Assessment on the Environmental Impact of Conventional Energy Forms

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Abstract. As the dominant energy forms in the world, fossil fuels, nuclear and hydropower occupy over 90% of energy resources in total. The greenhouse gas is the emission of fossil fuel incineration, which causes global warming and climate change. Nuclear and hydropower are renewable energy and almost do not have waste during power generation. However, both nuclear and hydropower have potential or long-term negative influences. According to the current energy field, this article mainly analyzes the direct and potential effects of three types of energy forms and predicts future targets in the energy field.

1. Introduction
With the rapidly increasing population, the electricity demand is rising dramatically. The energy sources used nowadays can be divided into two types, conventional energy (fossil fuel) and renewable energy (such as solar, hydropower, nuclear and so forth). Power plants using fossil fuel as energy production resources play a crucial role in the global energy systems. However, the adverse impacts of fossil fuel are exposed to the environment gradually. Initially, global warming is the most concerning environmental problem which is caused by the combustion of fossil fuel. Additionally, the air quality also affected to some extent. Although nuclear and hydropower are considered renewable energies and have higher efficiency in energy production than fossil fuel, they also get some negative influences. For example, hydropower has an impact on ecology, while nuclear is a radiation substance that might lead to a detrimental effect on human health. This article mainly ascertains the environmental impacts of fossil fuel, hydropower and nuclear energy and analyzes the alternative power.

2. Fossil Fuel

2.1. The Application of Fossil Fuel
Fossil fuel, which consists of hydrocarbon material in the earth's crust, usually is used as the source of energy. Although there are other various energy types explored and utilized globally, fossil fuel is still playing an important role in industry, electricity and heat production. According to IEA (2017), over 60% share of power production is from combustible fuels, therefore fossil fuel still predominates the power generation beyond question. Admittedly, the existence of fossil fuel stimulates economic development, but it takes an array of demerits to the environment and human health.

2.2. Climate change caused by fossil fuel emission
Carbon dioxide (CO2) is the typical and principal component in greenhouse gas (GHG). As shown in Figure 1, GHG also includes Methane (CH4), Nitrous oxide (N2O) and Fluorinated gases (F-gases) additionally [1] and it is obvious that the CO2 occupied above 70% of GHG emission.

![Figure 1](https://www.ipcc.ch/)  
*Figure 1 The proportion of GHG emission. (Source: IPCC (2014).)*

In figure 2, about half of GHG emission comes from industry and electricity and heat production in 2010. Fossil fuel used in global energy systems is considered as an exhaustible and non-renewable energy sources [2]. In most power plants, they mainly use coal and coke, natural gas, diesel oil and residual fuel oil as fuels [3]. The incineration of fossil fuels in industry, power plants and vehicles is mainly CO2 in that carbon occupies the dominant element in fossil fuel. Thus, the combustion of fossil fuel contributes to the majority of GHG emissions. Although mitigation measures have been settled in recent years, understanding the CO2 emission performance of fossil fuel in the power industry is of great urgency in the world [4].
Figure 2 The GHG emission of different economic activities in 2010 (Source: IPCC (2014))

In diverse countries, the CO2 emission is totally different due to population and the emission also has changed compared with several years ago. In Figure 3, it makes a comparison of the CO2 emission among several countries in both 2010 and 2018, in which the countries contributed the largest emission of CO2 generated by fossil fuel combustion and cement production. China and the United States were the top two CO2 emitters. From 2010 to 2018, the majority of countries had a higher CO2 emission, however, the United States and the UK released fewer CO2 conversely, which reflects that this environmental matter led by the usage of fossil fuel has been eliminated slightly and been paid more attention in some countries with the global climate becoming an increasingly concerning problem. Moreover, although most of the countries have the awareness of reducing the usage of fossil fuel, the more efficient feasible alternative power has not been found and this research still needs to be explored.
Due to the surge of GHG, the global climate has been affected to a great extent for instance the temperature of the earth has increased about 2 degrees according to UNFCCC (2015). By virtue of that, it is more likely that the occurrence of extreme weather including extreme cold and hot events takes an upward increase, leading to the flood risk and even rise of sea level. Meanwhile, it does not mean that global warming only affects the intensity and frequency of extreme weather[5]. Taking China as an example, because of the topography and prominent monsoon climate in China, it is more likely for China to be affected by global warming [5,6]. The reference [5,7] proved that the precipitation in China increased dramatically with the temperature rising.

2.3. Potential impacts caused by fossil fuel

Apart from global warming, fossil fuel also brings some negative impacts on air quality. The emission of fossil fuel incineration not merely includes CO2, but also covers sulfur dioxide (SO2), nitrous oxide (NOx) and particulate matter (PM2.5 and PM10). In 2015, almost 90% of SO2, 80%, of PM2.5 and PM10 in the air were released by thermal power plants and industrial sectors in China, while about 70% of NOx and over 90% CO were contributed by transportation and industry [8]. The typical threat to humans is that these contaminants in the air are detrimental to respiratory system. The existence of SO2, NOx, PM2.5 and PM10 have potential risk lead to cardiovascular and respiratory diseases, chronic bronchitis, increased morbidity. What is more, asthmatic people are highly likely to be stimulated and aggravated by SO2 and PM [9]. In addition, SO2 and NOx are the principal
contributors to acid rain which erode soil and buildings. In China, the removal techniques are quite advanced, and thermal power plants and industrial sectors can remove over 60% even to 90% SO2, PM2.5 and PM10, but NOx has a lower removal rate about 40% to 60% compared with SO2, PM2.5 and PM10 [8].

Fossil fuels have dominated the energy and power field for about several decades. The global warming caused by fossil fuels cannot be delayed anymore. With the increasing awareness of controlling the usage of fossil fuels in many countries, the CO2 emission current condition has been relieved slightly compared to the prediction but has not been eliminated. Additionally, other emissions of fossil fuel incineration are harmful to human respiratory and agriculture. In future research, the study should mainly focus on the removal technology of NOx, diminishing discharge of GHG and finding the proper renewable and sustainable alternative energy.

3. Hydropower

Hydropower is a zero-carbon, renewable and sustainable energy with high efficiency, using natural resource (the difference of water level) generates energy. Up till now, there have been about 3700 hydropower plants (HPPs). Hydroelectricity is almost eco-friendly and zero emission technology by virtue of high stability and efficient large-scale mode to store energy[10]. During power generation, the waste or other pollutants produced by HPPs can be ignored compared with fossil fuels. However, there are other potential environmental matters caused by hydroelectricity.

3.1. Biodiversity

Hydropower plant usually is a huge project with strict geographical conditions and the water level difference is indispensable, for which HPPs cannot be widespread in the application. However, the existence of HPPs must accompany with dams. It is the dams that stuck the migration and affect discharge, water temperature, solutes and sediment transport in that dams change the water flow, reduce connectivity and block the routine of fish to habitats[10,11]. Because of impoundment and reduction of attraction flow, fish might disorientate and even lead to the loss of migration[10]. For instance, as a consequence of HPPs, the Yangtze dolphin extincted in 2006 in China and habitats of salmon in some French rivers had also been threatened [12].

3.2. Geological effect

More and more researches demonstrate that the construction of dams and reservoirs during hydropower generation have a potential negative impact on the geological structure such as landslip and potential earthquake risk[12]. Hydropower resources usually exist in the deep mountain valleys, which is difficult to exploit on account of complex terrain. In order to make full use of and save land resources, hydraulic structures are usually placed underground, which might lead to underground excavation of these hydraulic structures squeezing the surrounding rock, causing expansion and deformation of the cave[13]. Furthermore, once the earthquake and landslip occur, the reservoirs and dams might also be destroyed during the accidents.

3.3. Climate change

Hydropower is considered as a significant eco-friendly energy resource and it also facilitates to alleviate and defer global warming to some extent. During generating electricity in HPPs, there is almost no CO2 produced. However, the concept of ‘clean energy’ has been doubted in recent years. The surrounding vegetation has been submerged or emerged because reservoirs and the components in water are changed such as organic carbon. Organic matter in the reservoirs is decayed and degraded in substrate sediment which is under anaerobic condition, and an array of CO2, methane and NOx is generated[14]. These GHG is released and discharged around the water surface. Thus, that is why HPPs still have effects on global warming.
With the increasing global environmental problems, although hydropower is a zero emission and sustainable resource, the adverse influence is the initial problem that needs to be overcome. Otherwise, from a long-term effect perspective, HPPs are quite harmful to both environment and ecology.

4. Nuclear
Nuclear is the third dominant energy source apart from fossil fuel and hydropower. Nuclear power is another typical renewable power, which does not emit CO2 directly, therefore nuclear become an increasingly controversial topic in the energy field. Undoubtedly, uranium and thorium indeed have strong radiation and there is constant radioactive waste produced in the nuclear reactor, which can be divided into low-level radioactive, intermediate-level radioactive waste and high-level radioactive waste[15]. Currently, high-level radioactive waste is stored and isolated underground or in surface storage tanks, large concrete bays, or pools until 10 half-lives, but finding sufficient and feasible disposal places is a difficulty[16]. What is more, high-level radioactive wastes possess high heat and boil continuously and the site should select a more stable geologic environment. If the improper disposal method or containers of radioactive waste is applied, the radiation to human and ecology is catastrophic. Thus, it is understandable that many people have misunderstanding about nuclear power station on account of the significant nuclear power plant accidents in the world (Three Mile Island nuclear power plant in 1979, Chernobyl nuclear plant in 1986 and Fukushima nuclear plant in 2011) [16]. With the technology being more and more advanced, the risk of nuclear power plants has diminished to some extent. At the same time, people should overcome the horror of nuclear in that nuclear power is not infinitely dangerous. Same to fossil fuels and HPPs, they are dangerous but do not cause people panic[17].

5. Conclusion
These three energy forms are the conventional and dominant energy resources but all of them are not perfect enough. According to the current global climate, the initial duty is to reduce the GHG released by power plants. A technology called carbon dioxide capture and storage (CCS) can reduce the emission of CO2 to great extent. The concept is to capture and transport emission to a permanent storage site[18] which is extremely expensive and has the potential risk of leaking[19]. For example, compared with the plant without CCS, the plant having CCS is able to remove over 85% CO2 emission, however, more fuels need to be burnt to acquire correspond same quantity of energy as the plant without CCS[20]. Although CCS has a sufficient removal rate of CO2 in power plant, the method of storage and disposal sites are quite difficult to find an ideal one.

For the effects of hydropower on ecology, it is irreversible but mitigation measures can be applied. The impacts on biodiversity might be reflected in a long-term period. Therefore, it is a good solution to do an environmental impact assessment before constructing new HPPs and find suitable mitigation measures. Nowadays fishways are a normal solution to avoid fish stuck by dams and cannot migrate back to the habitats or spawn.

There are some misunderstanding of people on nuclear power and the government should set some lectures for people to know more about nuclear to reduce horror. Admittedly, nuclear is dangerous but fossil fuels and hydropower are also dangerous. What is more, within the current technology, the risk of nuclear power plants has been diminished dramatically compared with several decades ago. However, the disposal of radioactive waste is still crucial because once the waste leak into environment, it is catastrophic to humans and other creatures.

Nowadays, the power forms are not limited to these three energies and there is also other renewable and green energy such as wind, solar and tide. Fossil fuel, hydropower and nuclear dominate the energy market in the world, but they are not the most feasible and ideal energy resource on account that they either might accelerate global warming or have an adverse impact on human and ecology. The initial target currently is to find efficient CO2 removal technology in fossil fuel. The secondary target is to find a green and more feasible with high energy density alternative energy resources to change the current condition. To sum up, no matter what impacts are brought by hydropower and
nuclear, it is suitable to use hydropower, nuclear, and other renewable resources as much as possible to avoid the emitting of GHG.

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