Environmental impacts of coal mining and coal utilization in the UK

Deniz Mamurekli[1]

Coal has remained the main source of energy in the UK from 1700 to the end of 1970s, and it still plays an important role in the power generation. The paper discusses the current coal consumption in the UK together with environmental impacts of coal mining, coal processing and coal utilisation for power generation. Since coal remains the single biggest contributor to greenhouse gases worldwide, methods for minimising environmental impacts of coal combustion are described in this paper including systematic application of the principles of clean coal technologies financed by the private sector.

Key words*: environmental impacts, greenhouse gases, coal processing, utilisation, power generation*

Introduction

The UK is basically a coal mining country where coal mining started on a systematic basis during 17th century which led to the development of the industrial revolution. Coal mining reached its peak in 1900 when there were some 3237 coal mines in the UK with the peak out put reaching to 287 Mt (million tonnes) annually in 1913 (Fig. 1) [11]]. Coal remained the main source of energy in the UK until the early 1980s with periodic step wise changes in the production and consumption pattern due to changes in circumstances as outlined below:

1. Between 1905 and 1942, coal output was generally above 250 Mt/yr,
2. Output fell to some 175 Mt/yr during the Second World War due to war efforts,
3. Since nationalization in 1945 up to 1970 output remained greater than 150 Mt/yr,
4. Between 1971 and 1984, coal output remained above 120 Mt/yr while the indigenous oil and gas production increased. By 1980 the UK became the net exporter of energy,
5. Between 1984 and 1985, there was a nation wide miner’s strike when the coal output was drastically reduced. This resulted in the Coal Authority adopting a policy of closing unprofitable mines,
6. Privatisation of coal industry took place in 1994 with current production reducing to about 20 Mt/yr.

The decline of coal production in the UK can be attributed to one or combinations of the following reasons:

- competition from oil and gas,
- environmental problems associated with the utilisation of coal,
- changing energy demand due to electrification of railways,
- introduction of the Clean Air Act in 1956,
- utilisation of natural gas from the North Sea rather than producing town gas,
- the need for reduction of Miner’s Union‘s bargaining powers,
- the international price of cheap imported coal.

At the time of privatisation in 1994, 60 deep mines produced a total of 31.5 Mt/yr of coal while 100 surface mines produced 16.8 Mt/yr [2]. Since then, deep mine closures have continued for a range of reasons, including lack of commercially viable reserves, uneconomic underground haul distances, geological problems, underground flooding and company failure. Total UK coal production was 20,5 Mt, 18,5 Mt and 17,0 Mt in 2005, 2006 and 2007, respectively, of which 9,6 Mt, 9,4 Mt and 7,7 Mt came from underground mining [3]. This paper is concerned with the contribution of coal to the energy requirement in the UK, environmental problems associated coal mining and utilisation, and measures taken to mitigate the green house effects caused by the consumption of coal.

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(Review and revised version 20. 10. 2010)

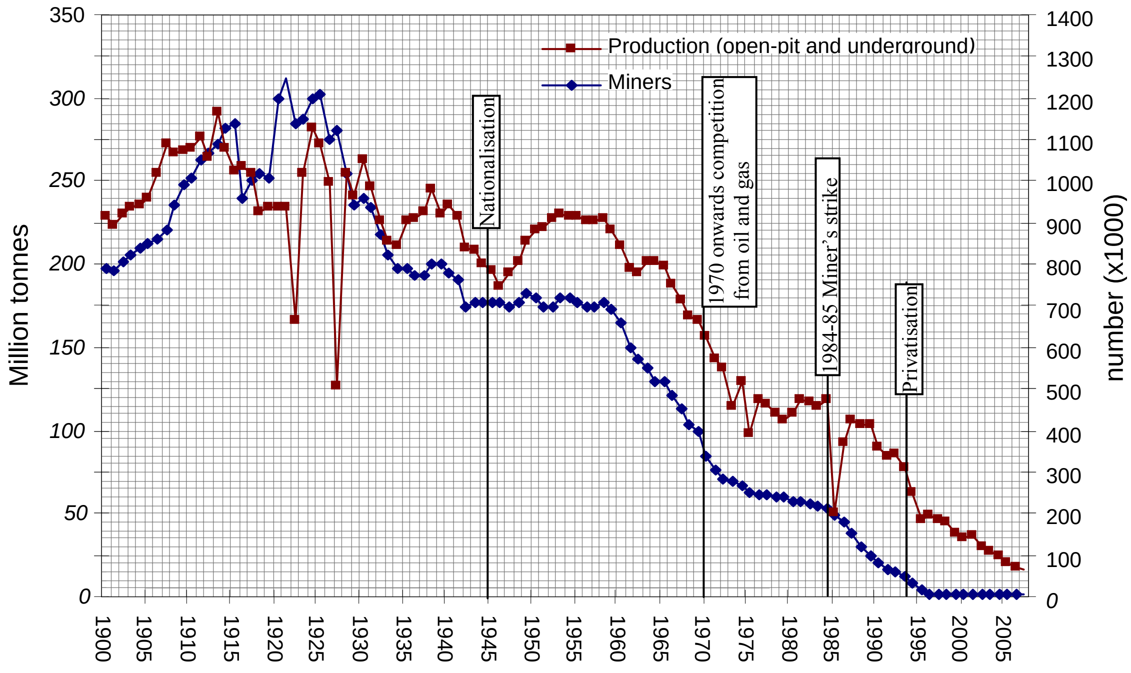

Fig. 1. Coal Production and Miners in the UK, 1900–2007 (Source: Singh et. al., 2008; BERR energy statistics: coal, 2008).

Sources of energy in the UK

Fig. 2 shows that the sources of energy used to generate electricity in 2007 in the UK were coal (34 %), oil and gas (44 %), nuclear (15 %) and renewable and others (5 %) [3]]. At present, more than 70 % of the UK's electricity supply comes from finite sources such as coal, oil and gas, with an additional 21.5 % being generated by the nuclear power sector.

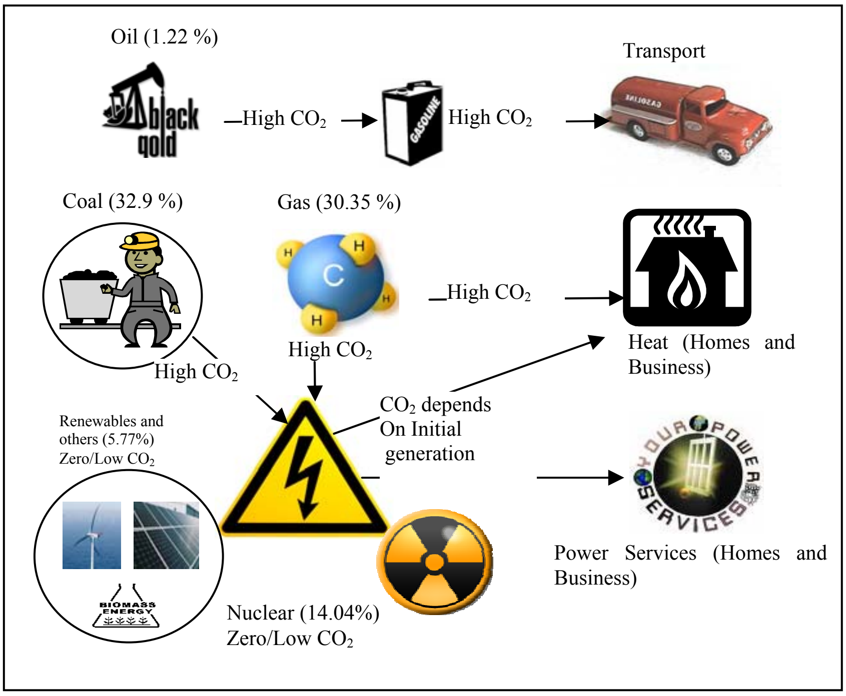

Fig. 2. UK energy systems.

Fig. 2 also indicates that use of oil in automobiles together with utilisation of oil, natural gas and coal for electricity generation, heating homes and business.

This also provides power services to homes and business that result in producing large amount of greenhouse gases. Nuclear power and energy from renewable sources are considered to have very little or no greenhouse effect. The UK government has set a target that by 2020, 20 % of the UK's electricity requirements should be met by renewable energy, utilizing energy from the sun, the wind, rivers and seas [14]]. The types of renewable energy sources currently utilized are as follows: active solar heating; onshore and offshore wind power; wave power; large and small scale hydro; biomass; landfill gas and sewage gas and geothermal aquifers.

Production of primary energy in the UK 1978–2007

Fig. 3 shows the contribution made by coal, petroleum, natural gas, nuclear power and hydro-electricity to the production of primary energy in the UK from 1978 to 2007 in Mt of oil or oil equivalent (OE) in logarithmic scale [2], [3], [6]]. In 1978, petroleum accounted for 32 % of total energy production, natural gas 20 %, coal 42 %, primary electricity (nuclear and natural flow hydro) 5.66 % and renewables <1 %. Total energy production increased between 1978 and 2007, from 180.2 Mt oil equivalents to 186 Mt oil equivalents primarily due to the growth in production of indigenous oil and gas [3], [14]]. The energy production in 1999 was at record levels of 297,7 Mt oil equivalents due to good performance of natural gas production at a level of 150.2 Mt oil equivalents, whilst in 2000 it was at record levels for production for natural gas at 108.4 Mt oil equivalents level. Fig. 3 also shows that during the period from 1978 to 2007 coal output reduced from 75,5 Mt oil equivalents to nearly 10,7 Mt oil equivalents in 2007 [2], [3]]. The role of hydro-electricity in the UK primary energy production is a minor one, contributing to 0,16 % in 1978 and 0,46 % in 2007. At present, renewables including solar power, wind, wave power and geothermal energy, solids renewables (wood and waste), landfill and sewer gas etc. account for 5,77 % of primary energy generated in the UK (Fig. 2). [It may be recalled that a standard tonne of oil equivalent equals to 396,83 therms (11630 KWh)].

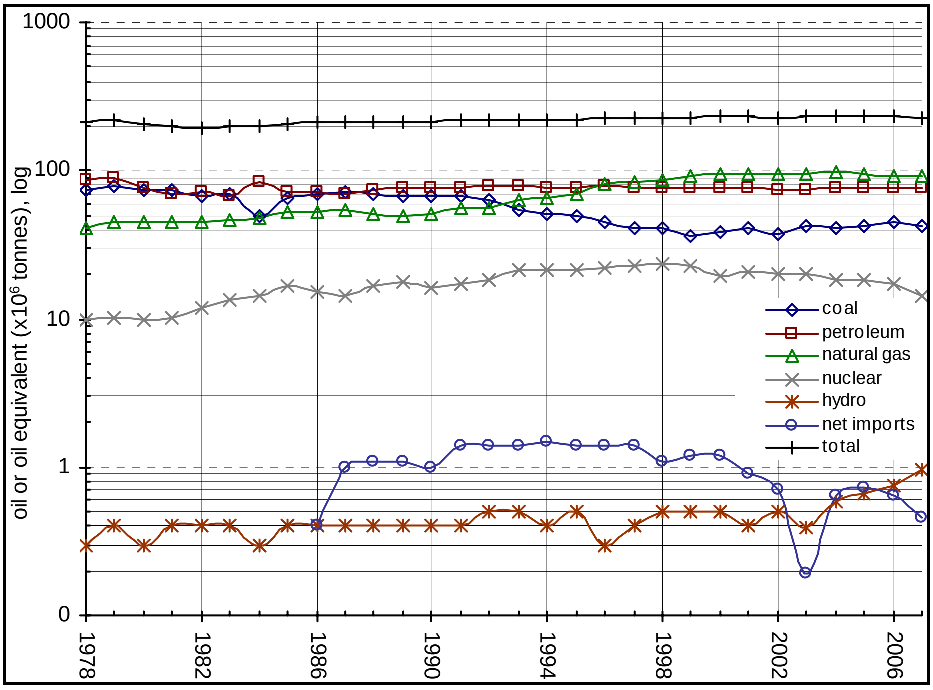

Fig. 3. UK production of primary energy, 1978–2007 (Data Source: DTI, 2007).

Consumption of Primary energy in the UK, 1978- 2007

Fig. 4 shows the consumption of primary energy in the UK including coal, petroleum, natural gas, nuclear electricity, hydro-electricity including net imports of electricity together with the total energy consumption.

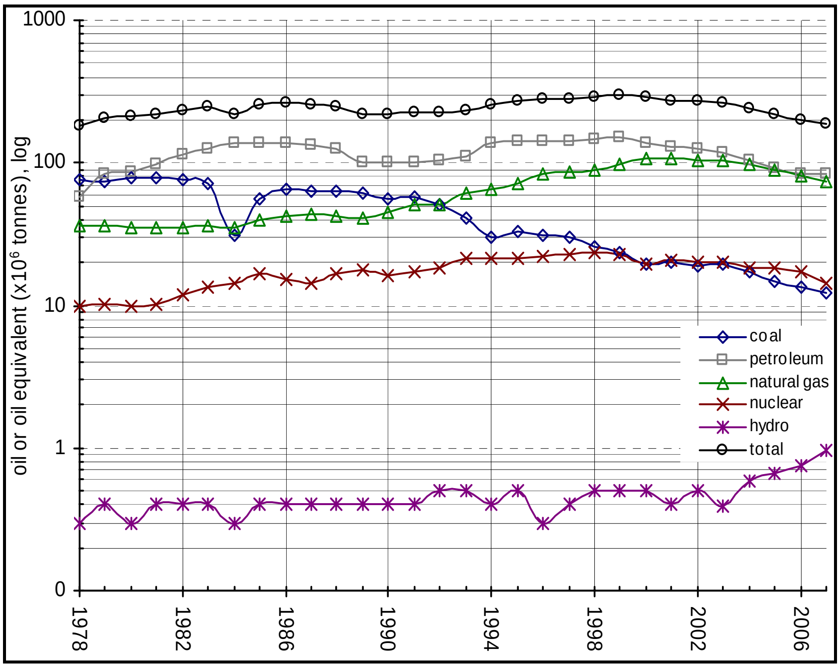

Fig. 4. UK Consumption of primary energy, 1978–2007 (Data Source: DTI, 2007).

It can be seen in Fig. 4 that the UK's total energy consumption between 1978 and 2007 remained steady, 211,8 Mt in 1978 reaching 226 Mt oil equivalent in 2007 with the peak consumption of 236.28 Mt oil equivalent in 2001. It may also be noted that the UK remained self sufficient in energy until 1985 and the contribution of hydro-electricity in energy consumption remains a minor one (below 1 Mt oil equivalents). It can also be seen in Fig. 4 that in 1978 coal consumption was 34.6 % of the total energy consumption in the UK which has reduced to 25 % in 1984-85 and 18 % in 2007 [3], [14]].

Supply and consumption of coal in the UK from 1978 to 2007

Fig. 5 shows the contribution made by indigenous coal production from underground mining, open cast mines, coal recovered from the tips etc., including stock changes, imports and exports to the energy consumption in the UK from 1980- 2007 [3]].

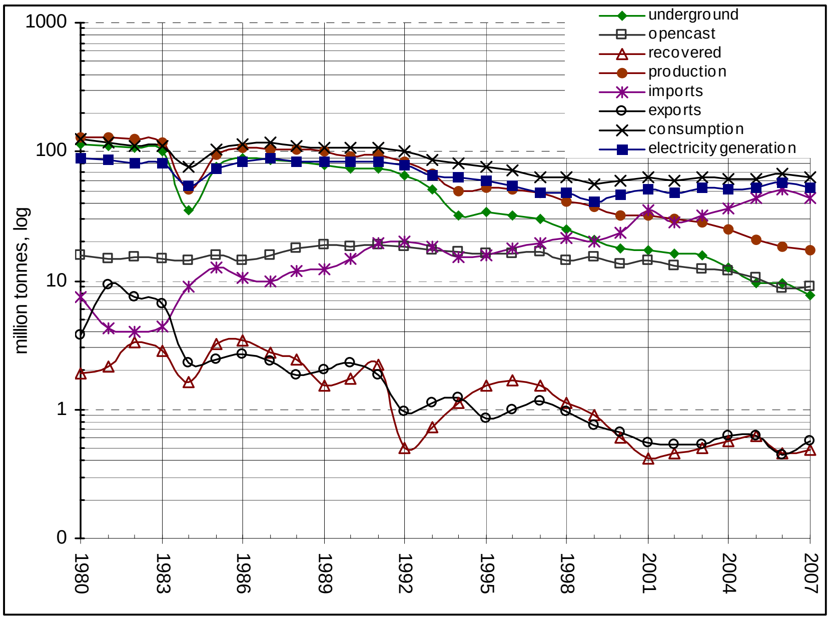

Fig. 5. UK coal supply and consumption, 1980 – 2007 (Data Source: BERR, 2008).

Coal production came from some 250 deep mines in 1980 producing 112 Mt which reduced to 9,56 Mt in 2005 from 6 deep mines. The output from the surface mining operations remains steady between 10 Mt/year to 18 Mt/year, depending upon the availability of the proven coal reserves. It may be noted that the amount of coal recovered from the tips etc vary between 0,4 Mt (2001) to 3,5 Mt (1986). Thus, the total production of coal in the UK has diminished from 130 Mt in 1980 to 20.6 Mt in 2005. Fig. 5 also shows the imports and exports of coal in the UK from 1980 to 2007. It is worthy to note that net imports of have increased from 3,5 Mt in 1980 to some 40 Mt oil equivalents in 2007. The consumption of electricity generation has reduced from 90 Mt oil equivalents in 1980 to 50 Mt oil equivalents in 2007.

Environmental impacts of mining

Coal is considered as the most polluting source of energy which creates environmental problems at various stages of its procurement from mining, transportation, stock piling, coal preparation and utilisation stages of operations. Coal produces a variety of pollutants during electricity generation and releases numerous toxic pollutants into the air, water and land [15]]. The environmental impacts of coal mining are complex and depend on the mining method and its location with respect to the place of utilisation.

Environmental impacts for coal mining range from mining subsidence, changes in ground water regimes and mining hydrology. Mining activities also give rise to the visual effects on the environment surrounding the mine including the release of methane into the atmosphere, the release of contaminated water and the generation of solid waste products. Fig. 6 schematically presents the environmental impacts caused by coal mining and coal utilisation processes [[9].

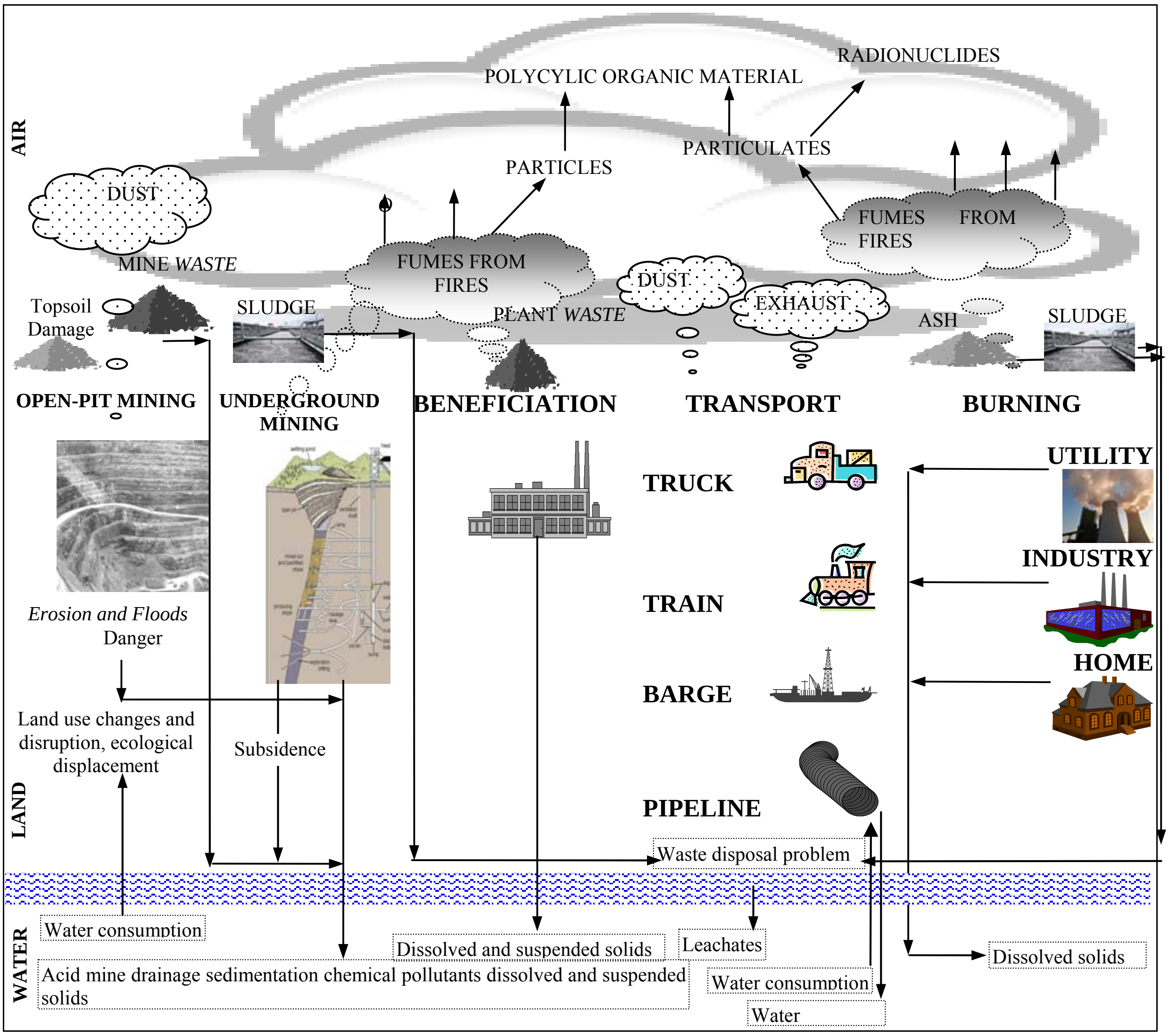

Fig. 6. Environmental impacts of coal mining, processing and coal utilisation (Data Source: Mamurekli, 1997 [[9]]).

Environmental problems in Surface mining

Surface coal mining operations require large areas of land to be temporarily disturbed creating a number of environmental challenges, including soil erosion, dust, noise, water pollution, and impacts on local biodiversity.

Acid mine drainage is composed of metal-rich water formed from the chemical reaction between water and exposed rocks containing sulphur-bearing minerals (FeS_2). Effective mine design can keep water away from the acid generating materials.

Dust levels can be controlled by spraying water on roads, stockpiles and conveyors and with dust collection systems. Noise can also be controlled through the careful selection of equipment and insulation and sound enclosures around machinery. Foliage planted in these buffer zones can reduce emitted noise levels while minimising the visual disturbance of mining operations on local neighbourhood. The emission of green house gases can be increased due to spontaneous combustion of stock piles. The water spraying is generally used to suppress dust emissions. The action of water and weathering causes water run-off and acidic leachates emissions which has a potentially high impact on the environment. As the acid pass through the coal, metals are dissolved producing a toxic flux that is usually high in aluminium, iron and sulphate [[1],[10]].

Environmental problems due to Underground mining

The land can deteriorate because of the presence of chemical wastes or physical hazards such as abandoned shafts, boreholes and tunnels. Mine wastes generated in huge quantities are mostly flammable and ready to spontaneous combustion. They may also contain heavy metals capable of leaching out into local rivers, streams and groundwater which may bio-accumulate along the aquatic food chain. Coal washing generates similar waste problems. Sulphuric acid is created when exposed coal gets wet and dissolves toxic metals which is very deadly to aquatic life and contaminates drinking water sources. Health and safety hazards include respiratory illnesses such as emphysema, black lung disease and chronic bronchitis; exposure to toxic fumes and gases; noise-induced hearing loss; heatstroke and exhaustion [[15]].

Coal-bedded Methane (CBM) contains C_2H_2, CO_2, N_2, H_3 and H_2, formed as part of the process of coal formation. The majority of gas is in the adsorbed state and attached to the coal surface in micro-pores. It is released in significant quantities from the coal seam and the surrounding disturbed strata during mining operations and continues to release throughout the life of the mine, and after the mine has been abandoned. CBM can be utilised rather than released to the atmosphere, providing variety of uses; including on-site/off-site electricity production, use in industrial processes and fuel for co-firing boilers.

Subsidence is another adverse effect of underground mining on the surface which can be predicted, by understanding of its patterns in a particular region, and ensuring the safe and maximum recovery of coal resource and providing protection to other land uses.

Environmental problems during Transport of coal

Trucks, rail, ports and barges which are used to transport coal, may all affect air and water quality, in addition to the environmental health impacts from blowing coal dust and air pollution coming from the vehicles themselves [15]]. The environmental impact of coal transportation is moderate and associated with energy consumption used for loading/unloading equipment, water usage for dust suppression and spillages occurring from rail cars, trestle conveyors and wharf transfer points. Noise from jack hammering and dust from unloading coal wagons can also cause environmental problems.

Degradation of eco-system

Coal mining causes extensive degradation to natural ecosystems such as forests and can scar the landscape irreparably. Damage to humans, animals and plants, occurs due to habitat destruction and environmental contamination disrupting ecosystems and endanger human health.

Steps are taken in modern mining operations such as good planning and environmental management minimise the impact of mining on the environment and help to protect biodiversity. Clean coal technologies have been developed and are widely used to limit particulate emissions, waste from coal production, trace elements, NO_x, SO_x and CO_2, limiting the negative effects of coal production and its use. Improvements in the efficiency of coal combustion for coal-fired power generation have already achieved significant reductions in CO_2 emissions [[13]].

Summary of the environmental problems due to coal mining and utilisation

The environmental effects due to coal mining and coal utilisation can be summarised as follows:

- Subsidence above mined area, sometimes damaging infrastructure;
- Dust, noise and vibration during blasting, loading and transportation processes.

- Destruction of groundwater regimes and rearranging the water tables;
- Impact of water use on flows of rivers and consequential impact on other land-uses;
- Mining operations rendering land unfit for other uses;
- Waste products in the power-plant ash containing radio-active minerals including uranium, thorium, and other heavy metals presenting health hazards;
- Release of major conventional air pollutants during coal combustion process (particulate matter, NOx, SO_2, Hg and other toxic substances, CO_2 and CH_4);
- Generation of acid rain;
- Coal-fired power plants without effective fly ash capture causing solid waste pollution problems.

Electricity generation

The production of green house gases (GHGs) is the major barrier in the use of coal in power generation worldwide. Most of the UK produced coal contains on average around 1,7-1,8 % sulphur. Scottish opencast coal reserves contain 0,9-1,2 % sulphur but some reserves are designated as very low sulphur coals (less than 0,2 % sulphur).

Coal will continue to make an important contribution to the medium term energy requirements of the UK. The use of indigenous coal is particularly important in reducing the dependence on imports. Recently, increasing demand of energy has led to strengthening world prices. A new regulatory regime has been necessary with a commitment to reduce emissions of GHGs by at least 20 % by 2020 and 50 % by 2050 [8]]. Renewable energy sources and combined heat and power (CHP) make considerable contribution to the reduction of carbon emissions. In 2006, 7 % of the total electricity generated in the UK came from CHP plants. The Government has a target of reaching at least 10,000 MWe of CHP electrical capacity by 2010, as part of its Climate Change Programme [5]].

Renewables provided 5 % of the electricity generated in the United Kingdom in 2007, 0,4 % higher than in 2006. Total electricity generation from renewables in 2007 amounted to 19,6 TWh, an increase of 8,5 % comparing to 2006. The main contributors to this increase were 917 GWh (+26 %) from onshore wind, 439 GWh from large scale hydro (+11 %), 253 GWh (+6 %) from landfill gas, 132 GWh (+20 %) from offshore wind, and 94 GWh (+9 %) from municipal solid waste combustion. There was a 572 GWh decrease in the co-firing of biomass with solid fuels (-23 %) [8]].

The renewable energy is expected to play an important role in improving the environmental performance of future energy production. Although, renewable energy is mostly inconsistent and site-dependent the UK Government has a target of 10 % of overall electricity production should be delivered from renewable sources by 2010.

Utilisation of coal for power generation

There has been a significant change in the perception of the future for coal-fired power generation in the UK. Coal is expected to be used in increasing quantities for power generation contradictory to thought of being dispensed with and replaced by gas-fired power generation and renewables [16]]. In parallel, the need to reduce emissions of CO_2 has become increasingly urgent because of their impact on climate change. Utilities are continuing a slow move toward cleaner coal-burning facilities and CO_2 capture and storage (CCS), while closing those that are unable to meet environmental regulations. However, burning coal emits about 9,000 Mt of CO_2 directly to the atmosphere, annually, about 70 % of this being from power generation [16]]. About 75 % by capacity of UK coal-fired power stations have opted in to the Large Combustion Plant Directive and, with flue gas desulphurisation systems fitted, will remain open to 2015 and beyond, thus contributing to security of supplies (Tab. 1) [6]].

Tab. 1. Current UK coal that have opted out or opted in under the large combustion plant directive (Farley, 2007).

Power station	Company	MWe	Power station	Company	MWe
Ironbridge	E.ON	972	Kilroot	AES	520
Kingsnorth	E.ON	2000	Eggborough	British Energy	2000
Didcot	RWE npower	1920	Uskmouth	Carron Energy	393
Tilbury	RWE npower	1050	Drax	Drax Power Limited	3960
Cockenzie	Scottish Power	1200	Cottam	EDF Energy	1948
Ferrybridge (2units)	SSE	1000	West Burton	EDF Energy	1924
Total opt out		**8142**	Ratcliffe	E.ON	2000
			Rugeley	International Power	996
Opt out: Each chimney allowed to operate only 20,000 hours in total from 2008 and must close by end 2015.			Aberthaw	RWE npower	1386
			Longannet	Scottish Power	2400
			Ferrybridge (2 units)	SSE	1000
			Fiddlers Ferry	SSE	2000
			Total opt in		**20 527**
			Opt in: must fit additional NO reduction by 2016.		

Large combustion installations account for over 95 % of steam coal utilisation in the UK with maximum use of indigenously mined coal. Coal powered combustion plants account for about 90 % of power stations in the UK. This type of power system has considerable scope to switch between coal and gas both in the shorts term through shifting loading of stations, and in the long term through converting plant and building new gas-fired power generating capacity. Technologies for the utilisation of ash residues produced from the combustion of coal, and the co-combustion of coal with supplementary fuels such as biomass and waste in conventional pulverised coal-fired power generation plant and advanced plant such as fluidised bed combustion and gasification plant [12]].

Furthermore, coal is one of the main sources to provide H_2, via coal gasification. The technological advances together with CCS have launched new prospects for environmentally acceptable, large-volume production of hydrogen. The UK Government recognises that the use of H_2 in stationary power applications and may improve the feasibility of renewable energy projects to produce electricity for remote/off grid island communities (the Western Isles, the Northern Isles and parts of the Highlands) where there are substantial renewable energy resources but the export of electricity to the grid is constrained.

Fig. 7 shows a schematic presentation of a coal fired power plant indicating the following unit processes:

1. Coal from the mine is delivered to the coal hopper, where it is crushed to five centimetres in size.
2. The coal is then pulverized to a fine powder, mixed with air and blown into the boiler for combustion.
3. The pulverized coal/air mixture catches fire instantly in the boiler.
4. Burning coal produces CO_2, SO_2 and NO_x which are vented from the boiler.
5. Water in the boiler tubes picks up heat from the boiler and turns into steam. The high-pressure steam from the boiler passes into the turbine which conducts rotating energy to a generator so creates an electric current.
6. Cooling water is drawn into the plant and circulated through condensers, which cools the steam discharged from the turbine. Steam from the turbine also passes through the condensers in separate pipes from cooling water. The cold water is warmed by the steam, which condenses back into pure water and feeds back to the boiler to begin the process of generating electricity again.
7. To reduce corrosion, water must be purified for use in the boiler tubes. Other waste water systems within the plant collect water used to clean pipes and other equipment, and sludge from the water purification process and other processes. Waste water is pumped out of the plant into the holding ponds.
8. Ash that builds up on the precipitator's plates is vibrated off and collected in large hoppers or bins. Fly ash and bottom ash are removed from the plants and hauled to dumping sites.
9. Voltage of electricity is increased by the use of transformers so it can easily be transmitted across the lines.

Green house affects

Over the past century, global temperatures have risen 0,7 °C on average and all the evidence points to the primary cause being an increase in GHGs (green house gases) in the atmosphere due to human activities, with CO_2 having the major impact [13]]. The major GHGs include water vapour, O_3, CO_2, CH_4, nitrous oxide (N_2O), hydro-fluoro-carbons (HFCs), per-fluoro-carbons (PFCs) and sulphur hexa-fluoride (SF_6). Coal is one of many sources of GHG emissions. GHGs associated with coal include CH_4, CO_2 and N_2O. CH_4 is mostly released from deep coal mining. CH_4 is a potent GHG and supplied 50 % of the overall global warming effect while around 18 % arise from CO_2. CH_4 emitted from abandoned coal mines in the UK each year equivalent to about 1,4 Mt of CO_2, expected to continue at significant levels beyond 2050 [5]]. CO_2 and N_2O are discharged when coal is used in electricity generation or industrial processes. As coal continues to face environmental challenges, highly effective technologies have been developed to deal with the release of airborne pollutants, such as SO_x and NO_x and particulate and trace elements, such as mercury.

UK emissions are only about 2 % of total global emissions. The energy supply sector currently accounts for around 35 % of emissions; transport of 24 %; industry 22 %; services 4 % and the residential sector 15 % [13]] respectively. In 2005, UK CO_2 emissions came to 554 Mt [5]]. In 2006, total UK CO_2 emissions were almost 555 Mt of which 149 Mt of those emissions were from domestic needs and transport emissions accounted for a further 87 Mt of CO_2 emissions (Fig. 8) [4]]. Addressing climate change become an important environmental issue and has also been escalated up the EU's internal agenda. The EU's Kyoto commitments estimate that as a result of current and planned actions by the EU and its member states, the EU are on track to reduce greenhouse gas emissions by 9,3 % by 2012, 15-30 % by 2020 and 60-80 % by 2050. The EU's obligations under the Kyoto Protocol, under which the UK's contribution is to reduce greenhouse gas emissions by 12,5 % below base year levels by 2008-12 [5]]. The Kyoto Protocol came into force in February 2005 which covers emissions of CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 sets targets for industrialised countries to reduce their overall emissions by at least 5 % below of existing 1990 levels, in the commitment period 2008-2012 [5]]. The current estimate of reduction for the UK's emissions is 23 % by 2010 to comply with the government's Climate Change policies [5]].

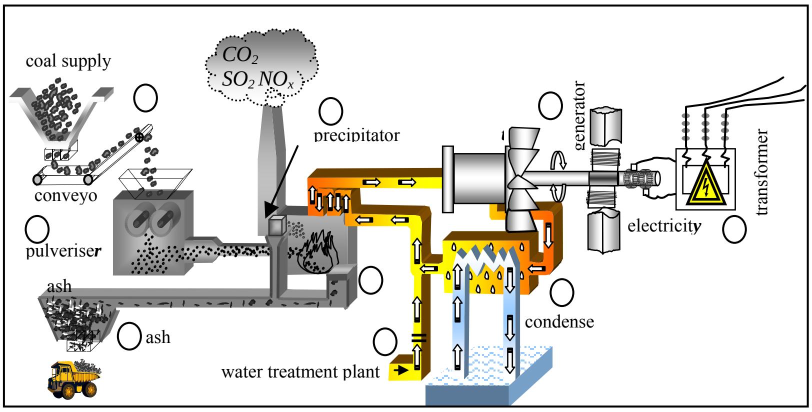

Fig. 7. Schematic representation of a coal-fired power plant.

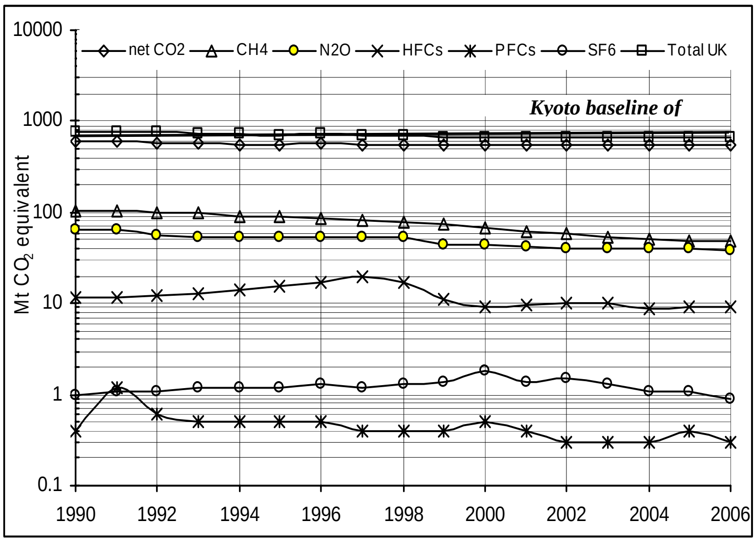

Fig. 8. UK greenhouse gas emissions 1990-2006 (Data source:DEFRA, 2008) policies [[5]].

Clean coal technologies

Various technologies are undergoing development in order to provide an environmentally satisfactory method of using coal as a basic fuel for clean coal-based power generation in new plants. The clean coal technologies suitable for large-scale power generation fall into two groups:

1. Advanced super critical (ASC): Coal is pulverised and burned in a boiler to generate steam that drives a turbo-generator. Flue gases are cleaned by electrostatic precipitators, flue gas desulphurisation (FGD) and selective catalytic reduction (SCR). By increasing the steam conditions to advanced supercritical (300 bar, 600 °C) the overall plant efficiency is increased from the 35 %, average for the UK power plants, to 46 % increasing the target for future development 50 % [6]].
2. IGCC: Coal is not combusted directly but reacts with oxygen and steam to form a "syngas" (primarily hydrogen and carbon monoxide). After being cleaned, it is burned in a gas turbine to generate electricity and to produce steam to power a steam turbine. Coal gasification plants are seen as a primary component of a zero-emissions system. The average efficiency of currently proposed IGCCs is around 42% and the long-term target is 50 % [6].

Both approaches offer advantages like as a higher efficiency and produce lower emissions than current coal plants (both meet Large Combustion Plants Directive (LCPD), rules for emissions post-2016); are suitable for the UK or imported coal (high or low sulphur content); and are suitable for CO_2 capture [6]].

Burning coal produces a range of pollutants that harm the environment: SO_2 (acid rain); NO_x (ground-level ozone), CO_2 and particulates (affects human health). Increasingly, coal-fired power plant is fitted with technologies for reducing the emissions of a number of primary pollutants:

1. FGD systems are used to remove SO_2. A mixture of Ca, Na and NH_4 based sorbent and water is sprayed over the flue gas, called wet scrubbers technology, which reacts with the SO_2 to form gypsum (a calcium sulphate) used in the construction industry. New developments in sorbent injection technologies are in progress and this type of FGD is expected to become more widely used in older coal-fired plants.
2. Reduction methods include the use of low NO_x burners which restrict the amount of oxygen available in the hottest part of the combustion chamber where the coal is burned. This procedure minimises the formation of the gas and requires less post-combustion treatment.
3. CCS technology involves capturing and liquefying CO_2 gases and storing it deep underground (≥ 2 km) which is in the development stage but is popular with the British government. The three main CO_2 capture technologies are as follows[[6]];
   a. Post-combustion solvent absorption (for supercritical and gasification)
   b. Oxyfuel firing (for supercritical only)
   c. Pre-combustion capture (for gasification only)

4. Electrostatic precipitators can remove almost all of particulates from the flue gas. The system works by creating an electrical field to create a charge on particles which are then attracted by collection plates. Other removal methods include fabric filters and wet particulate scrubbers.

Legislative Program for adopting Remedial Measures

The EU has a strong record of legislating for environmental protection. The mining and utilisation of coal in the EU complies with legislation that reinforces the commitment of the EU to sustainable development. The UK remains one of the few European countries on track to meet its Kyoto commitment to address climate change.To meet energy strategic concerns and environmental objectives, a number of measures may be taken that will allow coal to fulfil its vital role for the future of energy supply. The Government has set four goals for the UK's energy policy [13]]:

1. To reduce the UK's CO_2 emissions by some 60 % by about 2050, with real progress by 2020;
2. To maintain the reliability of energy supplies;
3. To promote competitive markets in the UK and beyond, helping to raise the rate of sustainable economic growth and to improve our productivity; and
4. To ensure that every home is adequately and affordably heated.

Many coal-fired generating stations in the UK have now signed up to the tough new limits on emissions required under the LCPD. The fact that they are prepared to make or have already made, in some cases-significant investment in FGD (Flue Gas Desulphurisation) technology shows a real commitment to ensuring a long term future for coal-fired generation in the UK. Also, a number of coal-fired generating companies have shown interest in retrofitting improved combustion technologies to their existing plant, or in building new coal-fired power stations, equipped from the outset with state-of-the-art, high efficiency generating sets and designed to accept the next generation of cleaner coal technology as it comes to the market.

Conclusions

Energy is an essential requirement for a successful economy and the economic well being of its population. Although, considerably more remains to be done in the UK to secure effective multilateral action for the longer term, the two long-term energy challenges in the agenda are as follows:

1. tackling climate change by reducing CO_2 emissions both within the UK and abroad,
2. ensuring secure, clean and affordable energy supply including reduction in imported fuel increasing trade deficits.

Coal will continue to make an important contribution to the medium term energy requirements of the UK as a part of a diverse energy mix, assuring security of supply, reducing the dependence on imports and mitigating the adverse impact on the balance of payments.

Cleaner electricity generation is an essential factor if coal is to have an important role in the world's sustainable energy development. A combination of clean-coal technologies at input, processing and output stages of the power generation processes together with the enforcement of emission control regulations, and private sector capital have the potential to mitigate the environmental impact of coal utilisation.

The most significant reductions in environmental impacts from coal usage will be the adoption of higher efficiency combustion technologies in power generation, such as ASC and IGCC. However, due to the large capital investment required, major reductions on impacts will only be achieved in the long term. More modest improvements can be achieved by improving the efficiency of existing processes across the coal value chain.

Renewable sources, other than hydro-electricity notably wind and solar energy, are consider to be disseminate, intermittent, and unreliable by very nature of their occurrence. Similarly, bad weather and night-time underline its short-term unreliability. These two aspects present a technological challenge of some magnitude for their successful adaptation in the short term. In the longer term, coal together with renewable energy resources are expected to lead to a low CO_2 emission future whereas use of more new nuclear power stations is still a controversial issue regarding safety and decommissioning.

Acknowledgements: *The author wishes to record his deep felt gratitude to his wife Dr. M. Mamurekli for her assistance in preparation of this paper. Thanks are also due to Dr A. S. Atkins, Faculty of Computing, Engineering and Technology, Staffordshire University for his valuable contribution to improve the quality of this paper.*

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