© November 2017 | IJIRT | Volume 4 Issue 6 | ISSN: 2349-6002

Technical Review of various sources of energy production and Carbon Capture and Storage

Japen Gor

***Abstract*-The most challenging issue in today's world is to provide the energy to the population of almost 9 billion people on the planet earth. Most of the countries have started looking for the best possible solution(s) for the replacement of the conventional fossil fuels to meet the energy demands. As an interest of saving environment the EU has setup some targets to achieve by 2020. The main aims are to reduce greenhouse gases and to increase the energy production by introducing renewable energy sources.**

The aim of this study is to look in to the power generation technologies available today or under process of development and their affordability as alternatives for the fossil fuels.

Despite of the severe consequences associated with the coal, it still accounts almost 40% of the total in production of the electricity and 25 % of other global primary energy productions (Worldcoal, 2010). Use of the natural gas is least adverse in all forms of fossil fuels, but is costlier than coal. Employment of advanced technologies can control the emission of CO_2 and discharge of other hazardous materials. In search of the alternates for fossil fuels various options have come to the light. Though few of them have been used for centuries for general applications, but never been used as primary power production sources.

Regardless of less approachable sun in UK, more than 100, 000 small solar heating systems are in operation (EON-UK, 2008). Biomass is another applicable source in EU, but when it is used as an independent power production technology, it eventually becomes costlier option. Wind energy has been the major focus in the EU including the UK, as this part of the world is having plenty of wind resource. EU has invested major funds on wind energy, in 2009, in all renewable resources.

I. INTRODUCTION

Earth is having abundant amount of the energy in different forms of the sources. Use of the fossil fuels for more than a century has generated many well known environmental problems, while on the other hand less efficient technologies and interrupted availability are draw backs of green energy sources. This report focuses on the different available options for the power generation in terms of the technologies, economic and environment effects. This report also suggests the best renewable alternate for the fossil fuel in UK and Europe. The report mainly covers three groups of sources classified as follow, (a) coal, Oil and gas, (b) wind and solar and (c) biomass and waste. The mentioned energy sources are compared and a clear and fair review is delivered in the report.

II. TECHNICAL REVIEW

Coal

Coal-fired power plants have two main components in the process in any technology. The boiler, which burns the coal to produce the heat energy and this heat, generates steam from the water. The steam goes to the next key component which is steam turbine generator; this is used to convert the heat energy of steam in to electricity. Modern coal fired power stations have dust and hazardous gas removal units in addition to the traditional stations. These units clean up the flue gas before it enters in to atmosphere. The above method is conventional and is called a pulverised coal Combustion (PCC) system (Breeze, 2005)

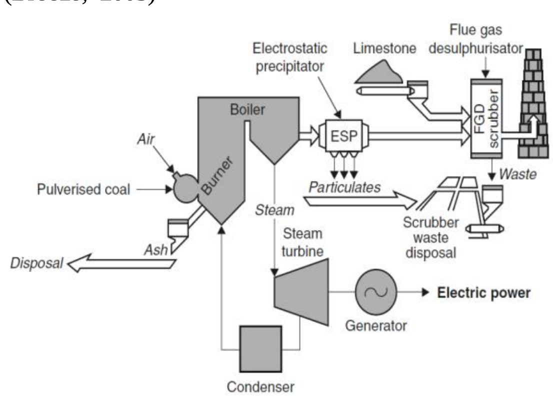


Figure: 1 Flow Diagram of Traditional Coal-Fired Power Plant (Breeze, 2005) (Source: Breeze P (2005). *Power Generation Technologies*. Burlington: Elsevier. P21.)

The state of the steam is crucial factor that directly affects the efficiency of the coal fired power plants. The different state of the steam and their relative efficiencies are mentioned in below table.

STATEOFTHE STEEAM	EFFICIENCY
Subcritical steam	36 to 38%
Supercritical steam	40 to 44%
Ultra-Supercritical steam	Up to 50%

(Elder, 2010).

To increase the efficiency of the cola power plants following techniques could be employed.

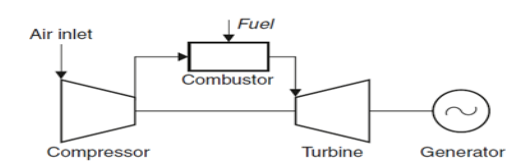
(a) Fluidised Bed Combustion: This is of two types (i) Pressurised Fluidised Bed Combustion and (ii) Non-Presurised Fluidised Bed Combustion. This technology can burn Coal, Biomass and common waste. It can reduce the emission of SOx and NOx up to 90%.

(b) Supercritical and Ultra Supercritical Technology: This systems function under too high temperature and pressure to produce the supercritical and ultra supercritical steams. These systems contribute to reduce CO_2 at a large scale.

(c) Integrated Gasification Combined Cycle: Oxidation of the coal produces the syngas (H_2+ CO). Syngas drives the combined cycle turbine to produce electricity (World Coal Association, No Date).

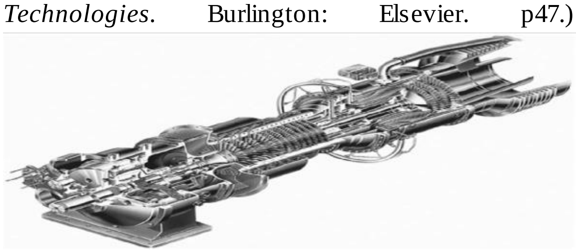
Oil and Gas :

Natural gas/ oil Turbine Technology



Block diagram of a gas turbine for power generation

(Source: Breeze P (2005). *Power Generation Technologies*. Burlington: Elsevier. p47.)



Cross section (photograph) of a gas turbine. Source: Courtesy of Solar Turbines Incorporated (Source Breeze P (2005). *Power Generation Technologies*. Burlington: Elsevier. p49.)

Figure 2: Block Diagram and cross section of a gas turbine

Electricity production in this method takes place using the kinetic or potential energy of the fluid (generally air) along with the pressurized gas. Air gets compressed in compressor to 15-19 times the atmospheric pressure. The efficiency of these compressors is up to more than 85%. The modern machines may have 10 to 12 compressors to deliver the best results. The combustion chamber gets this well pressurized air from the compressor(s) where the mixture of the fuel and air ignite to raise the temperature up to 1400 ^oC or higher. While leaving combustion chamber and entering the turbine this hot air may cause the damages to the turbine so it has to have its temperature well controlled, but on other hand the temperature should be as high as possible to achieve the best efficiency. Modern turbines may have 3 to 5 stages within them to provide the efficiency more than 85%. In few designs, the turbines and compressors may have been fixed on same shaft. While in another design two shafts get used, one to hold compressor and first stage of the turbine, which is crucial to run the compressor, and further stages of turbine as well and other shaft carries the generator and power producers. The efficiency of these systems crucially depends on the temperature of the compressed air. Latest advanced gas turbine designs incorporate few more stages to improve the efficiency further e.g. reheating etc. (Breeze, 2005)

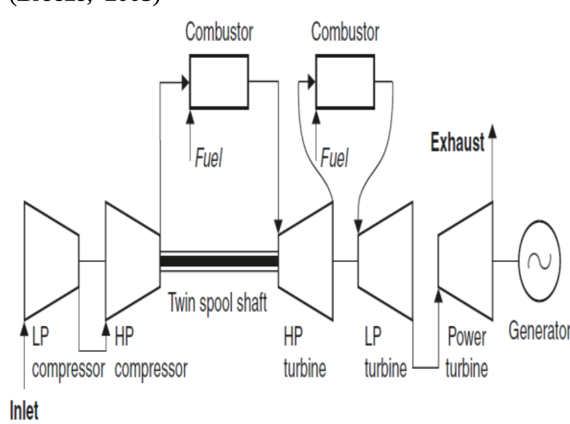


Figure 3 regeneration stage in gas turbine (Source:

Breeze P (2005). Power Generation Technologies. Burlington: Elsevier. p51.)

The figure represents the block diagram of advanced gas turbine cycle stages. Where LP represents low pressure and HP stands for High pressure.

Biomass

The technologies used for the generation of the electricity from biomass/waste involve either thermal conversion or bio-chemical conversion. The detailed classification of the technologies can be done as below.

Thermal Conversion process can be divided into following methods. These methods are based on heat mechanism to convert them in to other chemical forms.

Industrial Biomass Combustion process is the most simple combustion technology. The furnace combustion of biomass produces the hot gas for the industrial applications. Biomass- fired boilers get used to produce the steam, which gets sent to the electricity production. (OREGON, 2010)

Pyrolysis is anaerobic break down of organic compounds of biomass. It produces a range of the end products such as biochar, syngas and bio-oil. (OREGON, 2010)

Gasification method is used to produce process gas (CO, H_2, H_2O vapor, CO_2, tar vapor and Ash particles). There are three types of the gasifiers up draft, down draft and fluidized bed. (OREGON, 2010)

Co-Firing incorporates the firing of the biomass as a secondary source alongside the coal; this method also helps to reduce the emission of sulphur and nitrogen oxides and carbon dioxide. (OREGON, 2010)

Biochemical Processes

Anaerobic digestion breaks down the organic compounds present in biomass to produce the "biogas" in absence of the oxygen. This reaction highly depends up on the temperature of the DIGESTER (reactor). (OREGON, 2010)

Fermentation is an aerobic biochemical process which mainly produces alcohol. Sugar present in wheat, corn, barley, sugarcane and beet is broken down in to the ethanol using special types of enzymes in this process. This could be used with gasoline as an automobile fuel, because of its high octane number. (OREGON, 2010)

Biodiesel is a good substitute for the petroleum diesel which gets produced by chemical conversion of oilseed crops, waste vegetable oil or animal fats. (OREGON, 2010)

Co-Generation can be used in both the electricity generation and industrial stream production together. If the steam produced is used first for the industrial processes and then for the electricity production the arrangement is called BOTTOMING CYCLE, but if the electricity is produced first and then industrial steam work is done the arrangement is called TOPPING CYCLE (OREGON, 2010).

Wind

The actual wind turbine operation involves the simple aerodynamic force of lift to make the shaft produce the positive torque which applies on the rotating shaft connected to it. (Manwell et al, 2009)

Power output given by current wind turbines can be represented as follow.

$P = \frac{1}{2} C_p \rho A u^3$ (Burton et al, 2001)

Here Cp represents the power coefficient; ρ represents density of air (which is 1.225 kg/m3), A is the swept area of the rotor and u is the wind speed. (Burton et al, 2001)

Using the above equation the power production can be determined, and it helps to improve the system to achieve higher output as well. Significant output can be achieved by the selecting the site having good source of wind and by higher swept area of the rotor. (Burton et al, 2001)

Mainly the wind turbines can be classified in to two main types.

(1) Horizontal Axis Wind Turbine (HAWT): This is very common type of the turbine used on commercial scale. The axis of this turbine rotates parallel to the ground and hence it is called a HORIZONTAL type of turbine. There are two types of mechanisms possible for HAWT. (a) Up wind and: wind turbine facing the flow of wind (b) Downwind: turbine placed in the direction of the wind

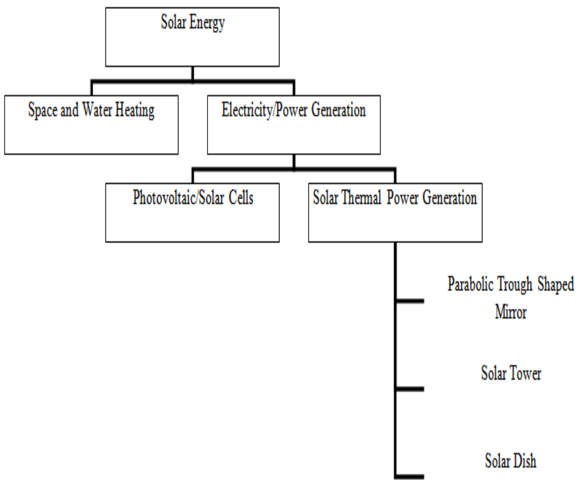
(2) Vertical Axis Wind Turbine (VAWT). Three well known turbines under this category are (a) Darrieus VAWT, (b) Savonius VAWT and (c) Giromill (Paraschivoiu, 2002)

Depending up on the applications of the wind turbines they could be classified in following two groups (i) Onshore wind turbines and (ii) Off shore wind turbines.

The classification of the wind systems could be done as follow. (i) Stand-alone systems (ii) Grid-Connected (iii) Building mounted turbines. (bwea, No Date).

Solar

There are two main uses of the solar energy, one to produce the electricity and two for the heating. Following chart shows the different technologies for the use of the solar energy for the power production.



Solar electricity can be produced in two ways. First and conventional method is to use the photovoltaic or solar cells, and second way is using the advanced solar thermal technologies.

The term "PHOTOVOLTICS" is a basic operation, which uses the energy of the light to produce the electricity at fundamental level of the particles (Knier, 2002). The electricity generated using the above principle is called as "photoelectricity".

Few materials have capacity to absorb the radiation released from sun and can use that to generate the electricity e.g. Silicon.

The traditional way of making PV panels was just using pure Silicon. The second generation PV panels were made up of the amorphous silicon or cadmium telluride. They are called "thin-film solar cells" (NREL, 2009). Latest third generation is made using non-silicon materials. They get printed with ink or dyes on conductive plastics (NREL, 2009). The third generation PV panels use the principle of the black-body, these materials are incredibly good absorber of radiation (Green, 2006).

These solar cells are very thin sheets in size and always been treated to have positive charge field on one side and negative charge field on another. The energy of the photons gets absorbed by these sheets to release the electrons and the flow of these free electrons is called electricity (Knier, 2002).

Solar thermal power generation method uses the heat energy trapped in the solar radiation. All the technologies under this method concentrate the solar energy at one object called as RECEIVER. Different shapes of the collectors could be used to concentrate the sun beams. These concentrated sun beams heat up the fluid carried by the pipe in the system. Function of the fluid is to pass the heat energy to the heat engine which eventually produces the electricity (Breeze, 2005).

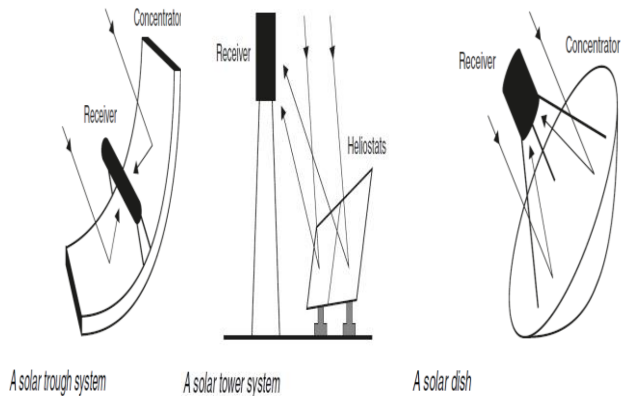


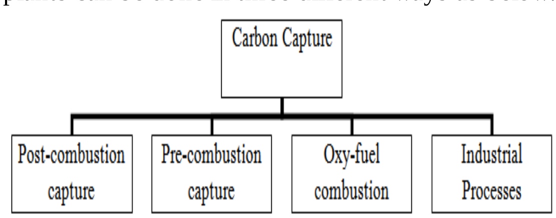
Figure 4: Solar thermal power generation collectors (Source: Breeze P (2005). Power Generation Technologies. Burlington: Elsevier. p188-192)

Space and water heating are two major applications after the power production from the solar energy and work on same principle. These methods are similar to the thermal power production technology. Photovoltaic cells or solar collectors could be used for these applications to concentrate the sun beams at a receiver and heat up the fluid carried by the pipe in the system.

III. CARBON CAPTURE AND STORAGE

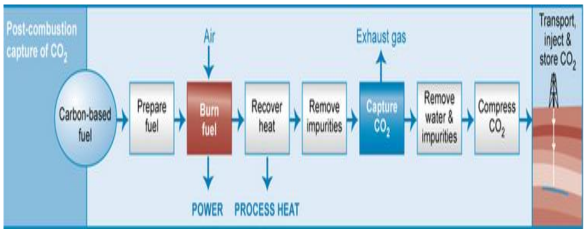
Carbon Capture Technologies

Carbon Capture of CO_2 at large scale combustion plants can be done in three different ways as below.



(a) Post-combustion capture:

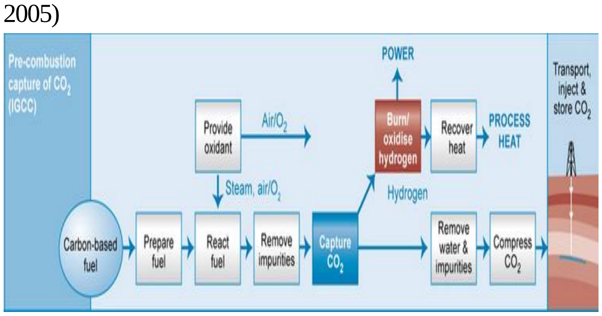
As a name suggests, the capture of the carbon in form of CO_2 takes place after the combustion of the fuel. This method is advantageous as it can be fixed on the already running plants, though it requires the supplementary space for the implementation (Energyglobal, 2010). Chemical absorption technique is used to capture the CO_2 emitted (Carbontrust, 2010)



(Source: http://www.science.org.au, 2008)

(b) Pre-combustion capture:

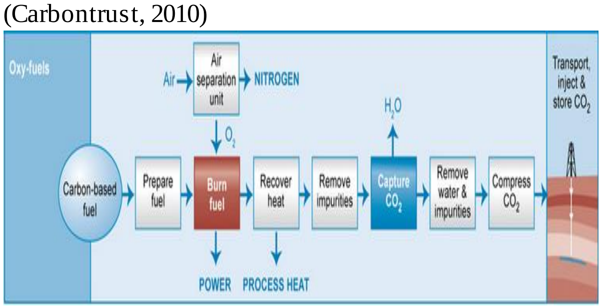
In this method, reformation or gasification of the fuel gets carried out to produce syngas (H_2+CO) before the fuel gets sent for the combustion. This procedure can be done with use of compact vessels and consumes less energy. (Energyglobal, 2010) (IPCC, 2005)



(Source: http://www.science.org.au, 2008)

(c) Oxy-fuel combustion systems:

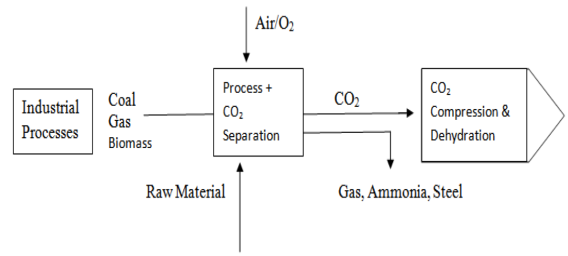
Almost pure oxygen gas is used for the combustion in this process, which produces the flue gas consists predominantly CO_2 and H_2O. The combustion of fuel in almost pure oxygen creates the stream of the CO_2, which can easily be captured. (IPCC, 2005) (Carbontrust, 2010)



(Source: http://www.science.org.au, 2008)

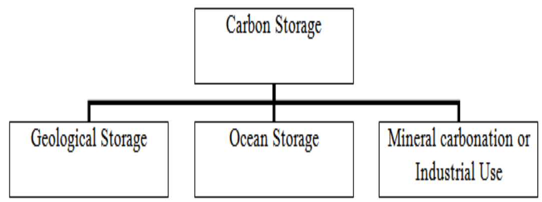
(d) Industrial Processes:

This process has been in practice for more than 80 years now (Kohl and Nielsen, 1997) (IPCC, 2005). Natural gas purification, synthesis gas for the production of NH_3 and alcohols etc. are the examples where the CO_2 gets captured from the process stream. (IPCC, 2005)



(Source: http://www.dailykos.com, 2009)

Caron Storage: Three major ways of the carbon storage are as below.



(Source: http://www.science.org.au, 2008)

IV. DISCUSSION

Economics of the Sources:

Economy of the power generation is as crucial as choosing the right technology for it. Power production depends up on various direct or indirect factors few of them are listed below. (1) Cost and availability of the fuel, (2) Operating cost, (3) Capital cost and recovery, (4) labor cost (5) Selection of the site. Etc.

According to the current figures of the world Coal Association, more than 5990 million tonnes (Mt) of the hard coal and 913 million tonnes of the brown coal was produced in 2009 (Worldcoal, 2010) (*Source: International Energy Agency 2010)*. At the same production rate, availability of the coal is anticipated to last for 119 years. Coal has shown more stability in prices than oil and gas for last few years (Worldcoal, 2010).

The UK has 17 coal fired power plants with the capacity of 100 MW or more. The electricity generated using this technology costs around 2.5 to 3p/KWh. These power plants produce about 700 kg of CO_2 per mWh electricity produced (EON-UK, 2008).

Energy Information Administration using oil and gas journal estimated world total reserve of oil to be 1,342.207 Billion Barrels and 6,254.364 Trillion Cubic Feet of natural gas in January 2009. (EIA, 2009)

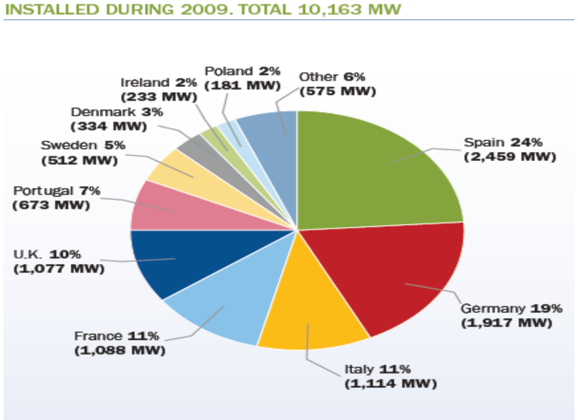
There are 2 oil-fired and 36 gas-fired power plants in the UK. Cost of electricity using oil and gas technologies would be about 4.8 to 6p/ kWh and 2 to 3p/kWh respectively. Oil-fired power plants produce 580 kg of CO_2 per mWh while gas power plants produce 370kg/mWh of CO_2 (EON-UK, 2008).

Out of all the possible technologies for the solar energy, disused above, only one technology has shown its real commercial application and that is solar trough technology. Solar power plants need very large area for the operation which might turn in to significant capital cost. Solar electricity for the domestic uses has several grants available from both UK and EU governments. The Department of Energy (US) has expected the production of electricity at commercial level to come down to average $ 0.067 per kWh using any of the solar thermal technology (Breeze, 2005).

In the UK, installation of solar PV systems for the house, cost about £6,000, while solar water heaters cost around £2,500-£4,000, they generate the power at less than 10p/kWh (EON-UK, 2008). The UK's biggest solar energy company expects the electricity to cost as much as 17p to 18p per unit of electricity at commercial scale (Vaughan, 2009).

EU has spent €13 billion on wind power, which is 39% of the total fund invested on electricity generation technologies in 2009; this incorporates 10,163 MW of wind power (ewea, 2010).

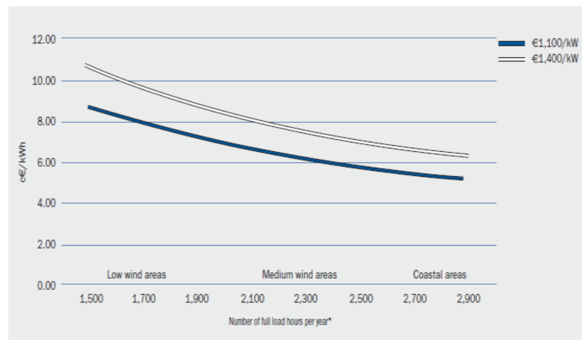
EU MEMBER STATE MARKET SHARES FOR NEW CAPACITY INSTALLED DURING 2009. TOTAL 10,163 MW



(Source: http://www.ewea.org, 2010)

EWEA estimates the cost of the operation and maintenance for the onshore wind power generation to be around 1.2 to 1.5 € per KWh over the life time of the wind turbine. Below figure gives the brief idea about the cost calculated by EWEA for the data collected for different regions classified in three categories as below (1) Low Wind areas (2) Medium Wind areas (3) Costal areas.

Calculated costs per kWh of wind generated power as a function of the wind regime at the chosen site (number of full load hours).



* Full load hours are the number of hours during one year during which the turbine would have to run at full power in order to produce the energy delivered throughout a year (i.e. the capacity factor multiplied by 8,760).

Source: Risø DTU

(Source: http://www.ewea.org, 2009)

The graph shows that cost of electricity generation in low wind areas ranges from 7 to 10 €/kWh, while that is 5 to 6.5 €/kWh in coastal areas for the chosen wind power systems shown in graph.

(ewea, 2010).

There are more than 135 wind farms in the UK with the capacity of more than 1900MW power in total. Large onshore wind farms produce electricity at the cost of 4.2 to 5.2p p/kWh, while offshore wind farms cost about 6.2 to 8.4pkWh (EON-UK, 2008).

Co-firing technology is the most economic for the electricity generation using the biomass and waste. Introducing Co-firing plant to existing coal-fired power plant depending up on the capacity may cost between $100/kW and $700/kW for US economy. Developing new biomass power plant, in 2005, was costing around $2000/kW but it is expected to come down to $1300/kW by the end of 2010 (Breeze, 2005). The above statistics are applied for USA. In recent time, the electricity generated using this technology costs about 4.0p-6.1p p/kWh in the UK (EON-UK, 2008).

Environmental Impact of the Sources

There are certain challenges associated with the use of fossil fuels such as production of oxides of sulpher, oxides of nitrogen, particulates, CO_2 and

CH_4 emissions, soil erosion, noise and water pollution etc. many of these are responsible for the changes in climate.

One of the major solutions of overcoming the effects of these pollutants is improving the efficiency of the power plant. There are many advanced technologies available; which can reduce the effect of these pollutants such as introducing CCS technology, electrostatic precipitators, fabric filters, wet scrubbers, hot gas filtration, flue gas desulphurisation system etc. (Worldcoal, 2010)

Solar power production systems are generally huge in size and because they use the large reflective surfaces they may cause the visual problems. Fluids used to concentrate the solar radiation in the industrial applications may contain hazardous oil or molten salts. Concentrating solar power systems may cause the problem in aviation industry as they reflect light beams back in to the atmosphere which can be a major drawback.

Wind power stations technically produce no emission of pollutants during the operation and are responsible for very small amount of emission during manufacturing and installation. It is estimated to eliminate a total of 7600 million tones of CO_2 by incorporating the wind energy in power production by 2030. Wind energy is one of the cheapest technologies available. major issues associated with the wind power plants are the noise and birds as they produce considerable amount of noise and birds get killed by the rotating blade whilst the operation. (eere, 2010)

Environmental effect of biomass directly depends on the type and form of biomass used. Deforestation is the biggest issue associated with use of biomass. Biomass is a good substitute for the fossil fuels and can bring the CO_2 level down significantly. The EU climate change policy strongly concerns about the nitrogen emitted from agricultural exercises. Biomass energy crops do not require higher nitrogen in fertilizers and are most efficient towards the use of the nitrogen as well. (Silveira, 2005)

V LAGISLATIONS

UK and European Union have several legislations to ensure that power plants are responsibly operated, and to provide secure and affordable energy supply. Few key acts for the power generation and relative consequences are listed below.

• Petroleum Act 1998, Revised acts Petroleum Act (Commencement No. 1) Order 1999, Petroleum (Current Model Clauses) Order 1999	Aim: This acts focus on the activities associated with the petroleum, offshore power generation, and submarine pipelines.
• Offshore Combustion installation regulation:	Aim: This regulation is applied to the offshore oil and gas combustion stations, where the rated thermal input is more than 50 MW (th).
• Gas directive implementing regulation:	Aim: This act is designed to monitor the measures relating to the oil and natural gas. This power is honored to the secretary of state.
• The offshore installation (Emergency Pollution Control) Regulations:	Aim: This act is design to focus on control the pollution, monitor and reduce the accidents at site and safety of the operator.
• Green House Emission Trading Scheme Regulation	Aim: This act provides the structure of the greenhouse emission allowances trading.
• Energy Act 2008 and Energy Act 2010.	Aim: The objective of these acts is to monitor offshore environment assessment, and to grant the license for the fair and appropriate exercises of the power production.
• Climate Change Act 2008	Aim: This act is designed to build up guidelines in order to achieve the reduction of green house gases and to ensure the actions taken towards it.

(UKooaenvironmentallegislation, 2010)

VI. CONCLUSION

Despite of that fossil fuels are major pollution creators; it is really difficult to cut them out as an option of energy production of our lives. Fossil fuels are the cheapest option available in all the sources of power production, but because of the environmental consequences associated with them the alternatives for them are desperately needed. In the EU and the UK the wind energy has emerged as an excellent solution of the fossil fuel disputes. Biomass stands second for the alternative renewable options in the Europe, which is easily available but is expensive compared to the wind technologies when not used as co-fired technology. They need to be build near the source of fuel otherwise transportation cost makes them more expensive. Biomass is not the complete carbon free technology as the fuel may contain organic compounds as well. Collecting a biomass is not easy and is not available all the year. Solar energy is great for the sunny countries. The UK is not a sunny country and hence solar energy is not really good alternate as a major energy source in UK, though it can be used alongside other technologies to distribute the energy load. Solar energy is not available in the night time and hence the power generation is not possible all day even in the sunny countries. Operating cost of the wind turbines or farms is low. With the new advanced technologies wind turbines can work even with the small amount of the wind available. Wind energy involves zero geological risk and that of atmosphere. UK has excellent amount of wind availability and hence wind technologies are the best alternate for the fossil fuels.

REFERENCES

[1] Breeze P (2005). Power Generation Technologies. Burlington: Elsevier. p21-224

[2] Burton T, Sharpe D,Jenkins N (2001). Wind energy: handbook. West Sussex: John Wiley & Sons Ltd. p11. Available online http://books.google.co.uk/books?id=4UYm893y-34C&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false Accessed on 17 Nov 2010

[3] Elder R (2010). CPE6300: Introduction to Fuel & Energy - Coal. Sheffield: University of Sheffield . p2-3.

[4] Green M.A. (2006). Third Generation Photovoltaics: Advanced Solar Energy Conversion. New York: Springer Science & Business Media. p7.

[5] Knier G. (2002). How do Photovoltaics Work?. Available: http://science.nasa.gov/science-news/science-at-nasa/2002/solarcells/. Last accessed 20th Nov 2010.

[6] Krohn S (editor), Morthorst P, Awerbuch S. (2009). The Economics of Wind Energy A report by the European Wind Energy Association. Available: http://www.ewea.org/fileadmin/ewea_documents/documents/publications/reports/Economics_of_Wind_Main_Report_FINAL-lr.pdf. Last accessed 28th Nov 2010.

[7] Manwell J.F., McGowan J.G.,Rogers A.L. (2009). Wind Energy Explained: Theory, Design and Application. 2nd ed. Great Britain: John Wiley & Sons Ltd. p2. Available online http://books.google.co.uk/books?hl=en&lr=&id=roaTx_Of0vAC&oi=fnd&pg=PR9&dq=Wind+Energy+Explained:+Theory,+Design+and+Application.+2nd+ed.+Great+Britain:+John+Wiley+%26+Sons+Ltd.&ots=O0ZyNyfI_7&sig=6lH8EZ8SzWFztiGRb9KPb2pqNlI#v=onepage&q=Wind%20Energy%20Explained%3A%20Theory%2C%20Design%20and%20Application.%202nd%20ed.%20Great%20Britain%3A%20John%20Wiley%20%26%20Sons%20Ltd.&f=false Accessed on 17 Nov 2010

[8] No Name (2009) Solar Photovoltaic Technology. Available: http://www.nrel.gov/learning/re_photovoltaics.html. Last accessed 22nd Nov. 2010.

[9] No Name . (2008). Capturing the greenhouse gang. Available: http://www.science.org.au/nova/108/108print.htm. Last accessed 29th Nov 2010.

[10] No Name . (2009). On carbon capture and sequestration. Available: http://www.dailykos.com/story/2009/9/25/784997/-On-carbon-capture-and-sequestration. Last accessed 22 Nov 2010.

[11] No Name . (No Date). IMPROVING EFFICIENCIES. Available: http://www.worldcoal.org/coal-the-environment/coal-use-the-environment/improving-efficiencies/. Last accessed 1st Dec 2010.

[12] No Name . (No Date). Small Wind Technologies. Available: http://www.bwea.com/small/technologies.html. Last accessed 1st Dec 2010.

[13] No Name. (2008). Energy World: Energy Sources. Available: http://www.eon-uk.com/EnergyExperience/661.htm. Last accessed 29th Nov 2010.

[14] No Name. (2009). World Proved Reserves of Oil and Natural Gas, Most Recent Estimates. Available: http://www.eia.doe.gov/emeu/international/reserves.html. Last accessed 27th Nov 2010.

[15] No Name. (2010). Advantages and Challenges of Wind Energy.Available: http://www1.eere.energy.gov/windandhydro/wind_ad.html. Last accessed 29th Nov 2010.

[16] No Name. (2010). Atmospheric Emissions - Power Generation. Available: http://www.ukooaenvironmentallegislation.co.uk/Contents/topic_files. Last accessed 29th Nov 2010.

[17] No Name. (2010). COAL MARKET & TRANSPORTATION. Available: http://www.worldcoal.org/coal/market-amp-transportation/. Last accessed 26th Nov 2010.

[18] No Name. (2010). Wind in power 2009 European statistics. Available: http://www.ewea.org/fileadmin/ewea_documents/documents/statistics/100401_General_Stats_2009.pdf. Last accessed 28th Nov 2010.

[19] No Name. (June 07, 2010). BioEnergy Technology. Available: http://www.oregon.gov/ENERGY/RENEW/Biomass/BioEnergyTechnology.shtml. Last accessed 16th Nov 2010.

[20] Paraschivoiu I. (2002). Wind turbine design: with emphasis on Darrieus concept. canada: Polytechnic International Press . p1-p2. Available online http://books.google.co.uk/books?hl=en&lr=&id=sefVtnVgso0C&oi=fnd&pg=PR5&dq=types+of+wind+turbine&ots=HjDTvQpt-i&sig=ydD0SB3kkk8r8lAT9vuaz8Bgegc#v=onepage&q&f=false Accessed on 18 Nov 2010

[21] Silveira, S (2005). Bioenergy- Realizing The Potential. London: ELSEVIER. p24.

[22] Vaughan A. (2009). Cost of solar energy will match fossil fuels by 2013, claims Solarcentury. Available: http://www.guardian.co.uk/environment/2009/may/12/solar-energy-price-fall. Last accessed 29th Nov 2010.