.3
Canada	0.20	3.9
China	--	0.2
Argentina	0.02	--
Total	**4.29**	**38.4**

Source: the EIA.

Oil Sands

In the latest years, drilling technology for oil sands (bitumen), which is a type of unconventional oil composed of a mixture of mud, sand, water and asphalt, witnessed

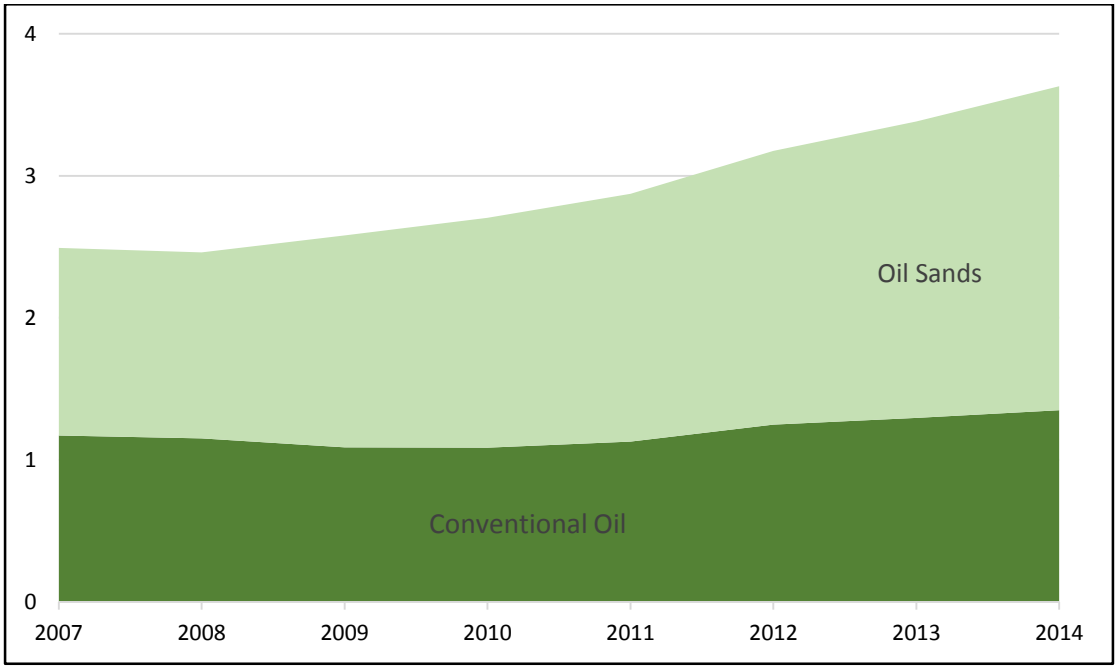
a development. Canada is the largest producer of this type of oil, with a production value exceeding 2 million b/d in 2014 (Table 6 and Chart 6). The Energy Council of Canada estimates Canada's reserve of oil sands at 174 billion barrels.

Table 6: Canada's Production of Oil (million b/d)

	2007	2008	2009	2010	2011	2012	2013	2014 E
Con. oil	1.17	1.15	1.09	1.09	1.13	1.25	1.30	1.35
Oil sand	1.32	1.31	1.49	1.62	1.74	1.93	2.09	2.28
Total	**2.49**	**2.46**	**2.58**	**2.70**	**2.87**	**3.18**	**3.38**	**3.63**

Source: The Canadian Association of Petroleum Producers (CAPP). E: Estimate

Chart 6: Canada's Production of Oil (million b/d)



Source: The CAPP.

Biofuels

Biofuel is the energy derived from living organisms whether plants or animals. It is among the most important sources of renewable energy, as opposed to other unrenewable natural resources like oil, charcoal and all types of fossil fuel. Brazil utilizes sugarcane to produce the ethanol as a biofuel, the process of which dates back to 1970. Biofuel entered the market as a form of liquid fuel produced from plant

substances due to the rise in oil prices and the need to achieve energy security. However, the biofuel technology has been subject to criticism because of its adverse impacts on the environment, causing food insecurity and carbonization of soil, as well as its contribution to an increase in some food prices globally.

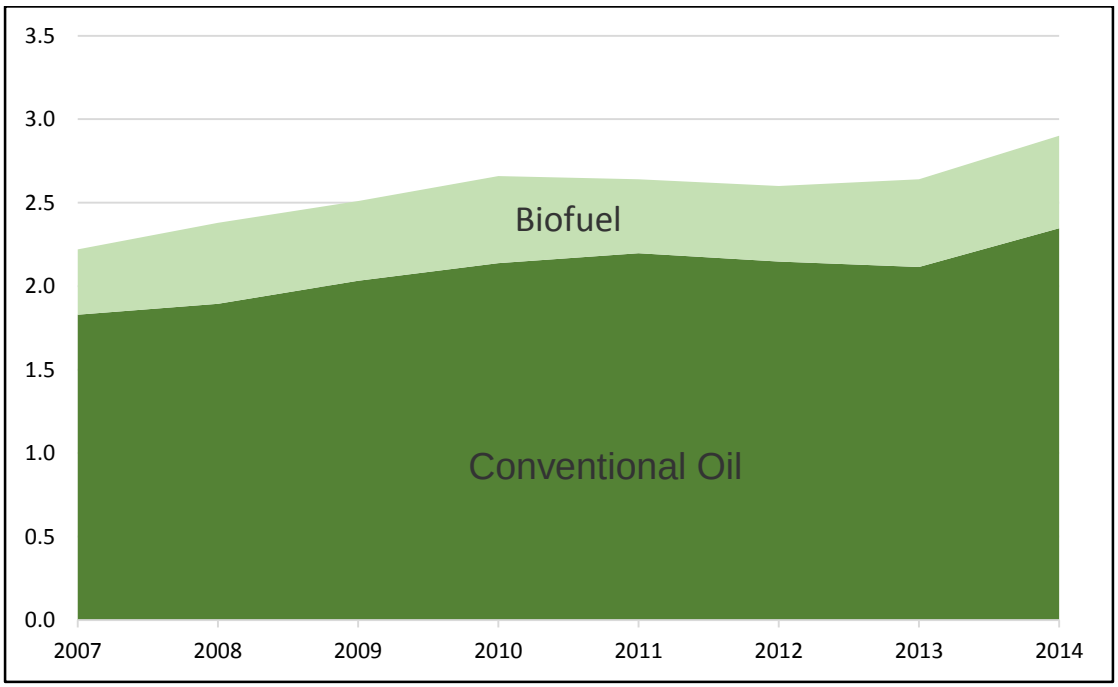
Brazil is considered the leader in the production of this type of energy. The U.S. Environmental Protection Agency has classified the fuel from the Brazilian sugarcane as an advanced biofuel. Table 7 demonstrates the Brazilian production of conventional and unconventional oil and biofuel.

Table 7: The Brazilian Production of Oil and Biofuel (thousand b/d)

	2007	2008	2009	2010	2011	2012	2013	2014
Oil	1,828	1,894	2,033	2,137	2,198	2,148	2,114	2,347
Biofuel	392	486	477	523	442	452	526	553
Total	2,220	2,380	2,510	2,660	2,640	2,600	2,640	2,900

Source: Organization of the Petroleum Exporting Countries (OPEC).

Chart 7: The Brazilian Production of Oil and Biofuel (million b/d)



Source: The OPEC.

Second: The Future of Energy

World economy growth is among the most important factors that affect the rise and decline of demand for energy. According to the IMF (International Monetary Fund)'s World Economic Outlook (WEO) report (April 2015), world economy is expected to grow by 3.5 percent in 2015 and by 3.7 percent in 2016 (Table 8). Thus, demand for energy is projected to continue growing in the upcoming years.

Table 8: Economy Growth Projections (percentage)

	2014	2015	2016
Global	3.4	3.5	3.7
The United States	2.4	3.3	3.1
Eurozone	0.9	1.4	1.6
Germany	1.6	1.6	1.6
China	7.4	6.8	6.3
Japan	-0.1	1	1.2
India	7.2	7.5	7.5
The United Kingdom	2.6	2.7	2.2

Source: The IMF's WEO report (April 2015).

According to the 2015 annual report of ExxonMobil company, oil accounted for 38 percent of oil sources in 1990, approximately the same as that in 2000. It decreased to 34 percent of the energy sources in 2010. ExxonMobil expects that oil will contribute to global energy generation by 32 percent in 2025, the same as that of 2040, which is equivalent to the consumption of 110 million b/d. In 2040, conventional oil is projected to account for 60 percent of total oil production globally, while the remaining percentage will be accounted for by unconventional oils, natural gas liquids and some biofuels.

The projections of the OPEC show that the bulk of the increase in the world needs of energy up to 2040 will be met by oil, gas and coal, as these sources are expected to contribute to covering between 70 percent to 80 percent of the prospective increase in world energy consumption. The OPEC estimates such increase at 44 million barrel of oil equivalent per day (boe/d) in 2020, 42 million boe/d in 2035, and 59 million boe/d in 2040. Estimates also indicate a rise in the share of natural gas during the upcoming decades, with reliance on it reaching 27 percent in 2040 compared to 22 percent in 2010. In contrast, the OPEC projects a decline in reliance on oil from 32 percent in 2010 to 24 percent in 2040 (Table 9).

Table 9: Estimates of Future Energy Consumption (million BOE/D)

	2010	%Share	2020	%Share	2035	%Share	2040	%Share
Oil	81.8	32	88.8	30	95.4	27	99.6	24
Natural gas	55.2	22	69.4	23	87.4	25	110.9	27
Coal	72.4	28	87.4	29	100	28	111.2	27
Nuclear energy	14.4	6	13.9	5	17.4	5	23.2	6
Other	32.6	12	40.8	13	51	14	65.2	16
Total	**265.4**	**100**	**330.3**	**100**	**351.4**	**100**	**410.2**	**100**

Source: The OPEC's projections report (2014).

According to projections of the OPEC, world demand for oil by the Organization for Economic Co-operation and Development (OECD) countries (34) will witness a decline from 45.8 million b/d in 2014 to 45.2 million b/d in 2019. Demand for oil from non-OECD countries, however, is expected to rise from 45.3 million b/d in 2014 to 50.8 million b/d in 2019. Shale oil production is also projected to increase from 3.4 million b/d in 2014 to 4.4 million b/d in 2019 (Table 10). According to estimates of

the OPEC for world production of shale oil, it is noteworthy that it stood at 3.4 million b/d in 2014, while the real American production of shale oil stood at 4.1 million b/d in the same year, according to data of the EIA.

Table 10: Projections of World Demand and Supply of Oil (million b/d)

	2013	2014	2015	2016	2017	2018	2019
Oil demand	**90.0**	**91.1**	**92.2**	**93.2**	**94.0**	**95.0**	**96.0**
Demand from the OECD	45.9	45.8	45.8	45.7	45.5	45.3	45.2
Demand from non-OECD	44.1	45.3	46.4	47.5	48.5	49.7	50.8
Oil supply	**90.0**	**91.5**	**92.6**	**93.4**	**94.3**	**95.2**	**96.2**
Supply from the OPEC	35.8	35.8	35.5	35.0	34.9	35.3	35.6
Supply from non-OPEC, including:	54.2	55.7	57.1	58.4	59.4	59.9	60.6
Shale oil	2.8	3.4	3.8	4.1	4.2	4.3	4.4
Difference between supply and demand	**0.0**	**0.4**	**0.4**	**0.2**	**0.3**	**0.2**	**0.2**

Source: OPEC's projections report (2014).

The OPEC's monthly report (9 February 2015) predicts average oil demand from OPEC countries to stand at 29.21 million b/d in 2015, increasing by 430 thousand b/d over previous predictions, thereby surpassing its level in the preceding year. However, the OPEC lowered its predictions for non-OPEC production growth by third in 2015 due to a slowdown in the U.S. shale oil boom and a decline in global oil investments. The estimation of the decline in the non-OPEC supply growth rate is mainly due to the announcement by international oil companies of reducing capital spending in 2015, plus the fall in the number of drilling rigs operating in the U.S. and Canada, and given the fact that non-OPEC supply will only increase by 850 thousand b/d in 2015, or 420 thousand b/d below its estimates in the last month's report.

Third: The U.S. Self-Sufficiency of Oil and Gas

According to estimates of the EIA, the U.S. will not achieve self-sufficiency of oil because its oil consumption will remain higher than its production during the estimation period (until 2040), as displayed in Table 11 and Chart 8. The difference between its consumption and production will be at its lowest level in 2020, the year in which shale oil production will peak. The U.S. total production of oil will stand at 11.98 million b/d, while its consumption will stand at 18.72 million b/d. The difference will be 6.74 million b/d, signifying that the U.S. will not dispense with imported oil. According to these estimations, the U.S. consumption of oil will continue declining due to the reliance on other energy sources and increased energy efficiency. It can be noted that the difference between the U.S. domestic consumption and production declined from 13.08 million b/d in 2008 to 7.19 million b/d in 2015 due to a rise in production of 4.73 million b/d as well as a decline in consumption of 1.16 million b/d at the same period. Therefore, the U.S. oil imports will fall down, while demand for oil from non-OPEC countries will rise, according to EIA forecasts as indicated in Table 12. Oil demand from emerging countries is projected to increase from 46.4 million b/d in 2015 to 51.2 million b/d in 2020, and to continue rising until 2040 to reach 74.7 million b/d

Table 11: U.S. Production and Consumption of Oil and Gas (million b/d)

	2008	2010	2012	2014	2015	2020	2025	2030	2035	2040
Production	6.59	7.40	8.66	10.74	11.32	11.98	11.49	10.82	10.42	9.97
Consumption	19.67	18.99	18.33	18.39	18.51	18.72	18.44	18.10	17.88	17.62
Difference	13.08	11.59	9.67	7.65	7.19	6.74	6.95	7.28	7.45	7.65

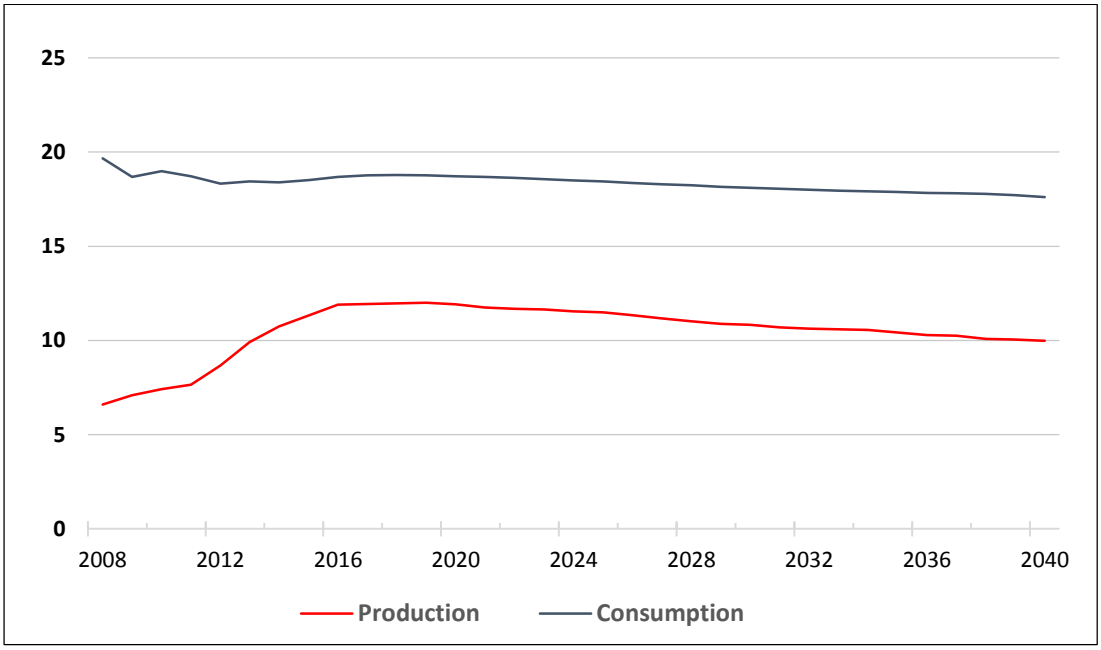
Source: the EIA.

Table: 12: Global Oil Demand Estimates (million b/d)

	2013	2015	2020	2025	2030	2035	2040
OECD	45.9	45.8	46.4	45.9	45.3	44.8	44.7
Emerging countries	44.1	46.4	51.2	55.9	62.1	68.3	74.7
Global	90.0	92.2	97.6	101.8	107.4	113.1	119.4

Source: the EIA.

Chart 8: U.S. production and Consumption of Oil* (million b/d)



Source: the EIA. *: including conventional and unconventional oil.

With regards to gas, the EIA predicts that the U.S. production will begin to surpass consumption in 2018, reaching 28.6 trillion ft^3, while consumption will reach 27.8 trillion ft^3 or an increase of 0.8 trillion ft^3 (Table 13 and Chart 9). This means that the U.S. can become a net exporter of gas starting as of 2018. Production is projected to increase by 6.21 trillion ft^3 over consumption in 2040. It is noted that the U.S. reliance

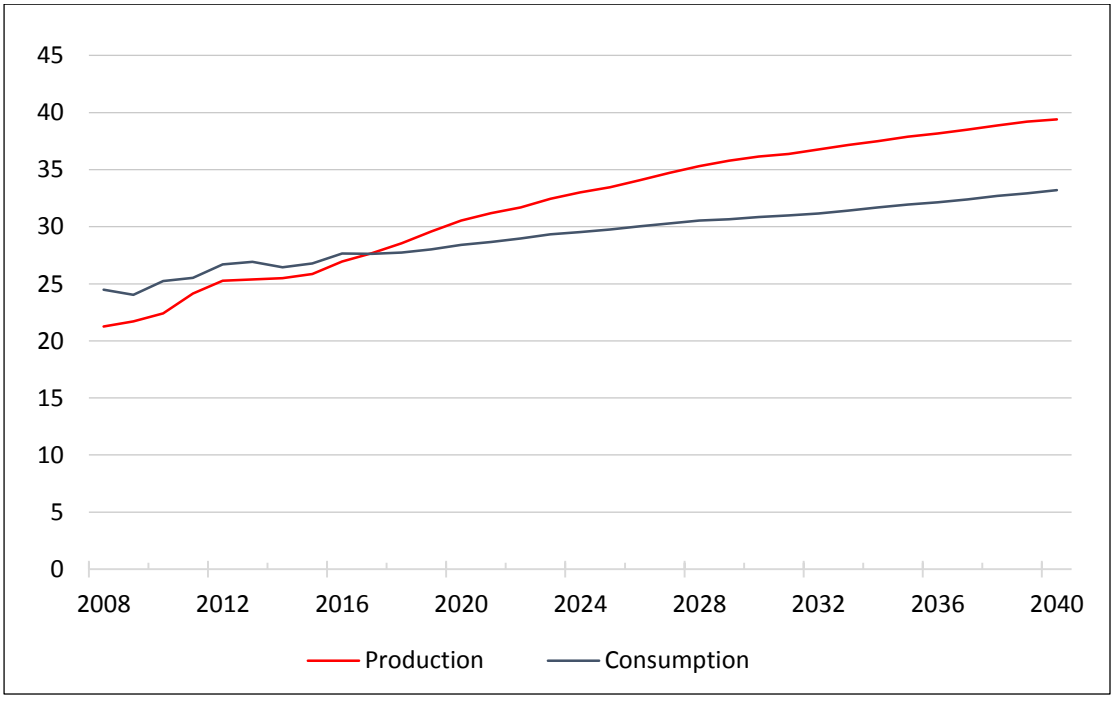
on gas, unlike oil, is on the increase, rising from 24.5 trillion ft^3 in 2008 to 26.77 trillion ft^3 in 2015, and is projected to stand at 33.2 trillion ft^3 in 2040.

Table 13: The U.S. Production and Consumption of Gas (trillion ft^3)

	2008	2012	2014	2015	2018	2020	2025	2030	2035	2040
Production	21.26	25.26	25.48	25.85	28.60	30.53	33.45	36.14	37.88	39.41
Consumption	24.49	26.70	26.45	26.77	27.80	28.40	29.75	30.84	31.94	33.19
Difference	3.23	1.45	0.97	0.92	-0.80	-2.13	-3.69	-5.29	-5.94	-6.21

Source: the EIA.

Chart 9: The U.S. Production and Consumption of Gas (trillion ft^3)



Source: the EIA.

Fourth: The Impacts of Energy Market Developments on the Kingdom

The Kingdom's economy relies largely and mainly on the oil sector, with the Kingdom having the most influential impact on global oil prices. Conversely, the

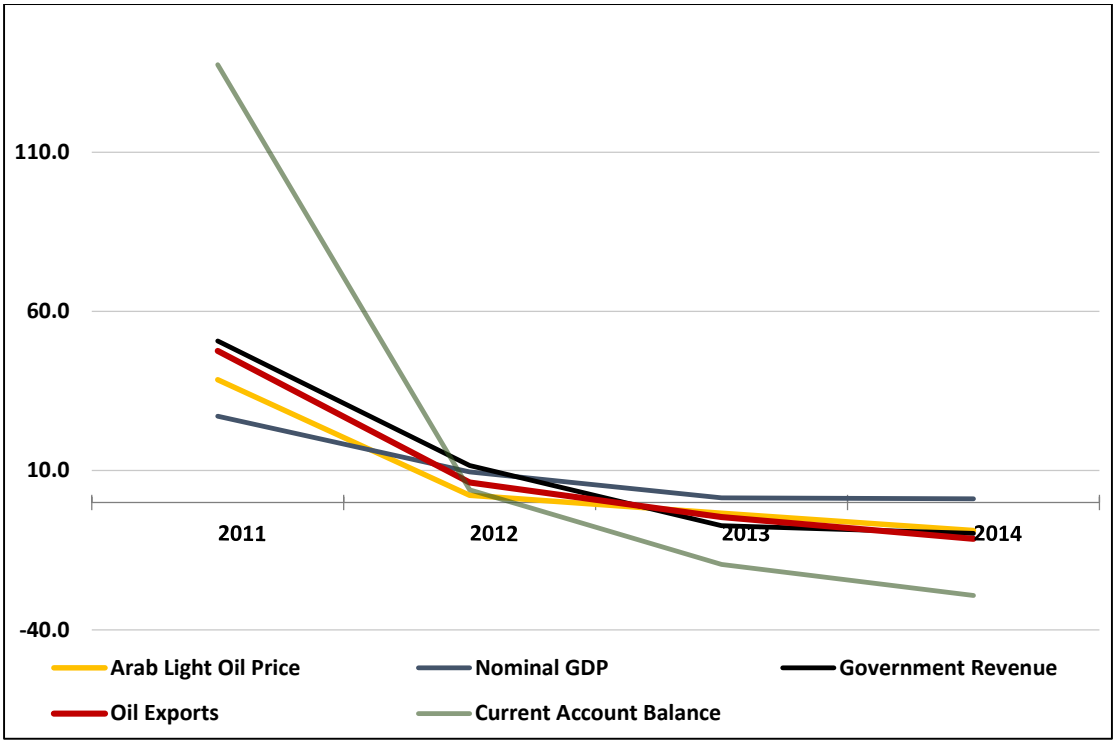
Kingdom's economy is influenced greatly, both positively and negatively, by changes in oil prices. Table 14 shows that some economic indicators are affected by the rise and decline in the price of the Arabian Light during the past five years. It is noted that in 2011, following the increase in oil prices by 38.6 percent, the nominal GDP increased by 27.1 percent; government revenues by 50.7 percent; and the current account surplus in the balance of payments by 137.5 percent. On the other hand, the decrease in oil prices of 8.8 percent in 2014 was accompanied by a decrease in government revenues by 9.7 percent and current account surplus by 29.2 percent as a result. In contrast, the nominal GDP rose by 1.1 percent, which is considered to have the lowest impact among the rest of indicators as the oil sector's share in the nominal GDP is less than 50 percent (Chart 10).

Table 14: The Most Important Economic Indicators in the Kingdom (SAR billion)

	2011	2012	2013	2014
Average Price of the Arabian Light (dollar)	107.8	110.2	106.5	97.2
Nominal GDP	2,511	2,752	2,791	2,822
Government revenues	1,118	1,247	1,156	1,044
Oil exports	1,191	1,266	1,207	1,069
Current account of the balance of payments	594	618	497	352
Growth percentage				
	2011	**2012**	**2013**	**2014**
Average Price of the Arabian Light	38.6	2.2	-3.3	-8.8
Nominal GDP	27.1	9.6	1.4	1.1
Government revenues	50.7	11.6	-7.3	-9.7
Oil exports	47.6	6.3	-4.6	-11.5
Current account of the balance of payments	137.5	3.9	-19.5	-29.2

Source: SAMA's annual statistics.

Chart 10: The Relationship of the Price of the Arabian Light to some Economic Indicators in the Kingdom (percentage change)



The Kingdom's non-oil exports will be affected by the decrease in oil prices due to the decline in the prices of petrochemical products, representing over 60 percent of total other exports of the Kingdom. This has reflected on the results of petrochemical companies listed in the domestic stock market. Table 15 shows some entities' evaluation of the prices of Brent Crude and the real GDP growth in the Kingdom, namely, Jadwa Investment, Samba Financial Group, the Institute of International Finance (IIF) and Consensus Forecast. Jadwa Investment estimated the growth of the real GDP in the Kingdom at 3.3 percent in 2015, which is the highest compared to the evaluation of the other entities. The evaluation of the Samba Financial Group for the Brent Crude price, on the other hand, stood at $60 per barrel in the same year.

Table 15: Some Entities' Forecasts for the Price of the Brent Crude and the Growth of the Kingdom's GDP

	Jadwa Investment May 2015		Samba Financial Group March 2015		The IIF April 2015		Consensus Forecast March 2015	
	2015	2016	2015	2016	2015	2016	2015	2016
Average price of Brent Crude (dollar)	61.0	68.0	60.0	70.0	62.5	70.0	60.4	68.1
The real GDP growth rate	3.3	2.1	2.6	1.5	3.0	2.7	1.0	2.6

Conclusion

This paper discussed several topics related to energy. In the first part, it focused on the most important sources of unconventional energy, like the U.S. shale oil and gas, oil sand and biofuel. It also contained an analysis of production data of some countries and challenges facing this type of energy. The second part of this paper addressed the topic of the future of energy regarding forecasts for world supply and demand for oil. In its third part, the paper covered the U.S. self-sufficiency of oil and gas by making a comparison between the American production and consumption of oil and gas. In the last part, the paper dealt with the impacts of the energy market developments on the Kingdom by reviewing the effect of the average price volatility of the Arabian Light on some economic indicators in the Kingdom.

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