The Dichotomy of Generating Electricity from Nuclear and Fossil Fuel Energy Sources

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Abstract- **This research focusses on the dichotomy between generations of electricity from nuclear and fossil fuel based energies. Nuclear energy is obtained from fissioning of uranium or plutonium atoms while fossil fuel based energy is gotten from coal, crude oil or natural gas. The research shows that heat from a reactor is used to drive turbine in nuclear power plant while heat from boiler is used to spin turbine in fossil fuel based power plant to generate electricity. The nuclear reactors described in this paper are Pressurized Water Reactor (PWR) and Boiling Water Reactor (BWR). The fossil fuel power plants talked about in this work are steam, gas turbine and combined-cycle power plants. The report did not only focus on environmental issues but discussed significant accidents in the mining of coal, drilling, transporting and distributing of oil and natural gas. The work also covered fatalities involved in these activities. Fatalities in nuclear energy field were also covered in this paper. The World worst nuclear power plant accident in Ukraine, Chernobyl disaster was extensively covered in this article. The conclusion of this paper dwelled on the global impacts of generating electricity from both nuclear and fossil fuel energy sources.**

***Key Words*: Nuclear Energy, Fossil Fuel, Uranium, Coal, Crude Oil, Natural Gas, Reactor, Boiler, Accidents, Fatality, Power.**

I. INTRODUCTION

Electricity is indispensable in the affairs of the modern man; irrespective of the economic, social and recreational activities one engages in, power is paramount. Electricity is derived from many sources including nuclear and fossil fuel based energies. The sources of nuclear energy mainly come from uranium and plutonium while those from fossil fuels are coal, natural gas and crude oil. Generating electricity from these sources has become global debate and the discussion will continue for a long time.

Nuclear energy otherwise known as atomic energy is energy that can be obtained from nuclear fission, nuclear decay or radioactive decay and nuclear fusion reactions. Fission reaction occurs when large nuclei of atoms split into smaller fragments or several parts while fusion reaction occurs when small nuclei are put or fused together to make a bigger one. Nuclear energy is currently harnessed principally through nuclear fission technology [1]**.** Generating electricity using nuclear fusion technology is at the research and development phase [2], therefore it is out of scope with this paper. Generating electricity from nuclear energy source has accident and environmental issues at both the front and the back ends of the nuclear fuel cycle. At the front end, accident and environmental ruins can occur when mining uranium ore from the earth. After the mining, the uranium ore is milled, converted, enriched and fuel fabricated before it can be used in the nuclear reactor to produce electricity. The back end of the nuclear fuel cycle is when the spent fuel (nuclear reactor has finished using uranium to generate electricity) goes through series of techniques such as temporal storage, reprocessing and recycling. These are done in an effort to make the spent fuel safe before final disposal as waste. The waste at the front end is said to be low-level because materials at this end are slightly contaminated. The waste at the back end is highly contaminated and very toxic, it is known as high-level waste. In the course of handling this waste and the procedures adopted, there are always accident and environmental worries.

Fossil fuel based energy comes from decomposing plants and animals that had been compressed and heated underground. This energy is enclaved in the Earth's crust and contains carbon and hydrogen. The carbon is its major element and formed hundreds of millions of years ago (this epoch is known as Carboniferous Period) even before the era of dinosaur [3]**.** Fossil fuels are dependable sources of generating electricity from electrical power plants [4]**.** Fossil fuel based energy is the major source of generating electricity in the world. Electricity generated from this source has a lot of concerns including accidents and the environment. Accidents such as explosions in coal mines, drilling and transportation of crude oil and natural gas are common in this industry. Oil spillage during drilling transporting and distributing of crude oil is environmental issue in this sector. The major environmental concern in using fossil fuel to generate electricity is the emission of greenhouse gases (e.gs carbon dioxide and methane) into the atmosphere. These gases corrode the ozone layer and cause global warming. The effects of these negative occurrences predispose the world to wildfires and floods.

The main objectives of this paper is to bring to the fore electricity generation differences from nuclear energy and fossil fuel based energy sources and to investigate the environmental impacts and accidents in generating electricity from these two energy sources; with climate change in mind.

II. METHODOLOGY

We used various environmental issues and accidents that occurred when electricity is generated from nuclear and fossil fuel power plants to demonstrate the most viable energy plant for the world today. Therefore positivist approach that is centered on objectivity is employed rather than interpretivist approach which is concerned with subjectivity. In so doing, the energy sources that fueled these plants were spelt out. The characteristics of nuclear and fossil fuel power plants were also brought to the fore in this endeavour. We did not only use longitudinal method to collect data but did the analysis employing both quantitative and qualitative approach.

2.1 Energy Sources of Nuclear Power and Fossil Fuel Power Plants

The energy sources of the vast majority of electricity generated from nuclear power plants come from uranium; plutonium is also used in some nuclear reactors while those from fossil fuel power plants are coal, crude oil and natural gas.

Uranium is found naturally in soil, rock and water. This mineral is silvery-white metallic chemical element in the periodic table. Natural uranium is dense, ductile, malleable and capable of taking a high polish. Uranium is allotted chemical symbol U and atomic number 92. It has the highest atomic weight (19 N) of all naturally occurring elements. Figure 2.1 shows a picture of uranium ore.

Fig 2.1: Uranium Ore

The uranium found in the earth's crust commonly has three isotopes or forms; these are uranium-238 (U-238), uranium-235 (U-235) and uranium-234 (U-234). The concentration of U-238 contains 99.2742% of natural uranium that of U-235 has natural uranium abundance of 0.7204% while U-234 contains 0.0054% of natural uranium concentration. Uranium-238 constitutes the vast majority of uranium in the world but cannot produce fission chain reaction. The uranium-235 makes up tiny percentage of uranium in the world but can produce energy by fission [5]**.** The uranium isotope that is therefore used in nuclear energy is U-235; its isotopic symbol is 23592U and neutron number is 143. Therefore the chemical symbol of U-235 is $^{235}_{92}U$ where the mass number is 235 (143+92). Before U-235 is used for nuclear energy for electricity generation, it is enriched from the natural level of 0.72% to between 4 to 5% [6]**.** Bomb-grade (atomic weapon) enrichment which is outside the scope of this paper could go over 90%.

One of the first steps towards enrichment of uranium for making nuclear fuel is to crush the uranium ore in a mill, add water to it to produce slurry of fine ore. The slurry is leached with sulfuric acid or an alkaline solution to dissolve the uranium, leaving the remaining rock and other minerals undissolved. The uranium solution is then separated, filtered and dried to produce uranium oxide concentrate, often referred to as 'yellowcake'; this is shown in figure 2.2.

Fig 2.2: Yellowcake

The enriched uranium is then transported to a fuel fabrication plant where it is converted to uranium dioxide powder as shown in figure 2.3.

Fig 2.3: Nuclear Fuel in Powder Form

This powder is then pressed to form small fuel pellets and heated to make a hard ceramic material. The pellets are subsequently inserted into thin tubes known as fuel rods, which are then grouped together to form fuel assemblies as shown in figure 2.4.

Fig 2.4: Nuclear Fuel in Pellet Form

Plutonium is a radioactive metallic element with silvery bright colour but takes on dull grey, yellow or olive green tarnish when oxidized in air. Its chemical symbol is Pu with atomic number (element with the highest atomic number to occur in nature) and mass number of 94 and 244 respectively. In general, plutonium is not found in nature, traces of its element originated from naturally occurring uranium-238 ores. It is actually created in nuclear reactor when uranium atoms absorb neutrons; all plutonium are nearly man-made [7]**.** Plutonium are fissionable and its five major isotopes are: Pu-238, Pu-239, Pu-240, Pu-241 and Pu-242. Among these isotopes, plutonium-239 contains the highest quantities of fissile material, and is notably one of the primary fuels used in nuclear weapons and nuclear reactors. Reactor-grade plutonium is about 60% pure Pu-239 and bomb-grade plutonium could be enriched to more than 90% pure Pu-239.

Coal is a solid carbon-heavy rock formed from plant debris on land millions of years ago. There are three main categories of coal, they are Lignite coal, bituminous coal and Anthracite coal. Regardless of variety, however, all coal are dirty; they are not only noted to emit the most carbon dioxide into the atmosphere but produce the most air pollutant. Incidentally, coal is the fossil fuel that is used to generate electricity most in the world.

Crude oil is a liquid fossil fuel, formed from marine plants and animals' debris. Petroleum is found in underground reservoirs; in the cracks, crevices, and pores of sedimentary rock; or in tar sand near the earth's surface. Crude oil can be accessed by drilling, on land or at sea, or by strip mining in the case of tar sands oil and oil shale.

Natural gas is also formed from marine plants and animals' debris and located in porous and permeable rock beds or mixed into oil reservoirs and can be accessed through drilling. It has low carbon dioxide emission as compared to coal and oil; because of this its pollution to the environment is not huge.

2.2 Nuclear Power Plant

Nuclear power plant that is a plant that is used to split atoms in a reactor to heat water into steam, use this steam to turn a turbine and generate electricity. The main component of nuclear power plant is the nuclear reactor; it is sometimes referred to as the heart of the plant. It contains the nuclear fuel (usually uranium), controls nuclear chain reactions and has systems that make it possible to start, sustain and stop the nuclear reaction in a controlled manner [8]**.** Nuclear reactors come in different shapes and designs; the two most outstanding designs are Pressurized Water Reactor (PWR) and Boiling Water Reactor (BWR).

The Pressurized Water Reactor pumps water into the reactor core under high pressure to prevent the water from boiling [9]**.** The operation is such that, water in the reactor core is heated by nuclear fission and then pumped into tubes inside a heat exchanger. Those tubes heat a separate water source to create steam. The steam then turns an electric generator to produce electricity. The core water cycles back to the reactor to be reheated and the process is repeated. Figure 2.5 shows schematic diagram of pressurized water reactor.

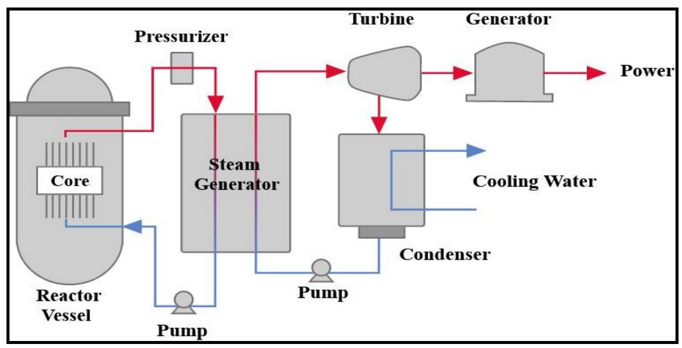

Fig 2.5: Pressurized Water Reactor

The Boiling Water Reactor heats water and produce steam directly inside the reactor vessel [10]**.** The process of this reactor is such that, water is pumped up through the reactor core and heated by fission. Pipes then feed the steam directly to a turbine to produce electricity. The unused steam is then condensed back to water and reused in the heating process. Figure 2.6 depicts schematic diagram of boiling water reactor.

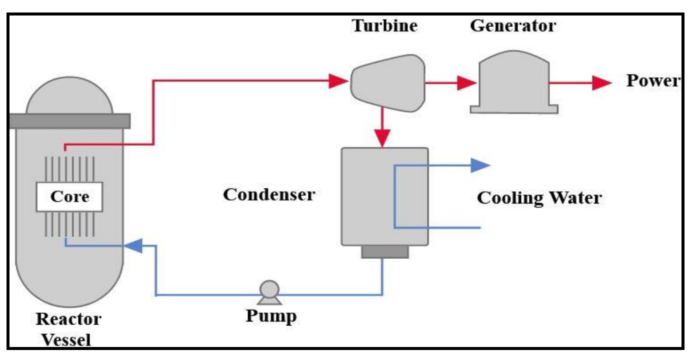

Fig 2.6: Boiling Water Reactor

Gas Turbine or Open-cycle Gas Turbine Power Plant does not use steam, rather liquefied natural gas is ignited and burnt; the heat creates pressure and produces high-temperature combustion gases with sufficient energy to rotate a gas turbine. The gas turbine drives a generator to produce electricity.

Combined-Cycle or Combined-Cycle Gas & Steam Turbine (CCGT) Power Plant incorporates gas turbine whose waste heat is reused to drive a steam turbine. The gas turbine is powered by high-temperature combustion gas, after being discharged from the gas turbine, the temperature is efficiently recovered by means of a heat recovery boiler. This produces steam of sufficient temperature and pressure to drive the steam turbine and generate electricity.

2.4 Environmental Issues and Accidents

Accidents occasionally occur in nuclear power plants that can lead to radioactive leakages and reactor meltdown. These malaises are also attributed to the fossil fuel energy industry. The most devastating of all these environmental issues and accidents are oil spillage, coal mine collapsing and natural gas

2.3 Fossil Fuel Power Plant

Fossil fuel power plant is electricity generating plant that uses coal, crude oil or natural gas to fire a boiler to produce steam that is used to turn a turbine to generate electricity. Figure 2.7 shows schematic diagram of fossil fuel power plant. Steam turbine, gas turbine and combined-cycle power plants are three examples of fossil fuel power plants. In this type of power plant, coal, crude oil or liquefied natural gas (LNG) fires a boiler to generate high-temperature, high-pressure steam. This steam is used to drive a steam turbine. A generator attached to the steam turbine produces electricity.

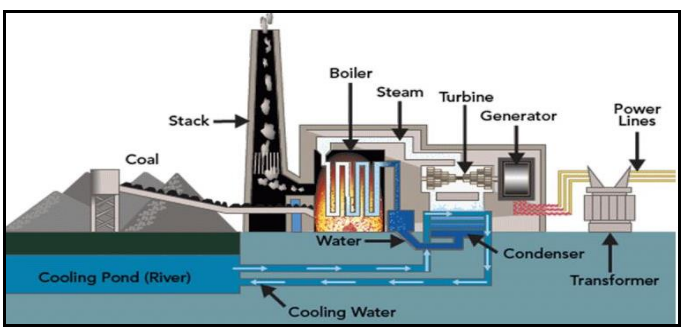

Fig 2.7: Fossil Fuel Power Plant.

explosion and fires. Where ever oil spillage occurs, flora, fauna and aquatic lives are destroyed. Coal mine and natural gas accidents result in loss of lives and properties. Coal ash which is a harmful product of coal waste is difficult to recycle and may seep into waterways thereby polluting them [12]. Fossil fuel power plants have the disadvantage of emitting fumes as shown in figure 2.8 that contain greenhouse gasses such as carbon dioxide (CO_2) and methane which are the main cause of global warming. Accidents caused by explosion and fire can also occur at fossil fuel power plants.

Fig 2.8: Carbon Dioxide Produced from Burning of Fossil Fuels

III. RESULTS and DISCUSSIONS

We focused the results of this paper on oil spillages, fatalities emanated from coal mine, natural gas and crude oil transportation accidents. The paper also threw light on eleven accidents that happened in nuclear power plants which affected human life.

Table I demonstrates that, the highest spill occurred at the Gulf of Mexico in United States while the least happened at the Coast of Nova Scotia in Canada. Oil spillage always has devastating environmental impact where ever it happens. A total of 930 million gallons of crude oil were spilled in ten accident cases described in this research.

Table I: Ten Major Oil Spillage Accidents in the world

Year	**Location**	**Country**	**Gallons Spilled (Million)**	**Cause**	**Cases (Oil Tanker, Field or Platform)**
978	Brittany	France	69	Damage Rudder & Hydraulic System	Amoco Cadiz (Oil Tanker)
1979	Atlantic Ocean	Trinidad & Tobago	90	Collision Between Two Tankers	Atlantic Empress (Oil Tanker)
1979	Bay of Campeche	Mexico	140	Explosion Aboard Oil Platform	Ixtoc 1 (Oil Platform)
1983	Cape Town	South Africa	79	Fire Aboard	Castillo de Bellver (Oil Tanker)
1983	Persian Gulf	Iran	80	Oil Platform struck by Tanker	Nowruz (Oil field)
1991	Coast of Angola	Angola	51	Explosion Aboard	ABT Summer (Oil Tanker)
1991	Coast of Nova Scotia	Canada	43	Explosion Aboard	Odyssey (Oil Tanker)
1992	Fergana	Uzbekistan	88	Blowout at a Well	Mingbulak (Oil Well)
1994	Arctic	Russia	84	Corroded Oil Pipeline	Kolva River (Oil Pipeline)
2010	Gulf of Mexico	United States	206	Natural Gas Blasted	BP Deepwater Horizon (Oil Platform)
Total			**930**		

Figure 3.1 depicts the accident with the largest spill of 206 million gallons as the BP Deepwater Horizon Oil platform. The case with the smallest spillage of 43 million gallons was Odyssey Oil Tanker. The BP Deepwater Horizon accident in the Gulf of Mexico in the United States killed 11 workers and injured 17. The oil spill spread up to approximately 2,100 km of the United States' Gulf Coast that is, ranging from Texas to Florida [13]. The research also showed that oil tanker accounted for five of the accidents. Each year, oil tanker accidents contribute between 10-15% of oil that enters the ocean world-wide [14]. Of course, some of these spills were not reported or detected.

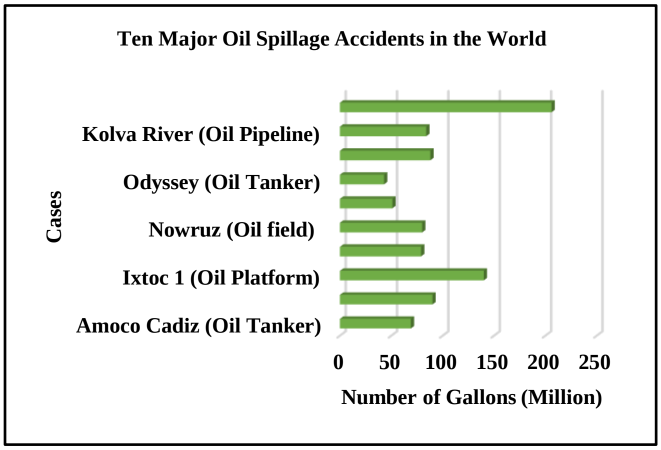

Fig 3.1: Ten Oil Spillage Accidents

Table II shows that the highest mortality in coal mine accident happened in China, the Benxihu Colliery Coal Mine whereas the least deaths occurred at Monongah Coal Mine in the United States. Explosions accounted for nine out of the ten major accidents that happened between 1906 and 1972. The total deaths from the ten major accidents were 6,514.

Table II: Ten Major Coal Mining Accidents in the World (1906-1972)

Year	Location (Coal Mine)	Country	Fatality	Cause
1906	Courrieres	France	1,099	Coal-Dust Explosion
1907	Monongah	USA	362	Firedamp and Coal-Dust Explosion
1913	Senghenydd Colliery	UK	439	Coal-Dust Explosion
1914	Mitsubishi Hojyo	Japan	687	Coal-Dust & Methane Gas Explosion
1942	Benxihu Colliery	China	1,549	Coal-Dust Explosion
1960	Laobaidong	China	684	Methane Gas Explosion
1960	Coalbrook North	South Africa	435	Collapse Pillars Supporting Tunnel Roofs
1963	Mitsui Miike	Japan	458	Explosion in a Tunnel
1965	Dhanbad	India	375	Firedamp and Coal-Dust Explosion
1972	Wankie Colliery	Zimbabwe	426	Multiple Explosions Underground
Total			**6,514**	

Figure 3.2 shows that, accident at one coal mine alone ended the life of 1,549 individuals and was the highest among the ten locations; the least fatality was 362 people.

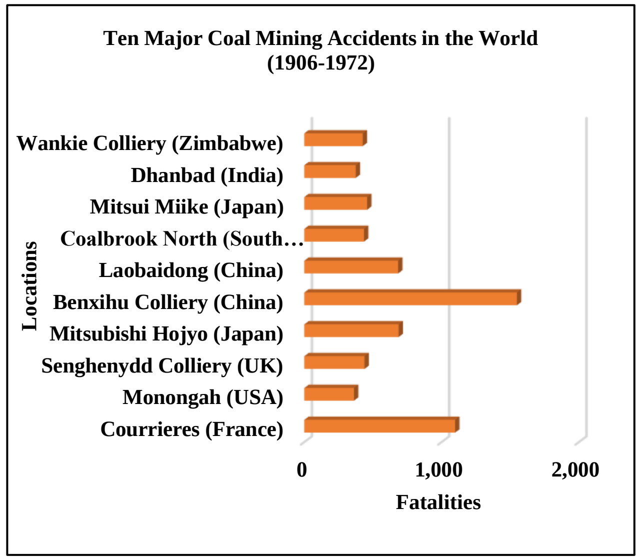

Fig 3.2: Ten Coal Mining Accidents (1906-1972)

Table III shows that, the accident with the largest fatality occurred at Soma Coal Mine in Turkey and the one with the least mortality happened at Kaohsiung Coal Mine in Taiwan. The major causes of these accidents from 2002 to 2014 also emanated from explosions. These accidents resulted in a total fatality of 921 individuals.

Table III: Ten Major Coal Mining Accidents in the World (2002-2014)

Year	Location (Coal Mine)	Country	Fatality	Cause
2002	Heilongjiang	China	124	Coal-Dust Explosion
2007	Ulyanov kaya	Siberia	75	Gas Explosion
2009	Heilongjiang	China	108	Gas Explosion
2010	Mezhdurechensk	Russia	91	Gas Explosion
2010	Pike River	New Zealand	29	Gas Explosion
2010	Amaga	Colombia	73	Gas Explosion
2011	Sorange	Pakistan	45	Gas Explosion
2011	Quetta	Pakistan	45	Collapsed Coal Mine
2014	Soma	Turkey	301	Gas Explosion
2014	Kaohsiung	Taiwan	30	Gas Explosion
Total			**921**	

Figure 3.3 shows the coal mine accidents with the highest death toll of 301 and the least 30 individuals respectively.

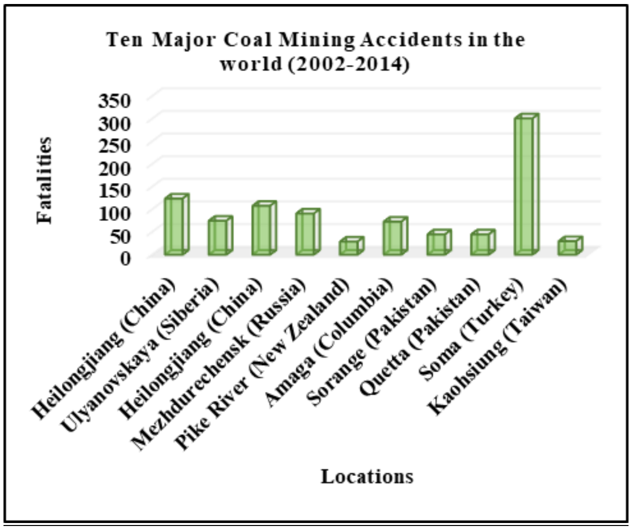

Fig 3.3: Ten Coal Mining Accidents (2002-2014)

The research indicated that, the total fatalities emanated from the twenty major coal mine accidents (1906-1972 and 2002-2014) were 7,435. Most of these accidents were caused by explosions. The coal mine accident in Benxi Hu in Liaoning Province, China is believed to be the worst mining disaster in the world [15]. Today, improvements in mining technology and stricter safety regulations have reduced coal mining related fatality to a large extend. Despite this achievement, coal mining accidents are still too common especially in China and in India. For instance, China produces more than one-third of annual global coal output and accounts for more than two-thirds of mining deaths around the world each year [16].

Table IV indicates that, the accident location with the highest death was Lagos in Nigeria while the site with the least death was Off the Coast of Sri Lanka. The total number of deaths in the seven crude oil accidents researched in this paper were 716.

Table IV: Seven Major Crude Oil Accidents in the World

Year	Location (Oil Tanker & Pipeline)	Country	Fatality	Cause	Injury
1979	Bantry Bay	Ireland	50	Explosion	
2006	Lagos	Nigeria	500	Explosion from Thieves Activity	
2010	Puebla	Mexico	29	Explosion from Thieves Activity	52
2010	San Martin Texmelucan de Labastida	Mexico	27	Explosion from Thieves Activity	50
2013	Huangdao	China	55	Explosion	
2018	Shanghai	China	32	Collision	
2020	Off the Coast of Sri Lanka	Sri Lanka	23	Explosion & Fire	
Total			**716**		

The area with the highest fatality had a death toll of 500 whereas the site with the lowest mortality had a death toll of 23 individuals respectively. Figure 3.4 shows this data.

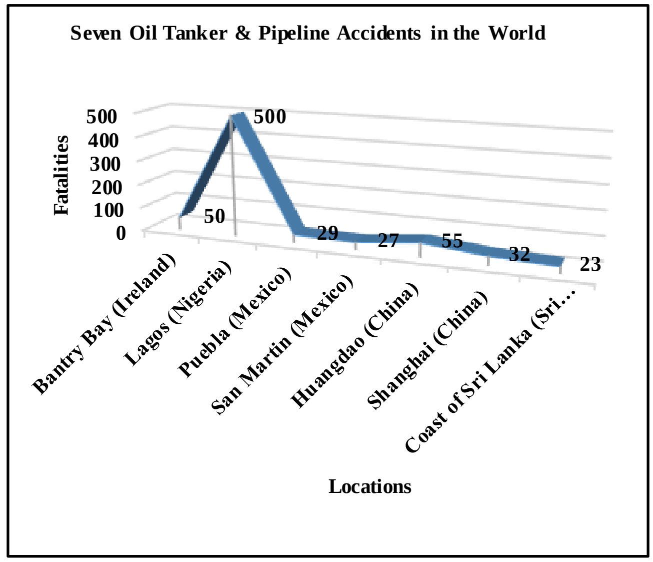

Fig 3.4: Seven Oil Tanker & Pipeline Accidents

For the nine natural gas accidents shown in table V, the Benito Juarez gas pipeline disaster in Mexico was the one with the highest fatality while East Java gas pipeline accident was the least. The research recorded a total of 172 fatalities emanated from the nine natural gas accidents.

Table V: Nine Major Natural Gas Accidents in the World

Year	Location (Gas Pipeline)	Country	Fatality	Cause	Injury
1965	Louisiana	USA	17	Explosion	9
1978	Benito Juarez	Mexico	52	Explosion	11
2000	New Mexico	USA	12	Explosion	
2004	Ghislenghien	Belgium	24	Explosion	122
2006	East Java	Indonesia	7	Explosion	
2010	San Francisco	USA	8	Explosion	
2010	California	USA	8	Explosion	
2012	Reynosa, Tamaulipas	Mexico	22	Explosion	
2014	Andhra Pradesh	India	22	Explosion	37
Total			**172**		

Figure 3.5 indicates the natural gas accident locations that had the highest death toll of 52 and the lowest fatality of 7 people respectively. The fatality from these accidents were caused by explosions.

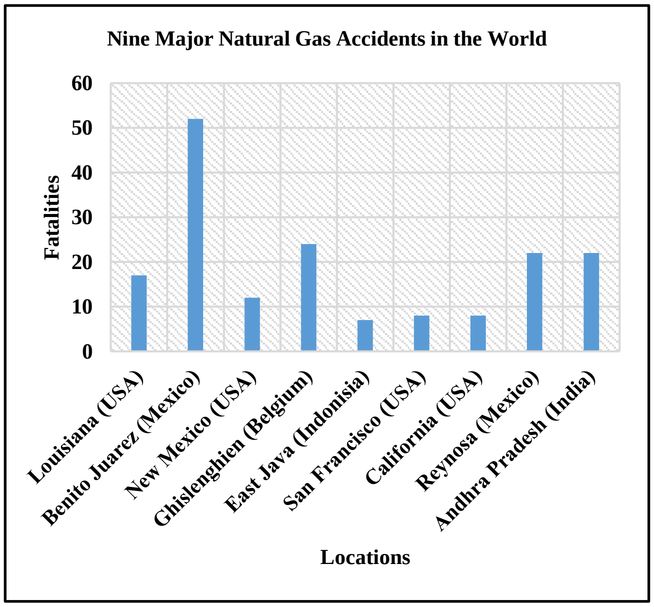

Fig 3.5: Nine Natural Gas Accidents

Even though the usage of natural gas to generate electricity is cleaner and safer than crude oil and coal, it also has its own hazards. For instance, in the United States, gas pipeline accidents caused 892 deaths and 6, 258 injuries since 1970 [17]**.** The Detroit Free Press in the US also reported that, there was 2,554 significant oil and gas pipeline accidents in the United States resulting in 161 fatalities and 576 injuries in the past decade alone. Every year, oil and gas drilling accidents in the US kill about 100 people [18]**.**

The accidents and fatalities do not end with the mining of coal, the drilling, transportation and distribution of crude oil and natural gas but extend to the generation of electricity from fossil fuel power plants. For instance, an accident at NTPC's Feroze Gandhi Unchahar Thermal Power Station in India claimed the life of 43 people and injured many more [19]**.** This accident was caused by build-up of pressure inside the boiler that resulted in an explosion and fire. Another accident at Big Bend Power Station in Apollo Beach, Florida, in United States killed 5 workers [20]**.** This accident was also caused by blockage under the plant's unit 2 boiler. Working in fossil fuel power plants is naturally hazardous. Even though safety precautions are put in place, many employees working at these stations around the world continue to lose their lives every year. These fatalities may be caused by electrocution, falling from height, explosions and fires.

Table VI depicts eleven nuclear power plant accidents in the world. The accident with the highest mortality occurred at Chernobyl in Ukraine. Three locations had the least mortality; these locations are Vinca in Serbia, Fukushima (1993) in Japan and Marcoule in France. The fatalities in the eleven nuclear power plant accidents researched in this article were 75.

Table VI: Eleven Major Nuclear Power Plant Accidents in the World

Year	**Location**	**Country**	**Fatality**	**Cause**	**Property Damage in Million (US $)**	**INES Rating**	**Injury**	**Indirect Death**
1958	Vinca	Serbia	1	Exposed to High Doses of Radiation		3		
1961	Idaho Falls	USA	3	Explosion at National Reactor Testing Station	22	4		
1976	Jasloyske Bohunice	Czechoslovakia	2	Malfunction during Fuel Replacement	1700	4		
1986	Surry, Virginia	USA	4	Feedwater Pipe Broke	2			
1986	Chernobyl (Pripyat)	Ukraine	50	Steam Explosion and Meltdown	6700	7		4000
1993	Fukushima	Japan	1	High-Pressure Steam			1	
1999	Tokaimura	Japan	2	Fuel Fabrication Facility		4		
2004	Mihama	Japan	5	Main Piping Burst	9	1	7	
2004	Fukui	Japan	4	Steam Explosion				
2011	Fukushima Daiichi	Japan	2	Loss of Coolant	1,200 - 2,100	7		573
2011	Marcoule	France	1	Explosion in Furnace used to Melt Metallic Waste		1		4
Total			**75**					

Figure 3.6 shows the site with the highest death toll of 50 and the highest International Nuclear Event Scale (INES) rating of 7. These accidents were caused by variety of factors including exposure to high level of radiation, loss of coolant, explosion and meltdown among others. The Chernobyl accident in 1986 was the world worst nuclear power plant disaster. It claimed the life of 50 people; 2 due to the explosion in the night of the accident and the rest due to acute radiation syndrome (ARS), coronary thrombosis and thyroid cancers later [21]**.** More than 4000 people also died indirectly as the result of the accident. The Chernobyl accident in Ukraine was caused by flawed reactor design which was operated by inadequately trained personnel [22]**.** This flaw resulted in explosion and fires releasing at least 5% of the radioactive reactor core into the environment, with the deposition of radioactive materials in many parts of Europe [23]**.** The worst affected countries are today's Belarus and Russia. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) concluded that, apart from some 5000 thyroid cancers (resulting in 15 fatalities), "there is no evidence of a major public health impact attributable to radiation exposure 20 years after the accident."

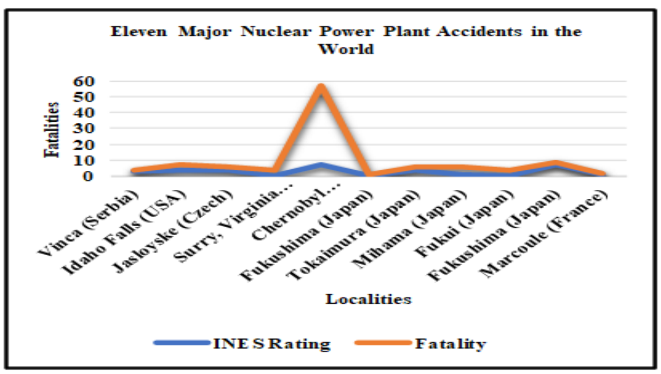

Fig 3.6: Eleven Nuclear Power Plant Accidents

Table VII demonstrates the total fatalities emanated from seven sites of coal mine, gas & crude oil transportation and nuclear power plant accidents. The coal mine had a total death toll of 801, natural gas transportation 157, crude oil transportation 716 and nuclear power plant 70 fatalities respectively.

Table VII: Fatalities of Coal Mine, Gas & Oil Transportation and Nuclear Power Plant Accidents

No	Coal Mine Fatalities	Gas Fatalities	Oil Fatalities	Nuclear Pw Plant Fatalities
1	124	17	50	3
2	75	52	500	2
3	108	12	29	4
4	91	24	27	50
5	29	8	55	5
6	73	22	32	4
7	301	22	23	2
Total	801	157	716	70

Figure 3.7 shows that, the highest mortality emanated from one accident location when transporting crude oil was 500 the lowest was 23 people. Coal mine accident at one site resulted in the death of 301 individuals as the highest while the lowest was 29. For natural gas transportation, the highest death toll at one accident scene was 52 souls whereas the least was 8. The figure also indicates that, 50 people died at one nuclear power plant accident, this constituting the highest while the lowest at one scene was 2.

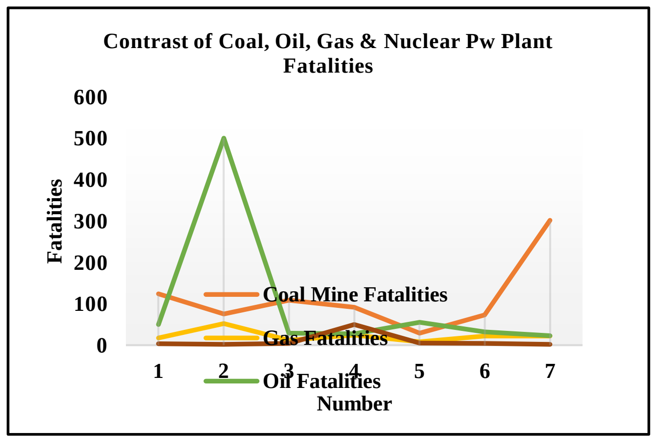

Fig 3.7: Mortality Comparison of Coal Mines, Oil & Gas Transportations and Nuclear Power Plants

Figure 3.8 shows that the total fatalities in percentage that occurred from accident at the seven locations was coal mine 46%; crude oil transportation 41%, natural gas transportation 9% while nuclear power plant was 4%.

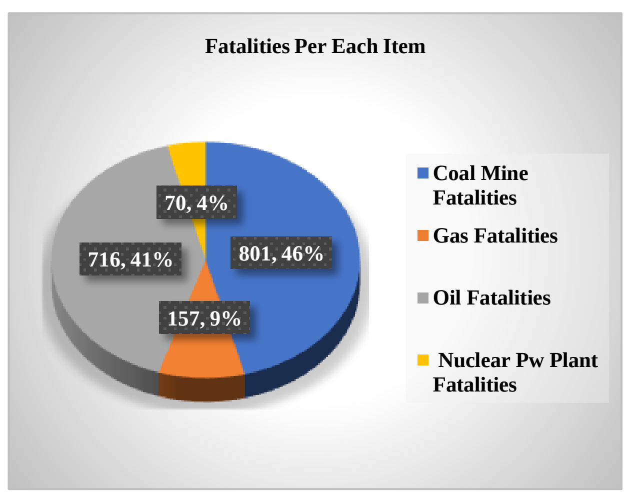

Fig 3.8: Fatality Comparison in Percentage

Figure 3.9 shows the addition of all the fatalities from coal mines, crude oil and natural gas transportations in percentage term under the auspices of fossil fuel based energy as 96% while those from nuclear power plants as 4%.

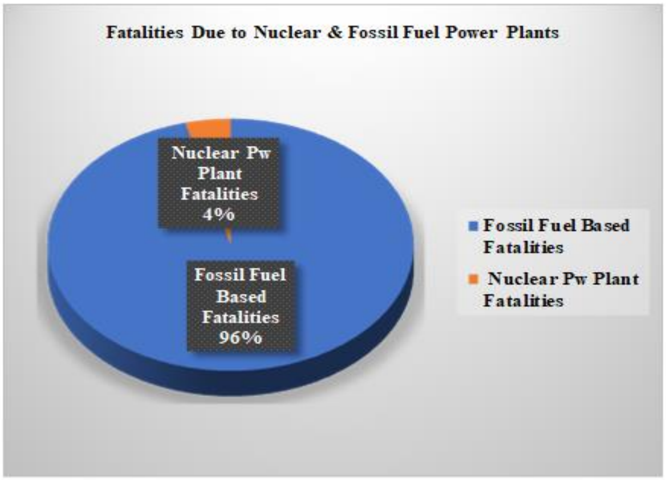

Fig 3.9: Fatality Occasioned by Nuclear Power Plant and Fossil Fuel Energy

Among the sources (fossil fuels and nuclear energy) of generation of electricity, coal has the largest carbon footprint (amount of carbon used to produce a kWh of electricity) and deathprint (number people killed per kWh of electricity produced). Nuclear energy has the smallest, even with the worst-case Chernobyl numbers. Natural Gas has the highest accident-related deaths [24]**.** Table VIII estimates the mortality rate for each energy source as deaths per trillion kWh of power generated over the last 40 years, plus an estimate of that source's contribution to global energy use.

Table VIII: Mortality Rate per Trillion kWhs of Electricity Generated

Sources of Energy	**Mortality Rate (Deaths/Trillion kWh)**	**Global Electricity**
Coal	100,000	41%
Crude Oil	36,000	4%
Natural Gas	4,000	22%
Nuclear Energy	90	11%
Total	**140,090**	**78%**

It should be noted that, the 36,000 mortality rate included 33% of other energy usage from crude oil. The remainder of the global electricity use is 22%; this came from renewable energy sources such as hydro, solar, wind, geothermal and the rest which is outside the scope of this paper.

IV. CONCLUSION

In this paper, the largest oil spillage accident occurred in the US, the BP Deepwater Horizon Oil platform which resulted in 11 fatalities while the largest crude oil disaster happened in Lagos, Nigeria where 500 people lost their lives. The largest natural gas accident was caused by explosion, the Benito Juarez disaster in Mexico had 52 fatalities. The coal mine accident in China, the Benxi Hu Colliery Coal Mine killed 1,549 people, perhaps the mining accident in the world with the highest fatalities. The Chernobyl nuclear power plant accident in Ukraine killed 50 people. A total of 9,328 fatalities were recorded from all the accidents enumerated in the paper.

Fossil fuel accidents are mostly anthropogenic consequence of extracting minerals from the crust of the earth. The impact of these accidents affect both terrestrial and marine ecosystems. The dependence of the world on fossil fuels is inconceivable, likewise the menace unthinkable. What is important is for the world to strike a good balance between their usage and the environment. From whatever angle one looks at it, burning fossil fuels such as coal, petroleum and natural gas to generate electricity is a global environmental and health issues and should be confronted globally. On the other hand, nuclear energy is the safest. In fact, the United Nation's Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) changed the estimate of additional deaths from the Chernobyl disaster from radiation in the public, from about 4,000 to about zero. Using nuclear energy to generate electricity in place of coal, natural gas and crude oil saves lives.

The electricity generated from both fossil fuel based and nuclear power plants are non-renewable. While fossil fuel power plants pollute the air and emit greenhouse gases, nuclear power plants do not pollute the environment nor emit greenhouse gases but rather emit radiation which can cause burns and predispose one to cancers, blood diseases, and bone decay. The impact of the former causes climate change and its attendance global warming while the latter does not. Both fossil fuel and nuclear power plants of comparable capacity have several mutual features. These two electricity generating facilities need heat to produce steam which spin turbines that in turn drive generators with the help of shafts. While in fossil fuel power stations steam production is achieved by combustion of crude oil, gas or coal, in nuclear power stations it is achieved by fissioning of uranium atoms.

ACKNOWLEDGEMENT

We are grateful to the Almighty God for the knowledge, wisdom, good hearth and insightfulness given us to write this article.

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