Energy Resources: Global Consumption and Environmental Degradation

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Abstract
The planet Earth is gifted by ample reservoir of energy and this abundant supply of energy allows life to continuously exist. The energy resources of the world are mainly divided into renewable and non-renewable sources. Non-renewable energy came from two sources such as fossil fuels and nuclear power. Fossil fuels include petroleum, natural gas, and coal. On the other hand, renewable energy is mainly derived from solar, wind, hydropower, geothermal, and biomass. Nowadays, the world is highly dependent on fossil fuels for energy consumption in the residential, agricultural, and industrial sectors. In the process of energy production various materials are released to the atmosphere such as greenhouse gases, particulate matter (PM), sulfur dioxide, and chlorofluorocarbons (CFCs). These chemicals put the environment and the organisms thriving on it in a great peril. These substances could cause acid rain, global warming, spread of the diseases, and reduction of the crop yield. It has been suggested that the best ways to attain sustainable energy and environment are to shift to alternative renewable energy sources, to use the appropriate technologies that can reduce the release of pollutants in the atmosphere in the course of energy generation, and to promote national industries among nations in the world.

Keywords
Energy Resources; Environmental Degradation; Global Consumption; Greenhouse Gases; Non-Renewable; Renewable

Introduction
The key pillar for human well being, economic development, and poverty alleviation is the access to energy [1]. Since the earliest human civilization up to the modern society energy has been the primary driver for economic growth. This is the main reason why humankind is continuously searching for the ample sources of energy. Hence, it is a pressing challenge in the global community to ensure that everyone in each nation of the world has an access to energy sources [1].

In the process of aiming for economic progress, much amount of energy has been generated from the environment. In the course in which it is utilized for various economic activities, environment and the organisms are being compromised because of its harmful emissions. The detrimental effects of some energy resources to the environmental and human health have been neglected for a long time. Realization appeared in the picture when
people came to a point of seeing that it is not worth to continue using the energy resources that have created great impacts to the environment. In the era of extreme climate change, the issue of environmental degradation is heavily felt by people in the world especially the amount of carbon dioxide emission increases over time which causes global warming. In fact, a total of 66.5% of global carbon dioxide emissions come from energy supply and transport [2].

In view of the scenario presented above, what should be the appropriate sources of energy to utilize in the present time to make the environment sustainable? Is it possible to attain environmental sustainability in the process of searching for energy security? How can the concerned authorities deal with this pressing challenge of time? In connection with those questions, this paper would like to present the available energy resources of the world and the current global energy consumption. Moreover, this will also explain some of the impacts of the energy resources to the environment. Finally, this will provide some suggestions in attaining sustainable energy and environment.

Energy Resources of the World

The energy resources of the world are mainly divided into renewable and non-renewable sources (Figure 1). The non-renewable energy refers to the energy resources that have been replenished for a long period of time. Non-renewable energy mainly came from two sources such as fossils [3] and nuclear power [4]. Fossil fuels include coal, natural gas and petroleum. On the other hand, renewable energy refers to the energy resources that have been replenished naturally for a short period of time. This is mainly derived from solar, wind, hydropower, geothermal, and biomass [3, 5].

Fossil fuels remain the dominant non-renewable energy sources of the world [6]. Among them, the dominant fuel source for electricity production is coal [7]. There are three forms of coal existing in nature. These are lignite (brown coal), bituminous (soft coal), and anthracite (hard coal). Coal varies in terms of carbon content. The higher the amount of its carbon content, the higher its energy density [8] and the cleaner it becomes [9]. The cleanest burning and most energy-intensive form of coal is anthracite [8].

Natural gas is another non-renewable source of energy which is derived from fossil fuel. Combustion of the natural gas generates high net energy yield [8]. This produces lesser amount of pollutants than other fossil fuels [10].

Oil is the most popular fossil-based fuel. This is tagged as the “runner of the economy” because of it is widely used in the entire planet for many economic activities. Because of its relatively inexpensive price, it has been patronized by many consumers.

The non-renewable source of energy which is not derived from fossil fuel is the nuclear energy. It is dubbed as the most efficient energy source. This operates by undergoing the process of nuclear fusion and fission. It requires Uranium as a fuel [4].

If the Earth contains non-renewable energy sources, it also possesses vast reservoir of renewable energy resources. Among them, the most prominent is the solar energy. As the name implies, energy from solar radiation is exploited in order to produce usable energy. There is a great potential to utilize this energy. According to studies, Earth has the ability to intercept solar radiation in the order of 8000 times greater than the human primary energy demand [7]. However, the capacity of the human beings to allow the entrapment of it is limited.

Aside from sun, a very famous source of renewal energy is wind. Using wind turbines on land or at offshore part of the sea, wind energy can be harnessed. This provides abundant amount of energy to humanity by converting its kinetic energy into mechanical energy in the gearbox [7].

One of the most environmentally friendly renewable energy sources on Earth is the biomass. This is tagged as environmentally friendly source because the CO₂ emitted as an outcome of the combustion process is offset by the CO₂ absorbed by the plant during its life cycle to produce biomass [7]. Biomass can be in the forms of bio-waste, bio-ethanol, and biogas.

In the area of ample supply of water coming from various aquatic systems, hydroelectric energy can be
harnessed. The mechanism of energy production involves the conversion of potential energy in water, in the form of heat to kinetic energy, which in turn is converted to electrical energy [8]. Run-of-river and reservoir/storage are two general types of hydroelectric technologies existing nowadays. This type of energy source depends on the run-off; hence, making it highly sensitive to climate change [11].

Energy Consumption of the World

The world today is highly dependent on fossil fuel for energy consumption in the residential, agricultural, and industrial sectors [11]. In 2016, the consumption of world’s primary energy grew by 1.0% [12]. The data of the agency depict that the top three most consumed energy resources worldwide in 2016 are oil, coal, and natural gas. These sources are non-renewable ones which were derived from the fossils.

In terms of increment to energy consumption, oil provided the largest rise amounting to 77 million tonnes of oil equivalent (mtoe) [12]. It is followed by natural gas and renewable power with 57 mtoe and 53 mtoe; respectively (Figure 2).

Figure 2: World consumption of energy in 2016 (Million tonnes oil equivalent) (Source: BP Statistical Review of World Energy [12])

The consumption of fuel in each geographical region of the world in 2016 is presented in Figure 3. Reports show that the dominant fuel utilized in African and American continents was oil. Natural gas was the dominant fuel used in Europe and Eurasia and the Middle East in same period. Also in 2016, coal dominated the fuel consumption in the Asia Pacific region which accounts for almost half of the energy consumption of the said region [12]. Reports of the [12] also indicate that Asia was the leading consumer of oil, coal, hydroelectricity in 2016. For the first in the history, Asia also serves as the leading consumer of renewable energy in power generation in 2016, overtaking Eurasia and Europe. In the same year, Eurasia and Europe dominated the consumption of the nuclear power and natural gas. Amounting for almost three quarters of global consumption (73.8%), Asia also dominates global coal consumption (Figure 4).

Figure 3: Regional Consumption by Fuel 2016 (%) (Source: BP Statistical Review of World Energy [12])

Energy consumption in per capita basis was also accounted by the past studies. For instance, BURN, an energy journal did the energy consumption investigation in 2010. Findings revealed that most developed countries like USA, Russia, and Canada have greater per capita energy consumption than most developing or less developed countries (Figure 5).

Figure 4: Fuel Consumption by Region in 2016 (%) (Source: BP Statistical Review of World Energy [12])

Figure 5: Per capita energy consumption in 2010 (Source: BURN Energy Journal [12])

Various types of energy used in USA for 2009 are indicated in Table 1. The most common types of energy utilized were oil, natural gas, and coal. Each energy type has specific advantages and disadvantages in terms of cost and its impacts to the environment and health.
The Impact of the Energy Resources to the Environment

As the time goes by, the demand for energy gets higher. In the process of energy generation various materials are released to the atmosphere. These materials include greenhouse gases, particulate matter, sulfur dioxide, and chlorofluorocarbons (CFCs) (Figures 6, 7, 8 and 9).

It was reported by [8] that bulk of the greenhouse gases released to the atmosphere were contributed by coal (300 Mt CO₂·EJ⁻¹). Aside from coal, other major contributors are natural gas, biogas, hydropower (pumped), and biowaste (Figure 6). Natural gas, biogas, hydropower (pumped), and biowaste contributed 118.1, 71.3, 52.5, and 40.8; Mt CO₂·EJ⁻¹ greenhouse gases emissions; respectively (Figure 6). In the same paper, [8] mentioned that the particulate matter (less than 10 μm) emitted to the atmosphere were mainly sourced from coal, bio-waste, bioethanol (sorghum), wood, and hydropower (pumped) (Figure 7). Among five major sources, coal (383.0 Mt CO₂·EJ⁻¹) remains the major contributor of particulate matter emissions. The contribution of biowaste was 159.4 Mt CO₂·EJ⁻¹ while 91.2 Mt CO₂·EJ⁻¹ for bioethanol (sorghum). Wood contributed 82.2 Mt CO₂·EJ⁻¹ of particulate matter (<10 μm) to the atmosphere while hydro (pumped) accounted for 80.4 Mt CO₂·EJ⁻¹ release of PM.

In terms of sulfur dioxide emissions, it was revealed by [8] that the highest contributor is coal (1.27 Mt CO₂·EJ⁻¹). The second, third, fourth, and fifth contributors are biowaste, bioethanol, biogas, and hydro (pumped); respectively (Figure 8). They emitted SO₂ amounting to 0.39, 0.23, 0.22, and 0.21 Mt CO₂·EJ⁻¹; respectively. Considering the recent data on CFCs emissions to the atmosphere, NGCC released the highest quantity which is Mt CO₂·EJ⁻¹. This source is followed hydro (pumped) with the contribution of 7.06 Mt CO₂·EJ⁻¹. Biowaste ranks third with the emission of 4.24 Mt CO₂·EJ⁻¹. PV (multi-Si) and PV (single-Si) rank fourth and fifth; respectively. The emission of PV (multi-Si) is 3.88 Mt CO₂·EJ⁻¹ while 3.78 Mt CO₂·EJ⁻¹ for PV (single-Si).

The aforementioned materials which are released to the atmosphere in the course of energy production are harmful to the environment and the organisms thriving in it. The greenhouse gases such as methane, oxides of nitrogen, oxides of carbon, and sulfur dioxide have been causing extreme climate changes. These changes in climate are characterized by irregular rain pattern, drought, flash flood, global warming and rise in sea level [11].

**Figure 5:** Energy Consumption per Person by Country in 2010 (Source: http://burnanenergyjournal.com/tag/united-states/) [13]
**Table 1**: Comparison of the Different Sources of Energy in United States of America in 2009 [13]

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<tr>
<td>Biofuels</td>
<td>1.6%</td>
<td>Expensive to produce, though costs are reduced because of extensive tax credits and incentives.</td>
<td>Some imported. Varies by source. Can be stored, some sources can be home prepared. May compete with food crops, especially internationally.</td>
<td>Some studies show disproportionate carbon dioxide emissions due to forest displacement. Fuel preparation and burning may produce harmful chemicals, depending.</td>
<td>Carbon dioxide, nitrous oxides, airborne particulate (amount dependent on sourcing)</td>
<td>Yes</td>
</tr>
<tr>
<td>Biomass</td>
<td>0.48%</td>
<td>Expensive to produce, though costs are reduced because of extensive tax credits and incentives.</td>
<td>Domestic sources. Can be stored. Sources are varied, from grasses and agriculture waste to landfill and industrial wastes.</td>
<td>May reduce landfill/waste. Some sources emit toxics.</td>
<td>Carbon dioxide, nitrous oxides, airborne particulates, methane (depends on fuel type)</td>
<td>Yes</td>
</tr>
<tr>
<td>Coal</td>
<td>21%</td>
<td>Historically one of the cheapest fuels, though cost increasing from air quality requirements (scrubbers on smokestacks) and increasing price of coal.</td>
<td>Domestically produced. Highly established system of sourcing &amp; transport, and low cost have lead to coal’s widespread use for electricity. Can be stored.</td>
<td>Major contributor to smog, acid rain. Emits mercury, lead, &amp; arsenic. Mountain top removal in mining. Mine accidents. Asthma &amp; pulmonary issues from airborne particulate.</td>
<td>Carbon dioxide, nitrous oxides, carbon monoxide sulfur oxides VOCs airbone particulates</td>
<td>No</td>
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<tr>
<td>Ethanol (see also biofuels)</td>
<td></td>
<td>Expensive to produce, though costs are reduced because of extensive tax credits and incentives, plus agricultural subsidy for corn.</td>
<td>Domestic and imported. May compete with food crops for animal feed. Can be stored.</td>
<td>Some studies show large carbon dioxide emissions due to rainforest/forest displacement. Reduces gasoline efficiency. VOCs &amp; methanol (in production).</td>
<td>Carbon dioxide, nitrous oxides, increases VOCs from autos when used as additive</td>
<td>Yes</td>
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<tr>
<td>Geo thermal</td>
<td>0.4%</td>
<td>Initial plant investment high but fuel free.</td>
<td>Few locations available, many areas in protected national park lands. Easy to build.</td>
<td>Low gas emissions.</td>
<td>Low amounts of methane, other gas emissions.</td>
<td>Yes</td>
</tr>
<tr>
<td>Hydro electric</td>
<td>2.8%</td>
<td>Initial investment high, fuel free.</td>
<td>Depends on rainfall. Energy can be stored through pumped storage, but is affected by drought. Permitting new large dams unlikely.</td>
<td>Affects wildlife &amp; natural water systems. Huge dams cause earthquakes, displace people, can be catastrophic if they fail.</td>
<td>Carbon dioxide, nitrous oxides, carbon monoxide sulfur oxides VOCs airbone particulates</td>
<td>Not during generation Yes</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>25%</td>
<td>Feel cost more than coal, less than oil. New plant construction expensive if used for electricity.</td>
<td>Domestically produced. Established sourcing &amp; transport. Can be stored, piped to homes and industries directly.</td>
<td>Can produce less carbon dioxide per watt than coal. Cutsen fossil fuel. One mode of drilling, “hydrofracking,” is in dispute; may pollute water, trigger earthquakes.</td>
<td>Carbon dioxide, nitrous oxides, carbon monoxide sulfur oxides VOCs airbone particulates</td>
<td>No (except some natural methane production)</td>
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### Table 1: Continuation

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Cost Comparison</th>
<th>Sourcing &amp; Storage</th>
<th>Environmental Impact</th>
<th>Safety Issues</th>
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<tbody>
<tr>
<td><strong>Natural Gas</strong></td>
<td>Fuel cost more than coal, less than oil. New plant construction expensive if used for electricity.</td>
<td>Domestic production, established sourcing &amp; transport, can be stored, piped to homes and industries directly.</td>
<td>Can produce less carbon dioxide per watt than coal. Cleanest fossil fuel. One mode of drilling, “hydrofracking,” is in dispute: may contaminate water, trigger earthquakes.</td>
<td>No (except some natural methane production)</td>
</tr>
<tr>
<td><strong>Nuclear Fission</strong></td>
<td>Fuel inexpensive. Operating costs high. Permitting, siting new plants difficult. Cost for spent fuel storage, security.</td>
<td>Domestic production, established sourcing &amp; transport. Fuel can be stored.</td>
<td>Spent fuel storage is unresolved. On average nuclear emissions and accidents less deadly, less cancer-causing than coal or gas, but meltdown has lead to land loss, cancer.</td>
<td>No</td>
</tr>
<tr>
<td><strong>Oil</strong></td>
<td>Expensive compared to other fossil fuels. Markets subsidized, taxed.</td>
<td>Established sourcing, transport. No national standard for refining. Can be stored. 50% U.S. supply imported.</td>
<td>Gas flaring during drilling emits extra carbon dioxide. Significant airborne particulate, carcinogens. Oil spills, foreign wars. Lead in gasoline present in some aircraft fuels.</td>
<td>No</td>
</tr>
<tr>
<td><strong>Solar Photovoltaic</strong></td>
<td>Initial costs very high, highest of all sources perhaps. No large plants in existence. Remote locales add cost for transmission. Tax incentives available.</td>
<td>Can be implemented on a small scale but large farms remote. Fuel cannot be stored, energy not produced at night. Most units imported from Asia.</td>
<td>Toxics used to produce solar cells, which depend on type of cells. Use of desert lands may be controversial. Advantage: doesn't require water for generation.</td>
<td>Not during generation</td>
</tr>
<tr>
<td><strong>Solar Thermal</strong></td>
<td>Initial costs very high. Remote locales add cost for transmission. Tax incentives and credits available.</td>
<td>Can be implemented on a small scale but large farms remote. Fuel cannot be stored, energy not produced at night.</td>
<td>Turbines require water which can be contentious if desert location. Requires a lot of land.</td>
<td>Not during generation</td>
</tr>
<tr>
<td><strong>Wind</strong></td>
<td>Turbine are expensive - offshore even higher. However, incentives &amp; tax credits have made wind competitive with fossil, according to some projections.</td>
<td>Can be installed on a small, distributed scale, but large farms remote, requiring transmission investment. Fuel cannot be stored.</td>
<td>Requires a lot of land. Kills some bats, birds, though new designs are slower &amp; less deadly. Advantage: doesn't require water for generation.</td>
<td>Not during generation</td>
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Figure 6: Emissions of greenhouse gases for renewable and non-renewable energy technologies [8]

Figure 7: Emissions of particulate matter (PM) less than 10 μm for renewable and non-renewable energies [8]

Figure 8: Emissions of SO₂ -eq (acidification potential) from renewable and non-renewable energies [8]
The sulfur dioxide released to the atmosphere could cause acidic rain by undergoing some chemical reactions. Acid rain depletes nutrients in the soil [14] which is detrimental to the plant growth (Figure 10). This type of rain can also cause leaf chlorosis and necrosis (Figure 10). Acid rain also leads to the decline of rice and fish production [15]. Among humans, SO₂ can cause eye irritation and respiratory diseases [13].

The CFCs have the capacity to deplete ozone layer (O₃). Various sources were derived from different emissions as given in Figure 10. The equations involved in the depletion process are represented in Figure 11. O₃ layer is found between troposphere and stratosphere which protects the Earth in the direct penetration of the ultraviolet rays. The hole of ozone layer in 1992 was 24.9 million square kilometer as seen in the satellite image Ozone Hole History [16]. This value was increased to 29.46 million square kilometer in 2006, the largest hole ever recorded in the history of the world. This condition leads to the sudden rise in the influx of ultraviolet rays which eventually brings harmful effects to the organisms in the planet. Few of the manifestations are the occurrence of the diseases and decline in the crop growth and survival [15].

Attaining Sustainable Energy and Environment

By considering the issue of environmental degradation on hand and energy insecurity on the other hand, experts are suggesting potential ways to attain sustainable energy and environment. These include shifting to alternative renewable energy sources, using...
the appropriate technologies that can reduce the release of pollutants in the atmosphere in the course of energy generation, and promoting national industries among nations of the world.

**Shifting to Alternative Renewable Energy Sources**

Within the coming 50 years, the global demand for food is expected to double [17], and global demand for transportation fuels is expected to increase even more rapidly [18]. With this, there is a great need for renewable energy supplies that do not cause significant environmental harm and do not compete with food supply [19]. Biofuels such as synfuel hydrocarbons or cellulosic ethanol that can be produced on agriculturally marginal lands with minimal fertilizer, pesticide, and fossil energy inputs, or produced with agricultural residues [20], have potential to provide fuel supplies with greater environmental benefits than either petroleum or current food-based biofuels.

Aside from biofuel, other sources of renewable energy such as tidal, wave, hydroelectric, solar, and wind can be harnessed. It is imperative to maximize its potential to produce energy which can address to the demand of the global energy requirement. These sources of energy can be replenished naturally for a short period of time and have lesser contribution to the carbon footprints in contrast to the fossil-based fuels [10]. Although renewable energy technologies have substantial land requirements and require more investment in infrastructure to harvest the energy [8]; however, a transition to renewable energy sources appears necessary [21] because of its lower degree of environmental impact.

The Union of Concerned Scientists (UCS), an organization of the science-advocates based in USA aiming for a healthy planet and safer world emphasized that the renewable energy use have several socio-economic and environmental benefits. These benefits include less production of greenhouse gases, improved public health, and stable energy prices [20]. In fact, the organization was able to gather data on the different amounts of heat-trapping gases produced by the different sources of energy. Data showed that non-renewable energy sources such as natural gas and coal have much higher emissions than the renewable sources (Figure 12).

**Use of Technologies to Reduce the Pollutant Emissions in the Atmosphere**

Production of pollutants due to generation of energy from various sources is inevitable. The best way to mitigate its amount released in the atmosphere is to use appropriate technologies. In reducing SO₂ release Flue-gas De-sulfurization (FGD) and Fluidized Bed Combustion (FBC) are suggested by [14]. In FGD, alkaline solution is used to absorb sulfur containing compounds from the chimney gases. In the case of FBC, coal is burned with finely pulverized limestone or dolomite. In this way, SO₂ is converted into fine particles of CaSO₃ which can be removed from the smokestack by an electrostatic precipitator.

Reduction of the particulate matter can be done by using electrostatic precipitation, bag filtration, and cyclone separation [14]. In electrostatic precipitation, gases containing the PM are passed thru a high voltage chamber prior to leaving the smoke stack. In bag filtration, fabric bags are used to trap PM. In cyclone separation, gases containing PM are spun in an outward motion similar to a centrifuge.

**Promotion of National Industries among Countries**

To ensure accessibility of affordable energy sources to all people in the world, the government of each country should have concrete plan about maximizing its energy resources and distributing equally to the people according to their needs. Government should implement policies and adapt programs leading to the establishment of the national industries that will supply sufficient amount of energy for its citizenry without compromising the health of its environment. These industries should be manned by the government itself. It is also essential for the government to tap its experts on energy resources in the course of energy exploration and generation.
Conclusion

One of the most valuable resources of the world is energy. In ecological and physiological points of view, this allows the organisms to survive because this provides the basic requirement in performing metabolic activities. On the other hand, in economic point of view; energy allows the economy to proceed because it supplies sources of power in factories, industries, and agricultural areas. The energy resources of the planet are mainly classified into two sources namely: renewable and non-renewable. Non-renewable energy came from two sources such as fossil fuels and nuclear power. Fossil fuels include petroleum, natural gas, and coal. On the other hand, renewable energy is mainly derived from solar, wind, hydropower, geothermal, and biomass. Nowadays, the world is highly dependent on fossil fuels for energy consumption in the residential, agricultural, and industrial sectors. During energy production some harmful materials are released to the atmosphere such as greenhouse gases, particulate matter (PM), sulfur dioxide, and chlorofluorocarbons (CFCs). These substances have the potential to cause acid rain, global warming, spread of the diseases, and reduction of the crop yield. With these, the quest of humans for sustainable energy resources is still continuing in order to protect the environment [23, 24]. As suggested by the experts, the potential ways to attain sustainable energy and environment include shifting to alternative renewable energy sources [19], utilizing appropriate technologies that can reduce the release of pollutants in the atmosphere in the course of energy generation [14], and promoting the national industries among the countries of the world.

References


