I. J. Engineering and Manufacturing, **2020, 4, 43-53**
Published Online August 2020 in MECS (http://www.mecs-press.net)
DOI: 10.5815/ijem.2020.04.04

Technical Improvement of Air Pollution Through Fossil Power Plant Waste Management

Sarmad Dashti Latif
Department of Civil Engineering, College of Engineering, Universiti Tenaga Nasional (UNITEN), Selangor 43000, Malaysia

Received: 06 May 2020; Accepted: 23 July 2020; Published: 08 August 2020

Abstract: Fly ash was generally released into the atmosphere in the past, but standards for air pollution control now require that it be captured before release by fitting pollution control equipment. During this process, there are many wastes for example ash and fly ash which is a waste. It is invisible, it has a nasty, and sharp smell. It affects human health when it is breathed in. It irritates the airways to cause coughing and shortness of breath. About 99% of the ash and fly ash in the air comes from human sources. The objective of this study is to reduce wastes and manage it. This project shows two different ways of waste management for two different locations which are Lukut, Malaysia, and Hanau, Germany. Both systems have advantages and disadvantages. The ash pond offers cheap costs and an easy process but exposes the fly ash and its sometimes-hazardous components to the environment. The electrostatic filter acquires more knowledge and is higher in Installation costs, but keeps fly ashes safe in a closed process the electrostatic filter seems to be more environmentally friendly and sustainable. The finding shows that this treatment was successful in reducing the wastes and managing it.

Index Terms: Fly Ash; Fossil Power Plant; Waste Management

1. Introduction

The idea of sustainable development is an assertion that economic and social growth is continuous in accordance with the natural environment. It is a search of such an economic model that would bring prosperity to mankind without damaging natural structures that sustain it. It includes utilizing, yet respecting, the natural capital. Sustainable development is not against progress, but rather a call for balance and moderation to reconcile key areas of humanity: ecology, economy and society [1,2,3,4].

Fly ash, also known as 'pulverized fuel ash,' is a coal combustion substance consisting of particulates (fine particulate matter of burning fuel) powered from coal-fired boilers along with flue gases. Ash falling to the bottom of the boiler is known as bottom ash. In modern coal-fired power plants, fly ash is usually collected by electrostatic precipitators or another particulate filter. This is known as coal ash along with bottom ash collected from the bottom of the boiler. The components of fly ash differ considerably depending on the source and composition of the coal being burned, but all fly ash contains significant quantities of silicon dioxide (SiO_2) (both amorphous and crystalline), aluminium oxide (Al_2O_3) and calcium oxide (CaO), the major mineral compounds in coal-bearing rock strata. The minor constituents of fly ash depend on the particular composition of the coal bed but may include one or more of the following elements or compounds contained in trace concentrations (up to hundreds ppm): arsenic, beryllium, boron, cadmium, chromium, hexavalent chromium, cobalt, lead, manganese, mercury, molybdenum, selenium, strontium, thallium, and vanadium, along with very small concentrations of dioxins. It even has the carbon unburnt [5].

Fly ash was commonly released into the atmosphere in the past, but air quality control regulations now demand that it be collected by suitable pollution control equipment prior to release. Fly ash is generally stored at coal power plants in the United States, or placed in landfills. Approximately 43 percent is recycled, mostly used in concrete production as a pozzolan to manufacture hydraulic cement or hydraulic plaster and as a substitute or partial replacement for Portland cement. Pozzolans maintain concrete and plaster environment, and provide more concrete protection against wet conditions and chemical attacks [6].

In cases where fly (or bottom) ash is not generated from coal, for example when solid waste is incinerated for electricity production in a waste-to-energy plant, the ash may contain higher levels of pollutants than coal ash. The ash produced there is also known as hazardous waste. COAL-based thermal power plants have been a major source of power generation in India, where 75 percent of the total power produced comes from thermal power plants based on coal. India's coal reserve is about 200 billion tons (bt) and its annual output reaches approximately 250 million tons (mt). Approximately 70 percent is used in the electricity sector. In India, unlike most developed countries, the carbon content used for generating electricity is 30–40%. High ash coal means more plant and equipment wear and tear, poor boiler thermal output, slogging, shaking and scaling of the furnace and most critical of it all, producing a significant volume of fly ash. In that order, India ranks fourth in the world in coal ash production as a by-product after the USSR, the USA and China. In Cement and Concrete Terminology (ACI Committee 116), fly ash is classified as 'the finely divided residue resulting from the combustion of ground or powdered coal, transported by flue gases from the fire box through the boiler.' Fly ash is fine glass powder, the particles usually of which are spherical in form and range from 0.5 to 100 μm [7].

During this process there are many wastes for example ash and fly ash which is a waste. It is invisible and has a nasty, sharp smell. It affects human health when it is breathed in. It irritates the airways to cause coughing and shortness of breath. About 99% of the ash and fly ash in air comes from human sources. Therefore, the main objective of this study is to reduce the wastes and manage it. The main source of ash and fly ash in the waste is industrial activity, such as the generation of electricity from coal. So, solution needs to be shown to reduce waste and manage it. This project shows two different ways of two different locations which are Lukut Malaysia, and Hanau Germany.

2. Literature Review

2.1 Background

For heat and power generation, fly ash is mostly generated through lignite combustion in dry-bottom boilers. In the European countries, particularly in Germany, lignite plays an important role in energy mix. In 2002 approximately 490 million tons of lignite (including a small amount of sub-bituminous coal) were mined and used for power generation in Europe [8]. An estimated 71 million tons of Ashes are produced during combustion. The bulk of the ashes are used to replenish and recover exhausted opencast lignite mines. In addition, the ashes are used as a filler in asphalt, in underground mining, for surface re-cultivation, soil gain, nutrition, cement production and as a concrete addition. The potential for coal combustion products (CCPs) to be used depends on their chemical, mineralogical, and physical properties. These properties are determined by the coal source, the form of coal feeding and the method of combustion. Consistent product quality is paramount when using ashes in hydraulic binders, cement and concrete.

2.2 Production of Coal Combustion Products (CCPs) in Europe

Since the European Union (EU) grew to 25 Member States in 2004, and again to 27 Member States in 2007, the total production of CCPs in the EU is estimated to be around 100 million tons (EU 27). ECOBA members send annual data on the development and usage of CCPs. Data about coal combustion products (CCPs) production and consumption in Europe are published annually. Unfortunately, data from all the 12 new EU Member States are not yet available to the European Coal Combustion Products Association (ECOBA), so it is not possible to provide more accurate details about EU 27 output for now. The statistics provided in this study therefore cover the situation in 15 EU member states.

The European Coal Combustion Products Association (ECOBA) statistics on the production and use of coal combustion products (CCPs) [5] represent the typical combustion products generated at coal-fired power stations during the combustion of hard coal and lignite. Coal combustion products (CCPs) are fly ash, bottom ash, boiler slag and fluidized bed combustion (FBC) ash, as well as dry or wet flue gas desulphurization products, in particular spray dry absorption (SDA) and flue gas desulphurization (FGD) gypsum products.

Fig.1 shows the growth of CCP production in the 15 EU member states between 1997 and 2017. The overall amount fell from 48 million tons in 1997 to 45 million tons in 1999, and increased again to 52 million tons in 2005 due to higher energy and heat output from coal combustion. In 2006, there were a total of 50 million tons of CCPs generated at European (EU 15) power plants, around 2 million tons less in the EU 15 member states compared with 2005. The decline was caused in some countries by lower coal combustion output due to higher hydro power output or the implementation of de-NOx and de-SOx controls. All combustion residues are up to 80 percent in 2006 and the FGD residues by weight up to 19 percent. In 2017, the overall amount fell from 28 million tons which completely reduced compared to previous years.

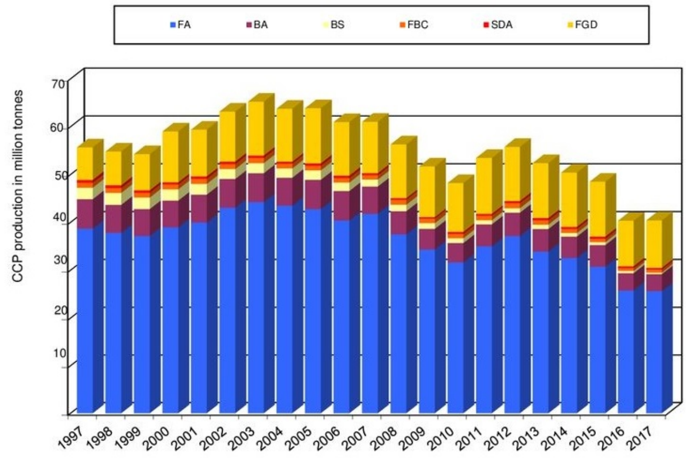

Fig. 1. Development of the CCP production in Europe (EU 15) from 1993 to 2017 [9]

Fig. 2 shows the growth of fly ash production forming hard coal and lignite combustion in dry-bottom boilers. While a smaller output of mostly hard coal fly ash is reported for the EU 15 member states in 2010, it must be noted that this figure does not reflect the situation in the single EU member states. For some countries the production was at or even higher than in the previous year.

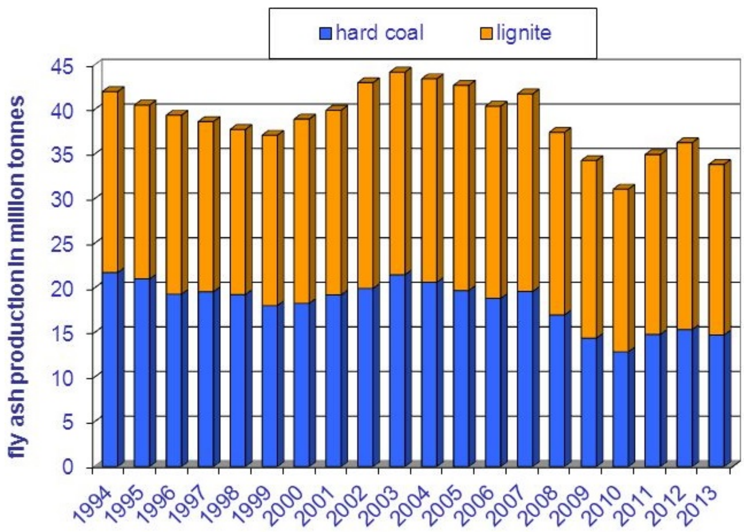

Fig. 2. Development of the production of fly ash from hard coal and lignite in EU 15 from 1994 to 2013 [10]

In the European countries, especially in central and eastern Europe, lignite plays an important role in the energy mix. Approximately 490 million tons of lignite (including a small amount of sub-bituminous coal) were mined and used in European power generation in 2002 (Fig. 3). An estimated 71 million tons of Ashes were created during combustion.

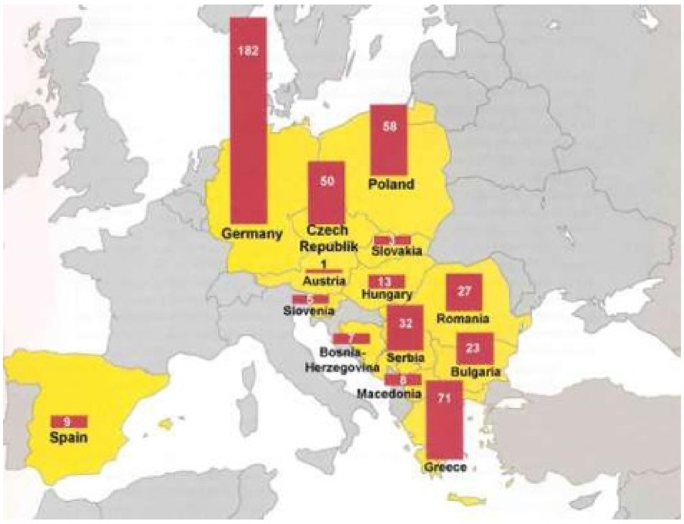

Fig. 3. Mining of lignite in Europe (Source EURACOAL [8])

2.3 *Classification of Fly Ash*

Particulate fly ash is generally spherical in shape and size range from 0.5 μm to 100 μm. Most of them consist of silicon dioxide (SiO2), present in two forms: amorphous, rounded and smooth, and crystalline, sharp, pointed and hazardous; aluminum oxide (Al2O3) and iron oxide (Fe2O3). In general, fly ashes are extremely heterogeneous, consisting of a mixture of glassy particles with different recognizable crystalline phases such as quartz, mullite, and various iron oxides. ASTM C618 describes two types of fly ash: Class F fly ash and Class C fly ash. The key difference between those groups is the amount of ash content in calcium, silica, alumina, and iron. Fly ash's chemical properties are primarily determined by the chemical composition of the burned coal (i.e. anthracite, bituminous, and lignite) [11].

2.3.1 *Class C Fly Ash*

In addition to having pozzolanic properties, the fly ash formed from the burning of younger lignite or sub-bituminous coal also has some self-cementing properties. Class C fly ash in the presence of water can harden and build power over time. Class C fly ash typically contains lime (CaO) of over 20 per cent. Unlike Class F, Class C self-cementing fly ash needs no activator. The amount of alkali and sulfate (SO4) is usually higher in fly ashes of class C [12].

2.3.2 *Class F Fly Ash*

Class F fly ash is usually created by the burning of tougher, older anthracite, and bituminous coal. This fly ash is naturally pozzolanic and contains less than 10 per cent lime (CaO). The glassy silica and alumina of Class F fly ash possessing pozzolanic properties requires a cementing agent, such as Portland cement, quicklime or hydrated lime, with the presence of water to react and create cementing compounds. Alternatively, adding a chemical activator such as sodium silicate (water glass) to a Class F ash will lead to geopolymer formation [12].

2.4 *CCPs from lignite in Germany*

2.4.1 *Production process*

Fly ash and bottom ash, and mineral products from flue gas desulphurization are obtained from the lignite combustion cycle in power plants (Fig. 4). Both such minerals can be used, and are thus called products for combustion (CCPs). Pulverized fuel is used in most Lignite power plants. Throughout coal mines, lignite is ground to fine particles, and is fed to particles burners pneumatically. The pulverised lignite is combusted in the power plant furnace. The heat generated in the water-steam-circuit heats the water; the turbine is powered by the steam which develops. A small part of the mineral matter from the lignite falls to the bottom of the furnace, where it is collected in a water bath as the bottom ash.

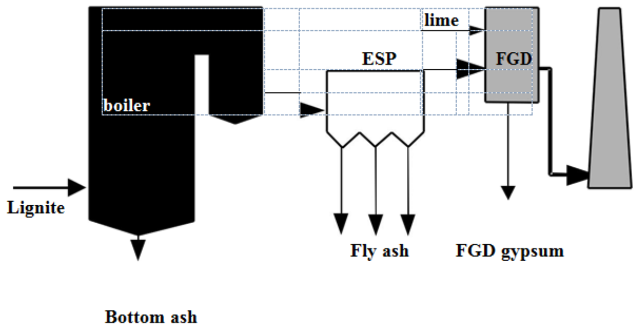

Fig. 4. Combustion process and CCPs in a lignite fired power plant

Much of the ash of around 80 per cent of the mineral matter is transferred to the electrostatic precipitator along with the flue gases. The fine-grained fly ash is isolated from the flue gas, e.g. at a ratio of 80:15:5 per cent by mass in a three-stage precipitator. The fractions are normally taken out together. The ratio of the low ash to the amount of fly ash generated in lignite power plants is approximately 1 to 4.

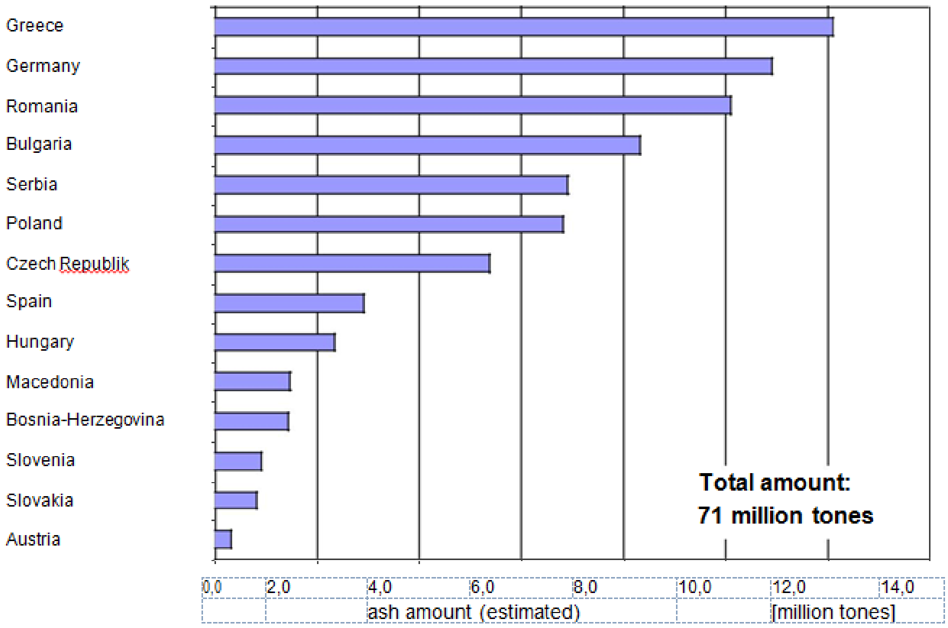

Fig. 5. Estimated amount of ash obtained from combustion of lignite in European countries (calculation based on data published by EURACOAL [8]).

In most of the European countries, after dust separation in the electrostatic precipitator (ESP) the flue gas is desulphurized in the flue gas desulphurization (FGD) installation, where FGD gypsum or other minerals are produced. The clean gas, free from dust and sulphur is carried off via the chimney or the cooling tower.

Based on data on lignite production and ash content published by EURACOAL [13] the amount of ash from lignite produced in Europe was estimated. If a range was given by EUREACOAL for the ash content, the mean value for the ash content was chosen for the calculation of the respective ash amount. Based on this calculation an estimated amount of 71 million tonnes of ashes were produced in Europe (Fig. 5).

2.4.2 Properties of fly ash from lignite in Germany

The conditions in pulverised fuel-fired power plants for the power generation from lignite result in two different types of ashes, which differ in their particle size distribution and fineness as well as in their chemical composition. One of these two types is the coarser bottom ash, which is discharged via a water bath at the bottom of the furnace whereas the other one is the fly ash discharged with the flue gases and separated in the ESP. It might be reasonable to use both ashes together for certain purposes but the separated use of fly ash is advantageous for more demanding applications, where the chemical reactivity of the ashes is used because the reactivity increases with the fineness. The chemical and mineralogical composition of the ashes is determined by the chemical composition of the lignite and the mineral phases resulting from the temperature in the firing. Mineralogically, lignite fly ash consists of about 30 to 70 % of amorphous (glassy) components. The remains are crystalline (mainly quartz). Amorphous SiO_2, Al_2O_3 and Fe_2O_3 are able to react chemically with the reactive lime in the ash at room temperature if water is added. Thus, they develop calcium silicate hydrates and calcium aluminate hydrates like cement, whose structure leads to hardening and strength of the mixture. Therefore, calcareous lignite fly ashes usually have pozzolanic hydraulic properties. However, these properties can only be used technically if the material is sufficiently consistent.

Special attention has to be dedicated to the content of free lime and sulphate. In contact with water they react and produce voluminous reaction products. Depending on the content of the reactive components long-term reactions can occur, which destroy already existing hardened structures. Moreover, the leaching of sulphates can influence the environment in certain applications. The chemical and mineralogical composition as well as the fineness is decisive for the reactivity of lignite ash. To use these properties, a certain consistency in the grain size distribution and in the chemical composition of the fly ash is required. The economic advantage of lignite fly ash compared to other mineral binders is that lignite fly ash as a fine reactive mineral does not need to be ground.

In table 1, the ranges of chemical composition of fly ashes from Germany, Greece, Poland and Spain are given. The ranges in single parameters are influenced by the composition of the lignite, with or without co-combustion, the kind of coal feeding to the burner and the burning technique. Updated figures will be given in a report of the ECOBA Working Group Calcareous Ash (under preparation).

Table 1. Ranges in chemical composition of lignite fly ash in selected European countries

Parameter	**Germany**	**Greece**	**Poland**	**Spain**
	/3/	/4, 5/	/6/	/7/
			[% by mass]	
SiO_2	20–80	21 – 35	20 – 88	49.8 / 53.3
Al_2O_3	1 – 19	10 – 14	0.6 – 9	17.3 / 18.2
Fe_2O_3	1 – 22	4.5 – 6.5	1.5 – 7	8.7 / 7.9
CaO	2 – 52	30 – 45	3 – 49	24.9 / 20.8
CaOfree	0.1 – 25	≈ 10		11.4/ 8.6
MgO	0.5 – 11	1.5 – 3	0.5 – 7	1.9 / 1.7
K_2O	0. – 2	0.4 – 0.9		0.3 / 0.3
Na_2O	0.01 – 2	0.5 – 1		1.7 / 1.6
SO_3	1 – 15	4 – 8	0.4 – 12.5	4.3 / 4.7
TiO_2	0,1– 1			
LOI	Max 5	3 – 7	1.6 – 2.2	2.3 / 1.8

Investigations in Germany [14] showed that the composition of fly ashes from the three main mining areas (Rhenish, Central German and Lusatian area) show characteristic differences. Whereas fly ash of the Rhenish and the Central German area contain high amounts of lime and sulphur those from Lusatian area show comparatively lower amounts. The chemical composition of lignite fly ash in the selected European countries can be used to improve the Malaysian fly ash waste management by evaluating and comparing it with the six-coal fired electric power plants in Malaysia.

Table 2. Ranges in chemical composition of lignite fly ash from German power plants in different mining areas [13]

	Mining area		
Parameter	**Rhenish area**	**Central German area**	**Lusatian area**
		[% by mass	
SiO_2	20 – 80	18 – 36	32 – 68
Al_2O_3	1 – 15	7 – 19	5 – 14
Fe_2O_3	1,5 – 20	1 – 6	6 – 22
CaO	2 – 45	30 – 52	8 – 23
CaOfree	2 – 25	9 – 25	0,1 – 4
MgO	0,5 – 11	2 – 6	2 – 8
K_2O	0,1 – 1,5	0,1 – 0,5	0,5 - 2
Na_2O	0,1 – 2	0,01 – 0,2	0,01 - 0,2
SO_3	1,5 – 15	7 – 15	1 – 6
TiO_2	0,1 – 1	0,5 – 1,3	0,2 – 1
Cl	< 0,2	< 0,1	< 0,02
C	< 2	< 1	< 2
LOI	max 5	max 5	max 5

The ranges in composition of lignite fly ashes from German power plants in different mining areas are given in table 2. This is due to the size of the mining area, the coal quality in the different parts of the mine as well as to the mining technology in respect to production of coal mixes from different seems. It has also to be considered that the ranges of fly ash from single power stations are even smaller.

2.5 Fly Ash in Malaysia

There are currently six coal fired electric power plants in Malaysia. Usually these power stations can generate a high volume of more than 2400 MW of electricity. There are four coal-fired electric power stations in peninsular Malaysia which produced at least 1400 MW of electricity. Coal fired electric power plant is one of the cheapest electric power generation in comparison with the amount of electricity that can be generated. Because of future growth, these power stations are still not enough to satisfy demand. Fly ash is a waste by-product of electric power plants using coal as their source of fuel. A coal-based power station had previously disposed of the waste amounts from their equipment by burying it in landfills or returning it to strip mines. Growth in power plants using coal as the fuel source has yielded hundreds of millions of tons of ash every year. With the advancement of technology and the economic crisis in Malaysia, infrastructure growth through the use of modern structural materials has been promoted but overall, with unsatisfactory cost savings results. This problem can however be solved by using industrial waste such as fly ash as a source to replace current building materials which are cost-effective. The key aspect of waste management is to avoid waste generation by minimizing the waste generated and also the reuse of waste materials by recycling.

2.5.1 Waste Management Association of Malaysia

The Association for Waste Management of Malaysia (WMAM) is a non-profit, scientific and educational association that offers a platform for discussion of all waste management issues. It aims to develop and sustain contact with local or foreign waste-management organizations [15]. Waste collection and disposal is the groundwork for local authorities to control waste disposal in Malaysia [16]. Waste collection, transport and disposal were not handled properly. Those include limits on dumping practices, and unsafe waste disposal sites. Fly ash is defined as one of the residues formed by the coal burning chamber in the electrical power plant and includes the small particles formed by the flue gas. Fly ash is a spherical, fine glass powder with an average particle size of 0.5 to 100 µm. The Fly ash class F and class C types are based on the fly ash's own chemical composition. The fly ash class F, made of anthracite and bituminous coal while the other is fly ash class C consisting of lignite burning or sub-bituminous coal. In fact, according to Manas, fly ash is capable of self-cementing [17].

2.5.2 Potential of Fly Ash

Table 3. Potential areas for fly ash utilization

The usage of Fly Ash	Description
Fly ash in Geopolymer	Geopolymer concrete with fly ash provided high compressive strength, low creep, strong resistance to acids and low shrinkage. The function of binder in concrete is replaced by geopolymer paste based on fly ash which also has pozzolanic properties as OPC and a high content of alumina and silicate.
Fly ash in manufacture of cement	Fly ash bricks have some benefits in terms of their properties over the traditional clay bricks and concrete bricks. Fly ash can also create unglazed tiles that can be used along footpaths.
Fly ash in manufacture of cement	The fly ash can be used as pozzolanic materials. This chemically reacts with calcium hydroxide at room temperature in the presence of moisture to form compounds that possess cementitious properties. Fly ash has a high quantity of reactive silica and alumina which complements cement hydration chemistry. This property makes fly ash a superb admixture for concrete processing.
Fly ash in ceramics	A process had been developed for producing ceramics from fly ash with superior resistance to abrasion.
Fly ash in road construction	Dependent on road construction, fly ash may be used to stabilize the soil for sub.

The use of fly ash in building construction had a strong track record for as far back as several decades. The efficiency advantages flying ash provide brick's mechanical and durability properties have been decently inquired and documented in real structures. Fly ash is actually being used as part of over half of all prepared mixed bricks produced in the United States, and many design experts tend to be unnecessarily conservative in the use of fly ash as part of construction materials [18]. Consequently, several studies have been carried out on cement and concrete applications that have been allowed and approved by the federal authorities. Table 3 demonstrates the possible applications of fly ash.

3. Data Collection and Discussion

3.1 Staudinger Power plant, Hanau, Germany Description and history

Staudinger power plant is located in the area between the rivers Rhine and Main in the Mid-West of Germany. This area is one of the densest populated areas in Germany which causes a high demand of electricity. The power plant consists of five power blocks with a total installed capacity of 1900 MW and a high voltage utility for grid connection. The coal bunker of the facility can hold up to 220,000 tons of coal. It is fully automated and feeds the burner of block 5 today. Most of the coal supply is provided by the river Main and the harbour of Staudinger. Additionally, the power station has its own train station. The capacity of the power station can supply 2 million people with electricity and 19,000 households with distant heat.

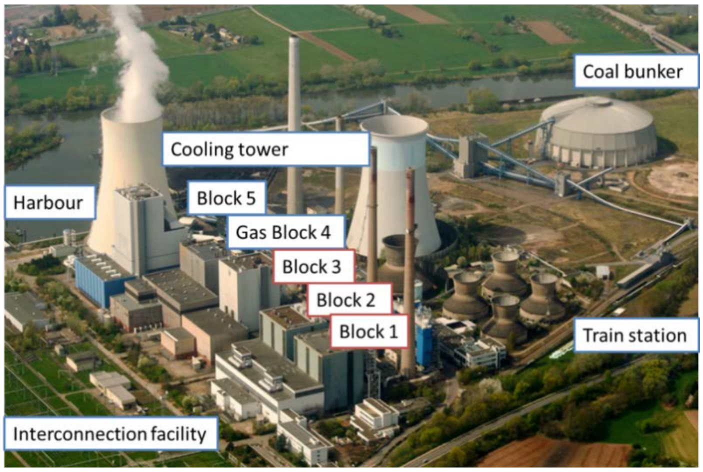

Fig. 6. Staudinger power station

The power plant consists of five power blocks and a train station, a harbour with a jetty, a coal bunker, a cooling tower and an interconnection facility. There are other facilities on site, which are in longer use. The history of Staudinger power plant started in year 1965, when block 1 and block 2 were opened with a combined capacity of nearly 500 MW. 1970 Block 3 was connected to the grid having a capacity of nearly 300 MW. All blocks were fired with hard coal and cooled by the river water of the Main and five ventilation cooling towers, if the water level dropped or a warm period heated the water too much. The three chimneys are 195 m high each.

1977 block 4 with 622 MW capacity started generating electrical power. This block in opposition to block 1, 2, 3 and 5 is run with gas. During the planning phase a lot of critics of environmental activist lead to the decision of using more environmental gas as a fuel. Additionally, this way no flue gas treatment was needed. The chimney of block 4 is 250 m high and therefore the highest chimney in the state of Hessia. The cooling tower is 128 m high.

In the year 1992 block 5 with 510 MW installed capacity was opened. This coal-fired power plant was by the time one of the most modern power plants. It has an efficiency of 42.5% and the fully automated control technology allows the plant to be monitored and operated by only one person. Another specification is the missing chimney. Block 5 leads its flue gases after treatment through the cooling tower.

Until 2013 the first three blocks were closed down due to an unprofitable economic situation not allowing any longer operation.

Today only Block 4 and 5 are in operation. This assignment will focus on Block 5 as an operation with gas as in block 4 does not produce any noticeable fly ash.

3.2 Fly ash treatment

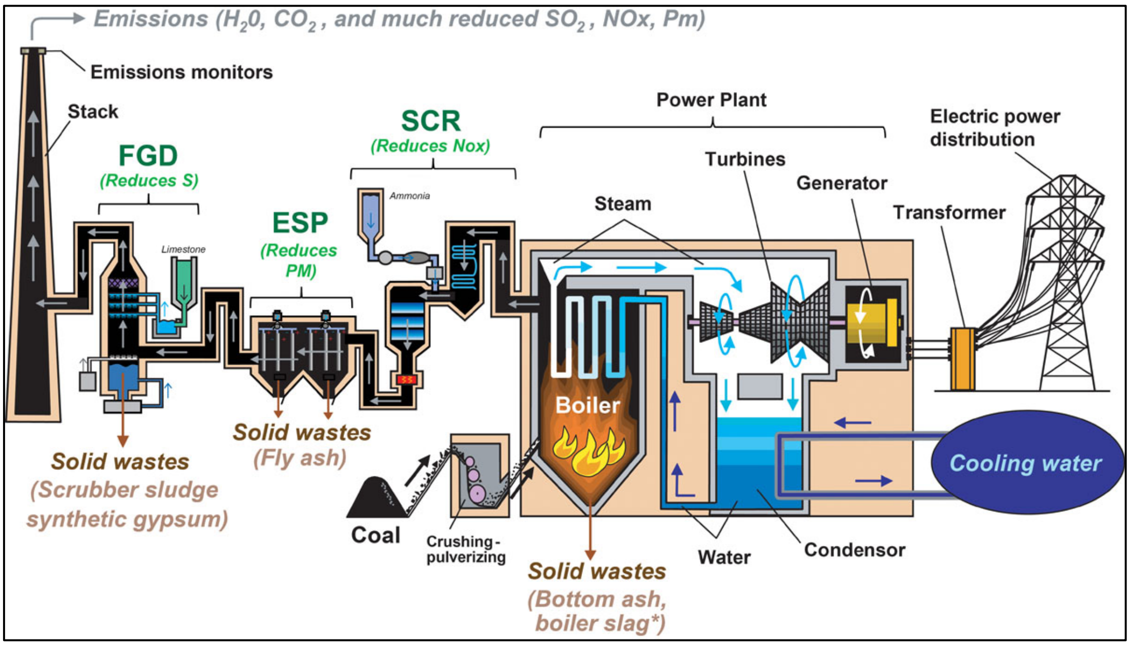

Fig. 7. Common pollution control equipment on coal-fired power plants and the by-product wastes produced by each

Block 5 captures its fly ash in an electrostatic precipitator. This Electrostatic Precipitator working in following principle: The fly ash particles fly through the precipitator where they are passing two plates or grids imposed with opposite high voltage (positive and negative). The negative grid charges particles and the positive grid attracts and collects the flying particles that are captured on a plate slab with a positive charge. By mechanical vibrations or shocks by generated hammer beater plates and dust particles fall and are collected in the hopper and then disposed to further processes. For higher efficiency in fly ash treatment, many electrostatic precipitators can be stacked above each other as it is practice in Staudinger power plant. [19]

The electrostatic precipitator has the advantage of being a closed system. The fly ash is never exposed to the environment and can be controlled collected for further use. Only a minimum amount of fly ash will be exhausted with the flue gas. The fly ash in Germany is used for different process in the construction sector. It can be used in brick factories or to strengthen cement.

3.3 Jimah Power Project, Negeri Sembilan, Malaysia Description and history

The Jimah Power project is comprised of a 1,400-MW nominal power plant and high-voltage interconnection facilities. The power plant includes two 700-MW steam-electric coal-fired plants, a coal tank with storage and handling facilities, one-time seawater cooling, and a tank for each unit for desulfurizing seawater flue gas (FGD), and a 500/275-kV switchyard. The project also included the high-voltage work required to connect the plant to the grid, including about 100 kilometres of transmission lines and an existing 500/275-kV substation extension. The plant is close to the mouth of the Sungai Sepong Beson river, Port Dickson district, Negeri Sembilan, Malaysia. The project included extensive dredging activities, land reclamation, and soil improvement. A consortium of Sumitomo Corp. of Japan and Sumi-Power Malaysia Sdn. offered all the project engineering, procurement and construction services. Bhd: Bhd. I'm from Malaysia. Toshiba Corp. provided the steam-turbine generators under consortium subcontracts, and Ishikawajima-Harima Heavy Industries Co. Project engineering was provided and boilers and associated equipment were supplied by Ltd. The air pollution control equipment includes low-NOx burners, electrostatic precipitators and desulfurizing equipment for seawater flue gas supplied with each boiler.

Fly ash output is around 7–10 per cent out of the annual consumption of coal. Most of the collected fly ash is deposited in nearby ash ponds and for building purposes only some of the fly ash has been used. With the environmental issue being a global concern, expanding the scope of this industrial waste is critical in order to reduce the rate of disposal. Several types of alkali activators may be used to activate fly ash. For eg, potassium hydroxide (NaOH), sodium silicate (Na2SiO3), potassium silicate (K2SiO3), calcium hydroxide (Ca(OH)2), and so on. The combined use of NaOH and Na2SiO3 is the most common method of making a geopolymer with strong compressive strength in terms of cost effectiveness than the single use of alkali silicate or hydroxide. An ash pond is an engineered system for bottom ash disposal and fly ash disposal. Wet disposal of ash into ash ponds is the most common form of disposal in Jimah Power Plant. Wet disposal was preferred for economic reasons, but the popularity of wet disposal has decreased with increasing environmental concerns regarding leachate from ponds. The wet method consists of building a large "pond" and filling it with slurry of fly ash, allowing the water to drain and evaporate over time from the fly ash.

Water removal from an ash pond is critical to constructability, project economics and long-term performance. Without proper dewatering of saturated ash materials before removal, excavations risk caving and cut slope collapse, creating safety hazards and potentially costly repairs. During closure, dewatering should be conducted to limit disturbance and re-suspension of an ash pond's solids, especially while construction activities take place in the immediate vicinity of the discharge structure. For fly ash, the Jimah Power Plant intends to enter into ash disposal agreements with multiple off-takers. This ash will mainly be used for cement production. For bottom ash, the Jimah Power Plant intends to enter into an ash disposal agreement with a local brick manufacturer. The fly ash and bottom ash will be transported off site by lorry. Fig. 8 shows the Jimah power plant project

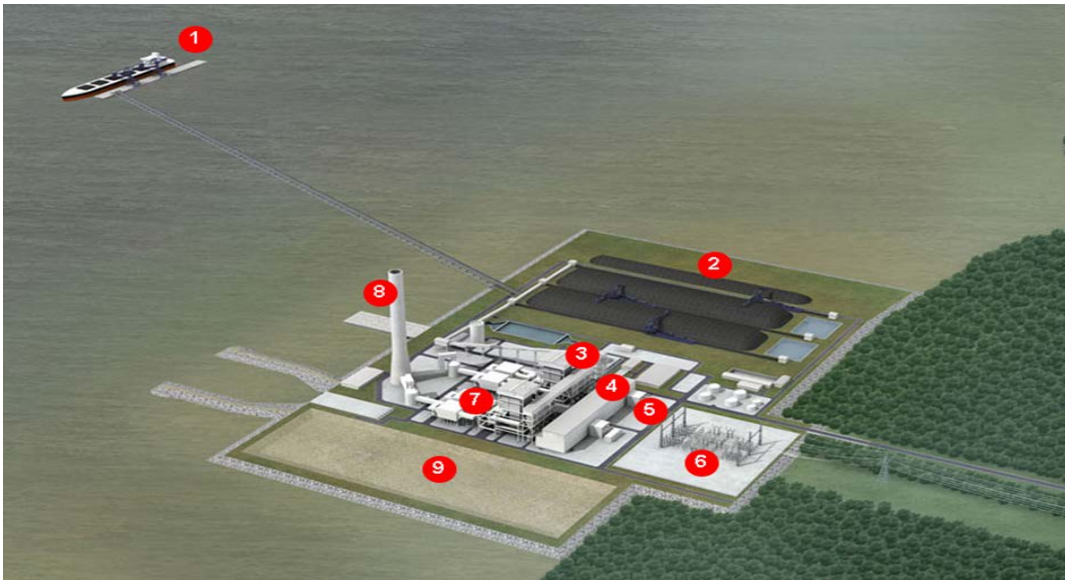

Fig. 8. Jimah Power Plant Project

Technical details of Jimah power plant according to the red point mentioned in Fig. 8:

1. **Jetty**: Being a pipe block, road and service track with a distinct set of technical requirements.
2. **Coal Yard**: The unloading and handling of coal and final delivery into the bunker of a power plant, ready for consumption.
3. **Boiler**: A device used to create steam by applying heat energy to water.
4. **Turbine**: Convert the energy from high-pressure steam into mechanical energy in shaft rotation to transform the generator.
5. **Transformer**: To step up the voltage of the generated power before it is evacuated into the Grid.
6. **Interconnection Facilities**: For delivering electricity from producers to consumers.
7. **Flue-gas desulfurization (FGD)**: A collection of technologies used to extract sulphur dioxide (SO 2) from fossil-fuel power plant exhaust flue gases.
8. **Chimney**: A device that provides ventilation from a boiler, pot, furnace or fireplace to the outside atmosphere for hot flue gases or smoke.
9. **Ash Pond**: An engineered structure for bottom ash disposal and fly ash disposal.

3.4 Ash Pond

As described above, an ash pond is an engineered system for the disposal of ash and fly ash from the floor. Wet ash disposal into ash ponds is the most common method of ash disposal but other methods include dry disposal in landfills. Dry handled ash is also recycled into useful materials for the construction. Wet disposal was favoured for economic reasons, but the popularity of wet disposal decreased with growing environmental concerns about leachate from ponds. The wet method consists of creating a large "pond" and filling it with slurry of fly ash, allowing the water to drain and evaporate over time from the fly ash. Ash ponds are typically built to enclose the disposal site through a ring embankment. The design of the embankments is based on similar design criteria to embankment dams, including zoned construction with clay cores. The design process focuses mainly on the handling of inlet and the stabilization of the slopes. Because of few federal and state ash pond regulations, most of them do not use geomembranes, leachate collection systems or other flow controls often found in municipal solid waste landfills.

When using ash ponds, at the power station, the ash is combined with water and drained into the ash pond as slurry. Through the pond to the power plant where it is recycled the ash settles and clean water is decanted. When the ash pond is completed, the ash also needs to be excavated and moved to a landfill or permanent disposal site in order to provide adequate storage space inside the pond. If that is not necessary, an additional ash storage pond shall be built.

4. Conclusion

In this study, there are two different ways of fly ash treatment in different countries, first there is the ash pond treatment in Malaysia, and secondly there is the electrostatic filter treatment in Germany. Both systems have advantages and disadvantages. The ash pond offers cheap costs and an easy process but exposes the fly ash and its sometimes-hazardous components to the Environment The electrostatic filter acquires more knowledge and is higher in Installation costs, but keeps fly ashes safe in a closed process the electrostatic filter seems to be more Environmentally Friendly and sustainable. As a result, it can be concluded that this treatment can be preferred and implemented in Malaysia as a successful treatment of waste management.

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Authors’ Profiles

Sarmad Dashti Latif is currently a master’s candidate at Universiti Tenaga Nasional, Malaysia. He is also working as a research officer at Department of Civil Engineering, College of Engineering, Universiti Tenaga Nasional, Malaysia. He received his Bachelor in Civil Engineering with first-class honours in 2018 at Universiti Tenaga Nasional, Malaysia. His current research interests are application of artificial intelligence for reservoir inflow prediction, rainfall prediction, water quality parameters, and other hydrological parameters.

How to cite this paper: Sarmad Dashti Latif, " Technical Improvement of Air Pollution Through Fossil Power Plant Waste Management ", International Journal of Engineering and Manufacturing (IJEM), Vol.10, No.4, pp.43-53, 2020. DOI: 10.5815/ijem.2020.04.04