



# Fossil Fuels and the Current Fuel Reserve in Developed and Developing Countries

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**Abstract:** Oil reserve is defined as an estimate of how much oil can ultimately be recovered. This broad definition is also called oil in place. It includes undiscovered or "yet to find" reserves. It's based on the probability of finding reserves in certain geological areas. It also assumes that new types of technology will make it economically feasible to extract the oil. Nigeria oil and gas reserves have increased to 37 billion barrels. It can also be said that reserves are those quantities of petroleum claimed to be commercially recoverable by application of development projects to known accumulations under defined conditions and it must satisfy four criteria which must be: discovered through one or more exploratory wells, recoverable using existing technology, commercially viable and remaining in the ground. These conditions have actually be met by some oil producing countries but how long will they rely on it to maintain a stable economic growth and development. No matter the trillion of barrels of oil stored by most countries in the world especially Nigeria will still not guarantee continuous growth in economic stability since the rate of usage is far more than that of discovery. This paper brings to the notice of everyone the current petroleum reserves for some developed and developing countries which will guarantee them a partial stable economic growth and development. Experience shows that initial estimates of the size of newly discovered oil fields are usually too low. As years pass, successive estimates of the ultimate recovery of fields tend to increase. The term reserve growth refers to the typical increase in estimated ultimate recovery that occurs as oil fields are developed and produced. We are currently in an energy crisis. Fossil fuels are the lifeblood of our society and for many others around the world. Our supply has a finite end, which may make some countries to make friend with those in the Middle East due to high oil reserves. See Tables 1 and 2. Despite these reserves, fossil fuels will run out one day and it is important to find other means of getting the energy we need to continue our society as we know it. That is the renewable sources of energy.

**Keywords:** Nigeria Energy Reserve, Fossil Fuels, OPEC, NNPC

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## 1. Introduction

Oil reserve is defined as an estimate of how much oil can ultimately be recovered. This broad definition is also called oil in place. It includes undiscovered or "yet to find" reserves. It's based on the probability of finding reserves in certain geological areas. It also assumes that new types of technology will make it economically feasible to extract the oil. Don't believe it when someone says the world will run out of oil on a certain date. Instead, oil will become too expensive to use long before it runs out [3, 8].

A more precise definition is discovered oil reserves. There are three categories. These are based on how likely it is the oil can be recovered using current technology [8].

1. Proven Reserves - There is a greater than 90% chance that the oil will be recovered.
2. Probable Reserves - The chance of actually getting the oil out is greater than 50%.
3. Possible Reserves - The likelihood of recovering the oil is significant, but less than 50%.

A fossil fuel is a fuel formed by natural processes, such as anaerobic decomposition of buried dead organisms, containing energy originating in ancient photosynthesis [9]. The age of the organisms and their resulting fossil fuels is typically millions of years, and sometimes exceeds 650 million years [10]. Fossil fuels contain high percentages of carbon and include petroleum, coal, and natural gas. Other commonly used derivatives include kerosene and propane. Fossil fuels range from volatile materials with low carbon to

hydrogen ratios like methane, to liquids like petroleum, to nonvolatile materials composed of almost pure carbon, like anthracite coal. Methane can be found in hydrocarbon fields either alone, associated with oil, or in the form of methane clathrates.

The theory that fossil fuels formed from the fossilized remains of dead plants [10] by exposure to heat and pressure in the Earth's crust over millions of years was first introduced by Georgius Agricola in 1556 and later by Mikhail Lomonosov in the 18th century.

Although fossil fuels are continually being formed via natural processes, they are generally considered to be non-renewable resources because they take millions of years to form and the known viable reserves are being depleted much faster than new ones are being made [9].

The use of fossil fuels raises serious environmental concerns. The burning of fossil fuels produces around 21.3 billion tonnes (21.3 gigatonnes) of carbon dioxide (CO<sub>2</sub>) per year. It is estimated that natural processes can only absorb about half of that amount, so there is a net increase of 10.65 billion tonnes of atmospheric carbon dioxide per year [11]. Carbon dioxide is a greenhouse gas that increases radiative forcing and contributes to global warming. A global movement towards the generation of renewable energy is underway to help reduce global greenhouse gas emissions.

Keep in mind that part of an oil field's probable and possible reserves get converted into proved reserves over time. These discovered reserves are just a small part of the oil in place. It's just not technically feasible to get most of the oil out in any given field [8].

The Nigerian National Petroleum Corporation (NNPC) last week disclosed that the country's oil and gas reserves have increased to 37 billion barrels (bbls) and 192 trillion cubic feet (tcf), indicating an appreciable growth. Chineme Okafor writes [2].

In his end of the year message to staff of the Nigerian National Petroleum Corporation (NNPC), the Group Managing Director, Dr. Maikanti Baru, disclosed that Nigeria has recorded some addition to its oil and gas reserves.

Baru said the country's oil and gas reserves had increased to 37 billion barrels and 192 trillion cubic feet respectively. He ascribed the growth to the relative peace that was instituted in the Niger Delta following repeated disruption of crude oil production activities by militants in the region [2].

Nigeria's oil production had largely experienced severe disruptions from the activities of militants in the Delta. Starting from February 2016, outputs from the country's oil fields diminished to all-time lows. Coupled with low oil prices, this impacted heavily on the country's oil sector.

Though with no details on the reserve growth, Baru said the NNPC would continue to find sustainable solution to the challenges posed by insurgency in the Niger Delta to keep this up.

He explained that the corporation had created security management platforms that would enable it identify and evaluate risks, develop and superintend implementation of investigations, as well as aggregate and deploy necessary

resources to guarantee a peaceful business environment in the region.

His disclosure came barely two months after United States' oil giant, ExxonMobil Corporation, announced the discovery of up to one billion barrels of oil reserves in the Owowo field which is offshore Nigeria.

Already, reports indicated that Nigeria's crude oil reserves was depleting and had subsequently dropped to 28.2bbls and 186tcf. This prompted the President of the Nigerian Association of Petroleum Explorationists (NAPE), Nosa Omorodion, to in October, 2016, raise the alarm over the development.

Decrying the lack of new exploration in the country, Omorodion requested the Federal Government to begin seismic work in the frontier sedimentary basins, which include Bida Dahomey, Anambra, Gongola, and Sokoto, to improve Nigeria's hydrocarbon reserves.

Even though Baru did not disclose how the country managed to ramp up its reserves to the current levels, the discovery by ExxonMobil, however, coincided with his announcement, and this provided a boost to Nigeria's efforts to increase her crude oil reserves from the prior levels to 40 billion barrels target, which was set for 2010 but could not be achieved as a result of lack of investment in exploratory activities.

The development also means that the country was perhaps 3bbls away from hitting its 40bbls proved reserve mark, though a function of oil prices and available technology.

Input from ExxonMobil:

According to reports, the Owowo field where ExxonMobil made its recent huge discovery spans portions of the contract areas of Oil Prospecting License (OPL) 223 and Oil Mining License (OML) 139.

The Texas-based oil and gas company had stated that the huge discovery has a potential recoverable resource of between 500 million and one billion barrels of oil, and that the Owowo-3 well, which was spud on September 23, 2016, encountered about 460 feet (140 metres) of oil-bearing sandstone reservoir.

According to the company's statement bearing the news then, the Owowo-3 well extends the resource discovered by the Owowo-2 well, which encountered about 515 feet (157 meters) of oil-bearing sandstone reservoir.

Then, its President, Stephen Greenlee, said on the discovery: "We are encouraged by the results and will work with our partners and the government on future development plans."

ExxonMobil further added that the Owowo-3 was safely drilled to 10,410 feet (3,173 metres) in 1,890 feet (576 metres) of water by its affiliate Esso Exploration and Production Nigeria (Deepwater Ventures) Limited and proved additional resource in deeper reservoirs.

As per interests, ExxonMobil reportedly holds 27 per cent interest and is the operator for OPL 223 and OML 139 where the discovery was made. Its joint venture partners include Chevron Nigeria Deepwater Limited (27 per cent interest), Total E&P Nigeria Limited (18 per cent interest), Nexen

Petroleum Deepwater Nigeria Limited (18 per cent interest), and the Nigeria Petroleum Development Company (NPDC) Limited, a subsidiary of the NNPC (10 per cent interest).

Also, ExxonMobil had recently announced the sale of its 60 per cent stake in Mobil Oil Nigeria Plc to NIPCO Plc, thus exiting from the Nigeria's downstream oil and gas sub-sector.

What this means to Nigeria:

Considering that Baru's 37bbls reserves disclosure may have been confirmed by the corporation and the Department of Petroleum Resources (DPR) as quantities of petroleum which by analysis of geological and engineering data, are estimated with reasonable certainty to be commercially recoverable from a given date forward, known reservoirs and under current economic conditions, operating methods and government regulations, it could as well be said that they are already proved reserves [2].

Additionally, the NNPC's disclosure also means that with oil at its fluctuating prices, the fields where the new findings were made are thus economical to produce from by operators. As stated by ExxonMobil, production from the Owowo field will in this regard start after stakeholders meet and decide.

THISDAY, however, contacted the Chief Executive Officer of the International Institute for Petroleum, Energy Law and Policy (IPELP), Dr. Timothy Okon, for an expert view on the development, what Nigeria stands to benefit from it [6].

Dr. Timothy Okon, a former top officer at the NNPC however said: "I think there has been a new discovery but when it comes to reserve definition, the price of oil features in the definition of what is proved and probable reserve.

"So, we need to be careful in the way this is presented because the definition of reserve needs to be clear."

He further stated: "There was a discovery in the deep offshore and ExxonMobil has the estimate but the discovery is a function of the ability to monetize what was found and oil prices are down now.

"However, generally, there have been one or two recoveries and it is correct to say there are new discoveries but it is better to be careful in saying you have increased reserves" [6].

### 1.1. Proven Reserves

Of the three categories, the most commonly used is proven oil reserves. That's where analysis of geological and engineering data demonstrates with reasonable certainty to be recoverable from known reservoirs.

Only the oil that is commercially viable under current economic condition is counted. That's because, if oil prices rise or new technology makes costs lower, then more fields become viable.

Reasonable certainty means that either actual production or conclusive testing has occurred. The testing includes drilling, or must be adjacent and similar to areas that have been drilled.

The size of the field is determined by the edges where the oil contacts adjacent gas or water formations.

Oil is not counted as proven if engineers are uncertain whether it can be recovered under current economic conditions or it's in completely untested areas. Some engineers also don't count oil locked up in shale, coal or gilsonite [8].

### 1.2. World Reserves

There are 1.642 trillion barrels of oil in the world as of January 2014. That's enough to last another 50 years since the world uses 90.5 million barrels per day. Only proven reserves are counted in the total world reserves. Therefore, this number changes slightly every year, thanks to changes in oil reserves [3, 8].

### 1.3. Largest Reserves

The world's largest proven reserves are in just a few geologically unique areas. That's because reserves are the graveyards of prehistoric plants and tiny marine organisms. Their remains settled at the bottoms of ancient oceans and lakes 300-400 million years ago. Layers of sediment covered them, increasing the pressure and temperature. That changed the chemical composition into oil.

We are using up this oil faster than Nature is creating new reserves.

This amount is finite, which is why people refer to oil as a non-renewable resource.

Most of the big fields in the proved oil reserves are in the Middle East, Venezuela, and Russia. These countries have no incentive to produce accurate estimates. The market price of fossil fuels is driven more by production capacity versus demand than by reserves. This capacity depends on investment decisions made by a small number of decision-makers in Saudi Arabia, Kuwait, Venezuela, and Russia [3].

Table 1 [3] shows the barrels of proven oil reserves for the top 20 countries:

*Table 1. Barrels of Proven Oil Reserves.*

S/N	COUNTRY	BILLION BARRELS
1	Venezuela	297.7
2	Saudi Arabia	268.4
3	Canada (including shale oil)	173.2
4	Iran	157.3
5	Iraq	140.3
6	Kuwait	104
7	United Arab Emirates	97.8
8	Russia	80
9	Libya	48.47
10	Nigeria	37.14
11	United States	30.53
12	Kazakhstan	30
13	Qatar	25.24
14	China	18.1
15	Brazil	13.22
16	Algeria	12.2
17	Mexico	10.07
18	Angola	9.06
19	Ecuador	8.24
20	Azerbaijan	7

The list alone doesn't give the whole story, because of the

relationships between the countries. Most of them produce more than they use, so they export to those that use more than they produce (importers).

To increase their negotiating power, some of the oil exporters have banded together to manage world supply and influence prices. Although this is an illegal monopoly in most countries, it is perfectly legal in international law. The exporters have done so to keep the price of oil fairly high. Since oil is a non-renewable resource, when it's gone these exporters have nothing left to sell. Therefore, they want to get the highest profit possible while it lasts. They can only do this if they collude, rather than compete.

That's why the Organization of Petroleum Exporting Countries (OPEC) was formed in 1960. Twelve (12) OPEC members hold 80% of the world's proven reserves. The biggest importers are the United States, the European Union, and China [3, 4].

#### 1.4. U. S. Reserves

The U.S. Energy Information Administration reports a slightly higher figure for proven reserves - 35.6 billion barrels as of 2013. During the year, 5.5 billion barrels were discovered.

The largest reserves are in Texas, North Dakota, the Gulf of Mexico Federal Offshore, Alaska, and California. After years of stagnation, U.S. reserves are now growing again thanks to higher oil prices that make new technologies cost-effective. Horizontal drilling and hydraulic fracturing can extract oil from shale and other "tight" (very low permeability) formations. Texas and North Dakota accounted for 90% of the total growth [3, 5].

Also, the U.S. maintains the world's largest strategic petroleum reserve. It holds 727 million barrels. It's used to keep the economy running smoothly when there is crisis or shortage. Since it is not open for production, it's not included as part of the U.S. proven reserves.

#### 1.5. Shale Oil Reserves

The United States has 3 trillion barrels trapped in the Green River shale oil formation in Colorado. It costs \$40-\$80 a barrel to recover it, making it barely worth it even when oil is \$100 a barrel. Extraction could also deplete the water table and damage the environment. However, if technology continues to improve and prices rise, it would be feasible to produce 100,000 barrels a day for 30 years [12, 14].

There are 15.4 billion barrels in the Monterey Shale formation near Bakersfield, California. There are also smaller

shale oil deposits in North Dakota and Texas. However, these use fracking to get the oil out, which is opposed by environmental groups [12].

#### 1.6. Oil Sands

Oil sands reserves are located in Canada, Venezuela, Russia and the United States. However, most of it (166 billion barrels) is in Alberta, Canada. The U.S. imported 1.236 billion barrels from these fields in 2014 [13].

Oil sands are sand mixed with a thick substance called bitumen. The bitumen must be heated before it can be used as oil. Two tons of sand must be mined, using three barrels of water, to get one barrel of oil. The process is controversial because it uses a lot of energy and water, and leaves a scar on the environment that can be seen from space. However, miners are required to restore the area to its original condition after mining [13].

## 2. The Economics of Oil Reserves

Keep in mind that no one can know for a fact how much oil is hidden below the earth's surface. Any number you see is a professional calculation based on geological engineering surveys. As oil prices go up, technology lowers costs, and more exploration is done, it becomes financially feasible to get more oil out. For that reason, any oil reserve projection is a moving target. That is known as "reserves growth."

Estimating oil reserves is an inexact science. For example, estimates of U.S. proved oil reserves have remained unchanged, at around 20 billion barrels, since 1948. That is despite a production level of 2 billion barrels each year.

Paradoxically, if the price of oil rises and those few decision-makers become convinced that oil in the ground appreciates faster than any other investment, they have an incentive NOT to increase production capacity. But, if they become convinced that new technologies will shortly replace oil, they then have an incentive to increase oil production while it still has some value, even if the price of oil is already falling. Perceptions of future technological advances could have a tremendous impact on the oil market. (Source: Interview with Gavin Longmuir, a consultant with International Petroleum Consultants Association, Inc. He has over 25 years' experience as a petroleum engineer in the global oil industry, specializing in the development of future oil fields, economic evaluations of exploration opportunities and assessment of new technologies. His Ph.D. is from the University of Strathclyde, Scotland [6].

Table 2. Total Oil Proved Reserves.

	at end 1995	at end 2005	at end 2014		at end 2015	Share of total	R/P ratio
	Thousand million barrels	Thousand million barrel	Thousand million barrel	Thousand million barrel	Thousand million barrel		
US	29.8	29.9	55.0	55.0	6.6	3.2%	11.9
Canada	48.4	180.0	172.2	172.2	27.8	10.1%	107.6
Mexico	48.8	13.7	10.8	10.8	1.5	0.6%	11.5
Total North America	126.9	223.6	238.0	238.0	35.9	14.0%	33.1
Argentina	2.4	2.2	2.4	2.4	0.3	0.1%	10.2

	at end 1995	at end 2005	at end 2014		at end 2015	Share of total	R/P ratio
	Thousand million barrels	Thousand million barrel	Thousand million barrel	Thousand million barrel	Thousand million barrel		
Brazil	6.2	11.8	16.2	13.0	1.9	0.8%	14.1
Colombia	3.0	1.5	2.4	2.3	0.3	0.1%	6.3
Ecuador	3.4	4.9	8.0	8.0	1.2	0.5%	40.4
Peru	0.8	1.1	1.4	1.4	0.2	0.1%	34.3
Trinidad & Tobago	0.7	0.8	0.8	0.7	0.1	♦	18.1
Venezuela	66.3	80.0	300.0	300.9	47.0	17.7%	313.9
Other S. & Cent. America	1.0	1.5	0.5	0.5	0.1	♦	9.9
Total S. & Cent. America	83.7	103.6	331.7	329.2	51.0	19.4%	117.0
Azerbaijan	1.2	7.0	7.0	7.0	1.0	0.4%	22.8
Denmark	0.9	1.3	0.6	0.6	0.1	♦	9.6
Italy	0.8	0.5	0.6	0.6	0.1	♦	14.7
Kazakhstan	5.3	9.0	30.0	30.0	3.9	1.8%	49.3
Norway	10.8	9.7	6.5	8.0	1.0	0.5%	11.3
Romania	1.0	0.5	0.6	0.6	0.1	♦	19.5
Russian Federation	113.6	104.4	103.2	102.4	14.0	6.0%	25.5
Turkmenistan	0.5	0.5	0.6	0.6	0.1	♦	6.3
United Kingdom	4.5	3.9	2.8	2.8	0.4	0.2%	8.0
Uzbekistan	0.3	0.6	0.6	0.6	0.1	♦	25.3
Other Europe & Eurasia	2.2	2.2	2.1	2.1	0.3	0.1%	15.0
Total Europe & Eurasia	141.2	139.5	154.6	155.2	21.0	9.1%	24.4
Iran	93.7	137.5	157.8	157.8	21.7	9.3%	110.3
Iraq	100.0	115.0	143.1	143.1	19.3	8.4%	97.2
Kuwait	96.5	101.5	101.5	101.5	14.0	6.0%	89.8
Oman	5.2	5.6	5.2	5.3	0.7	0.3%	15.3
Qatar	3.7	27.9	25.7	25.7	2.7	1.5%	37.1
Saudi Arabia	261.5	264.2	267.0	266.6	36.6	15.7%	60.8
Syria	2.6	3.0	2.5	2.5	0.3	0.1%	253.7
United Arab Emirates	98.1	97.8	97.8	97.8	13.0	5.8%	68.7
Yemen	2.0	2.9	3.0	3.0	0.4	0.2%	176.5
Other Middle East	0.1	0.1	0.2	0.2	^	♦	2.8
Total Middle East	663.3	755.5	803.8	803.5	108.7	47.3%	73.1
Algeria	10.0	12.3	12.2	12.2	1.5	0.7%	21.1
Angola	3.1	9.0	12.7	12.7	1.7	0.7%	19.0
Chad	-	1.5	1.5	1.5	0.2	0.1%	52.4
Republic of Congo	1.3	1.5	1.6	1.6	0.2	0.1%	15.8
Egypt	3.8	3.7	3.7	3.5	0.5	0.2%	13.2
Equatorial Guinea	0.6	1.8	1.1	1.1	0.1	0.1%	10.4
Gabon	1.5	2.1	2.0	2.0	0.3	0.1%	23.5
Libya	29.5	41.5	48.4	48.4	6.3	2.8%	306.8
Nigeria	20.8	36.2	37.1	37.1	5.0	2.2%	43.2
South Sudan	n/a	n/a	3.5	3.5	0.5	0.2%	64.9
Sudan	0.3	0.6	1.5	1.5	0.2	0.1%	39.2
Tunisia	0.4	0.6	0.4	0.4	0.1	♦	18.6
Other Africa	0.7	0.5	3.7	3.7	0.5	0.2%	38.3
Total Africa	72.0	111.3	129.3	129.1	17.1	7.6%	42.2
Australia	3.8	3.7	4.0	4.0	0.4	0.2%	28.3
Brunei	1.1	1.1	1.1	1.1	0.1	0.1%	23.8
China	16.4	15.6	18.5	18.5	2.5	1.1%	11.7
India	5.5	5.9	5.7	5.7	0.8	0.3%	18.0
Indonesia	5.0	4.2	3.6	3.6	0.5	0.2%	12.0
Malaysia	5.2	5.3	3.6	3.6	0.5	0.2%	14.2
Thailand	0.3	0.5	0.4	0.4	^	♦	2.3
Vietnam	0.8	3.1	4.4	4.4	0.6	0.3%	33.3
Other Asia Pacific	1.1	1.4	1.3	1.3	0.2	0.1%	12.0
Total Asia Pacific	39.1	40.8	42.6	42.6	5.7	2.5%	14.0
Total World	1126.2	1374.4	1700.0	1697.6	239.4	100.0%	50.7
of which: OECD	149.2	244.0	253.9	255.3	38.0	15.0%	29.7

	at end 1995	at end 2005	at end 2014		at end 2015	Share of total	R/P ratio
	Thousand million barrels	Thousand million barrel	Thousand million barrel	Thousand million barrel	Thousand million barrel		
Non-OECD	976.9	1130.4	1446.1	1442.3	201.3	85.0%	58.0
OPEC	786.6	927.8	1211.1	1211.6	169.9	71.4%	86.8
Non-OPEC	339.6	446.6	488.9	486.0	69.4	28.6%	24.9
European Union #	8.3	7.0	5.6	5.6	0.7	0.3%	10.1
CIS	121.5	122.2	141.9	141.1	19.1	8.3%	27.8
Canadian oil sands: Total	41.5	173.6	166.2	166.2	27.0		
of which: Under active Development	3.6	10.2	24.4	24.4	4.0		
Venezuela: Orinoco Belt	-	-	221.7	222.3	35.7		

^ Less than 0.05.

♦ Less than 0.05%.

n/a not available.

# Excludes Estonia and Latvia in 2005.

Notes: Total proved reserves of oil - Generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions. The data series for total proved oil does not necessarily meet the definitions, guidelines and practices used for determining proved reserves at company level, for instance as published by the US Securities and Exchange Commission, nor does it necessarily represent BP's view of proved reserves by country.

Reserves-to-production (R/P) ratio - If the reserves remaining at the end of any year are divided by the production in that year, the result is the length of time that those remaining reserves would last if production were to continue at that rate.

Source of data - The estimates in this table have been compiled using a combination of primary official sources, third-party data from the OPEC Secretariat, World Oil, Oil & Gas Journal and independent estimates of Russian reserves based on official data and Chinese reserves based on information in the public domain.

Canadian oil sands 'under active development' are an official estimate. Venezuelan Orinoco Belt reserves are based on the OPEC Secretariat and government announcements.

Reserves include gas condensate and natural gas liquids (NGLs) as well as crude oil.

Shares of total and R/P ratios are calculated using thousand million barrels figures.

OECD means ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT.

OPEC means ORGANIZATION OF PETROLEUM EXPORTING COUNTRIES [1].

### 3. Conclusion

Table 2 shows the BP Statistical Review of World Energy for June 2016. It can be seen from the table that Canada has

the highest proved oil reserve in the North America; Venezuela has the overall highest proved oil reserve in the South and Central America. While Saudi Arabia and Iran have the highest and higher proved oil reserve respectively in the Middle East. In Africa, Libya and Nigeria have the highest and the higher oil reserve. The Russian Federation has the highest in the Europe and Eurasia.

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