A Critical Discussion of Traditional and Renewable Power Generation Systems

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30th Aug. 2024

Abstract:

Nowadays, there is increasing demand on energy in the various life sectors, such as: electricity, district heating and transportation. The worldwide energy is mostly produced from typical fossil fuels such as: coal, oil and gas. These sources are limited amount and causes significant environmental impacts. This article discusses the different types of fossil fuels, and also demonstrates the major renewable energy sources such as solar, wind and biomass. The main goal of this study is to compare these forms of energy and to examine the sustainability of the renewable sources of energy from various aspects such as: technological, economical and environmental. The major finding from this report is that an advanced study of the potential issues concerning future energy generation is essential for understanding the complex challenges, and to assist in the development of the future strategies.

Keywords: Traditional energy source, Renewable energy, fossil fuels, and energy sustainability.

Contents

Introduction

According to (Stultz and Kitto, 1992) power plants generate electricity and district heating. Electricity is the exclusive product of the condensation power plants, and it is the major product from extraction - condensation turbines in power plants where the steam of the extraction considered as a by-product. Electricity, district heating and steam are the basic products of combined heat and power stations (CHP). The exhausted heat from power generation turbines has another function; it can be used as useful process heat. The exhaust heat from power generation turbines has another function; it can be used as a process heat. There are two major categories to classify the energy based on its origin. The most common and used is: the energy from the fossil fuels, which includes coal, oil and natural gas. The second source called the renewable energy sources such as: solar, wind and biomass. Figure (1) demonstrates the major types of global energy supply from 1971 to 2007 (IEA/H2/AR-2002).

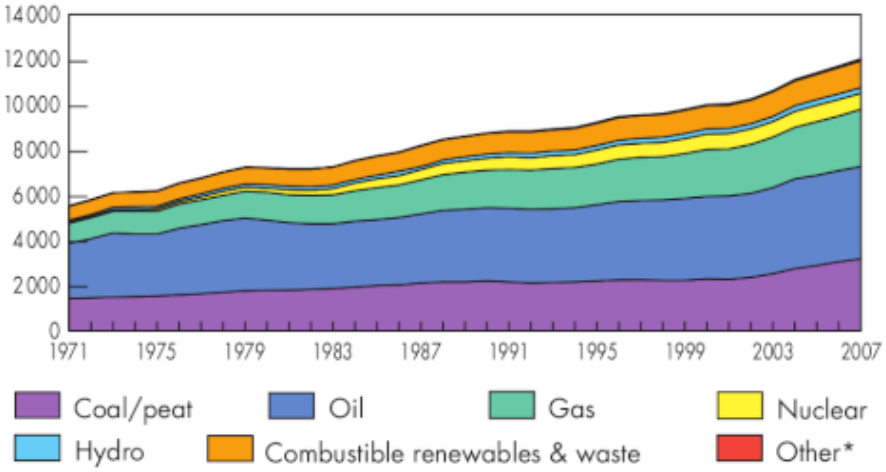

Figure 1: Evolution from 1971 to 2007 of world total primary energy supply by fuel (Mtoe) (IEA/H2/AR-2002).

Fossil fuels considered as a crucial factor in the industry, economy and power production sectors in the Europe and many other countries around the world. They have considerable role in electricity generation, at the present time more than 50% of the EU electricity is produced from conventional energy sources (mostly: coal and natural gas) (Brussels, 2006). It is predicted that the global demand on fossil fuels in power generation will continue till 2050, especially in some regions with developed economies (Brussels, 2006).

There are two major factors that cause remarkable concerns of the current energy sources: First, there are limited quantities of fossil fuel resources. Second, depending on fossil fuels to satisfy the global energy demand from heating and transportation will cause unexpected environmental consequences (Ristinen and Kraushaar, 2006).

For these reasons it is critically important to seek for alternative sources to cover our energy requirement, by investigating in the renewable, environmentally friendly sources of energy.

Recently, a remarkable increase in the use of renewable energy sources over than other appeared economies in Europe and the rest of the world. At the same time, the sharp increase in petroleum prices in 2005 have contributed in huge governmental re-consideration of the renewable energy sector (Waldau, 2011). Although there is continuous disagreement between the USA and the European Union on what should be done to control the climate change, renewable energy sources are expected to have great role to activate the Kyoto Protocol and introducing the tradable green certificates globally. Renewable energy entered several vital sectors such as: electricity generation, district heating and transportation systems. This can be achieved by developing in the renewable sources of energy such as: Solar, wind and biomass which is expected to have crucial role in transportation systems (Waldau, 2011).

1- Crude Oil:

Crude Oil is an extremely complex mixture formed from the decomposition process of organic materials with sediments before millions of years ago (Wallington, et al., 2006). Many useful fractions can be derived from crude oil such as: liquefied petroleum gas, gasoline, kerosene and many other heavy oils. Crude oil products are usually used on wide range in transportation systems such as: automobiles, public transport and planes. It can also be used in the industry in the oil-fired burners mostly heavy oils. Heavy oil can be distinguished by its high density, which makes it having the higher boiling point over the other products of crude oil.

2- Coal:

According to (Maden & Mole, 1996) coal is row fossil fuel and supplies over 42% of the global energy. It is considered the major energy source in the world to produce electricity. Therefore, there is growing efforts to improve the efficiency of coal power plants by developing the technology to mitigate the harmful effects of the greenhouse gases that produced by combustion process. Figure (2) shows the distribution of coal in various processes in 2007.

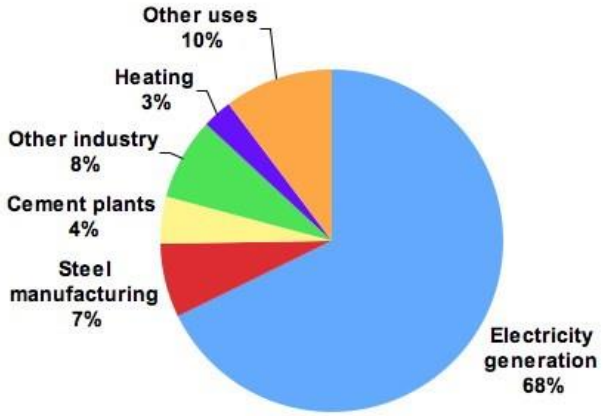

Figure 2: Coal use by sector, 2007 (International Energy Agency, 2009)

3- Natural Gas:

Natural gas is a mixture of many hydrocarbons mainly methane (75-95) percent by volume. It is produced via anaerobic decomposition of dead organic substances. Natural gas can be found naturally in porous geological formations; also, it occurs associated with other gases such as nitrogen oxides and carbon oxides in the extraction process of crude oil.

According to study done in 1990 by (Golob and Brus, 1993) the amount of natural gas estimated to be around 23% of over all fossil fuel resources. At the same time, it contributed to produce around 12% of the global energy produced by conventional fossil fuels (Maden and Mole, 1996). Natural gas can be distinguished by its great energy content, a counted to be double that of coal. For this reason, it can be utilized in various applications, even more than coal and oil.

4- Solar Energy:

Solar energy is the energy that maintains life on Earth for all species. It supplies a significant solution for all communities to have their demand for clean, abounding sources of energy in the future. Solar energy comes from the nuclear reactions (interactions) at the core of the sun, where the energy produces from converting of hydrogen to helium. Sunlight is freely available, secure from geopolitical stress, and expose no danger effect to our environment and our global climate systems from pollution emissions. There are two methods to utilize solar energy: the first one is by transmitting instantly to electricity; this can be achieved by using photovoltaic cells. The second method is by extracting the energy indirectly as with wind, which originally derived from sunlight (Foster, et al., 2010).

5- Wind energy:

Historically, wind has been used for pumping water for example in Netherlands. Wind power can be used to generate electricity as sustainable energy source. Wind power basically generated from wind turbine. The geographic locations of the regions are the major factor to determine the average electricity generated, for example to produce 600 W/m^2 a wind velocity over 8 m/s is required at 50 m above ground. There are two main categories when introducing wind power: onshore (on land) and offshore (in the water) wind power. In addition, there are two designs of wind turbines: vertical and horizontal.

6- Biomass:

Biomass is renewable source of energy it is estimated that bio-fuel, which is derived from biomass, is supplying about %13 of the global energy Hall & House, 1994). Biomass can be considered as sustainable source of energy because its plants are works continuously over the year. There are growing interest to increase the use of bio-fuels in the developed countries, while there are contrasting situation in the developing countries. This is because of utilizing various biomass substances in the non-industrialized countries (Pimentel et al., 1994).

Discussion:

There are three crucial factors should be considered, when evaluating the major sources of energy. These factors are technological, economical and environmental aspects. The following points explain the effect of each of these factors on the 6 main sources of power production:

1. **Oil**

- Technology:

Oil fractions can be used to produce electricity on two methods: directly by using a set of considerable diesel generators (4-stoke internal combustion engines connected with enormous electricity generators), and indirectly via using heavy oil-fired boilers that connected with steam turbines to produce super heated steam as in steam power plants.

- Economy**:**

Both of these methods are costly and mainly used in the countries that have considerable quantities of reserved oil.

- Environment**:**

There are many environmental challenges that face the use of oil (heavy oil) in operating power grid. For example, burning heavy oils can be considered as harm waste in the industrialized countries. High range pollution has been reported during the burning of oil, because of its high viscosity (Fingas, et al., 1993).

2. **Coal**

- Technology:

Nowadays, there is growing interest to develop coal power plants, which is supplying the majority of the global electricity. There are many developed technologies to burn coal in a coal power plants, high CO2 reduction can be achieved through using more efficient and cogeneration processes. These technologies are promising great efficiency for example 45% for Integrated Gasification Combined Cycle (IGCC) plant and 55% for a Coal Gasification Molton Carbonate Fuel Cell Combined Cycle (IG-MCFC-CC) plant (Uchiyama, 1994).

- Economy**:**

The considerable and cheap reserve of imported coal is replacing the local production in most European countries. Having the ability to choose the coal suppliers makes the energy market depend mainly on the imported coal instead of the expensive domestic production, especially at the winter season where there is extreme demand on energy. Many European countries (for example: France and Netherlands) plans to cut-off the domestic coal production and the German, British and Spanish coal market also tries to reduce the demand on the local resources. It is found that supporting coal industry will exhaust these countries economy (Anonymous, 1997).

- Environment:

Burning of coal can be considered as the major contributor to increase the percentage of the green house gases in the atmosphere over than other conventional sources together. Because during the burning process the carbon will convert to carbon dioxide CO_2, while this process is takes different path when combusting oil and natural gas, because of the associated elements that will burn via pure oxidation process.

3. Natural Gas

- Technology**:**

There are various techniques can used to produce power from natural gas, such as: Co-generation, Combined Cycle Technology, re-burning, and co-firing. The basic cycle consists of gas turbine. The mechanism of the simple gas turbine plant is: the compressed air will be mixed with the gas via nozzle-mixing and by providing spark in the combustion chamber a great amount of heat released. This will inter the gas turbine and convert the heat energy of the combustion process to mechanical energy in the turbine. Finally, the turbine is connected by shaft with suitable generator which converts the mechanical energy to electrical energy (Sandgren & Sorteberg, 1994).

- Economy:

It is assumed that natural gas utilization will be increased, because of its high efficiency and low CO_2 emissions compared with the other non-renewable energy sources. Advanced technology has been used to develop natural gas fuel cells, which is promising to cover the electricity generation in the U.S with low construction cost (Anonymous, 1999).

- Environment**:**

Using natural gas has great advantage to reduce the amount of green house gases that will cause by combusting other traditional fuels such as coal and oil. Burning natural gas possesses less CO_2 and NO_x emissions to the atmosphere, with relatively zero amount of SO_2 or particulate matter emission (National Gas Supply Association, 1998). According to study by Swiss reported about 790,000 tonnes of CO_2 equivalent/ TWh_{el} for the natural gas life cycle analysis LCA global warming potential (GWP) FOR 100 years (Sandgren & Sorteberg, 1994).

4. Solar Energy

- Technology:

The major sunlight can be transformed into electricity by photovoltaic conversion using a solar cell, which depends on the photoelectric properties of a semiconductor such as, silicon or cadmium / telluride based (Fuchs and Masoum, 2011). More energy strikes the earth in one hour (4.3x10^20J) than all the energy consumed on the planet in a year (4.1x10^20J) (Foster, et al., 2010).

- Economy:

The current cost of solar technologies that produces electricity via photovoltaic cells is much higher than the cost of electricity by fossil fuels and even the rest renewable sources. Photovoltaic cell is new technology by more developing and governmental support the cost can be fall. On the other hand, large grid connection is needed to transport the generated electricity, which requires more financial support because of the high cost of the system (Foster, et al., 2010).

- Environment**:**

Photovoltaic solar cells are generating clean electricity, because of using sunlight instead of fuel, PV systems do not emit any chemical hazards to the environment that causes air and water pollution, consume natural resources, endanger the health of the species.

5. Wind energy:

- Technology:

Wind mills convert the energy from the wind to a mechanical force. This force rotates a horizontal shaft connected to gearbox, which increases the revolution of the shaft to hundred times. This gearbox also connected to generator, which converts the kinetic energy to electrical energy. The final efficiency of the modified wind mills is between the ranges from 27 to 36 percent. it is remarkable that windmills has operation limits, it is stop working at very low and very high wind velocities (World Energy Council, 1994).

- Economy:

The fuel used to operate the wind turbine is air, which is available and free. Wind power plants have high construction cost, this is mainly taken by setting concrete infrastructure and the control system. The majority of costs are capital cost between 75-90 percent, while the rest can be count as operation and maintenance costs (British Wind Energy Association, 2000).

- Environment**:**

Windmills have very low green house gas emissions; mainly from the construction materials such as cement and steel. Canadian wind turbines are approximately emitting 7.4 grams of carbon dioxide per kWh of produced electricity (Beals & Hutchinson, 1993).

6. Biomass:

- Technology**:**

Planting crops is a new technique to grow biomass and it can be used as alternative to use forests and the waste from agricultural sources. The climate conditions and woody regions are the best medium to grow biomass. For example, cold, high rainy and density areas reported the highest rate biomass growth (Golob & Brus, 1993).

- Economy**:**

Although the huge global amounts of biomass resources, there are significant economic challenges slowing the utilization process of biomass as energy source. There are important factors should be considered when building biomass power plant such as: the location and the size. Each of these factors has its noticeable effect on the power plant economy (Golob & Brus, 1993).

- Environment**:**

The combustion process of bio-fuels emits low amounts of harmful gases to the atmosphere; this is as a result of formation, transportation and energy consumption during the process. The biomass production can be considered as a carbon capture and utilization method, because it is sequestrating CO_2 during its growth period (Lundborg, 1994).

Conclusions:

Using fossil fuels in to generate electricity have greater technological advantages that the renewable energy sources. Fossil fuel power plants have higher thermal efficiencies than the other power plants. This was achieved by the continuous developing in these power plants. The availability of fossil fuel in some regions makes considerable economic benefits; whilst in other areas, where there is shortage of this resource, significant economic consequences will rise. Also because of the limited quantities of the fossil fuels (for example crude oil) the global economy will be unstable. From this point investing in renewable energy sources are promising many stable and valuable results. On the other hand, there is a growing concern over the significant environmental consequences of using fossil fuels. Therefore, it is important to understand all of the technological, economical and environmental aspects associated with each technology. It can be concluded that an advanced study of the potential issues concerning future energy generation is essential for understanding the complex challenges, and to assist in the development of the future strategies.

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