Future trends for PFA in cementitious systems

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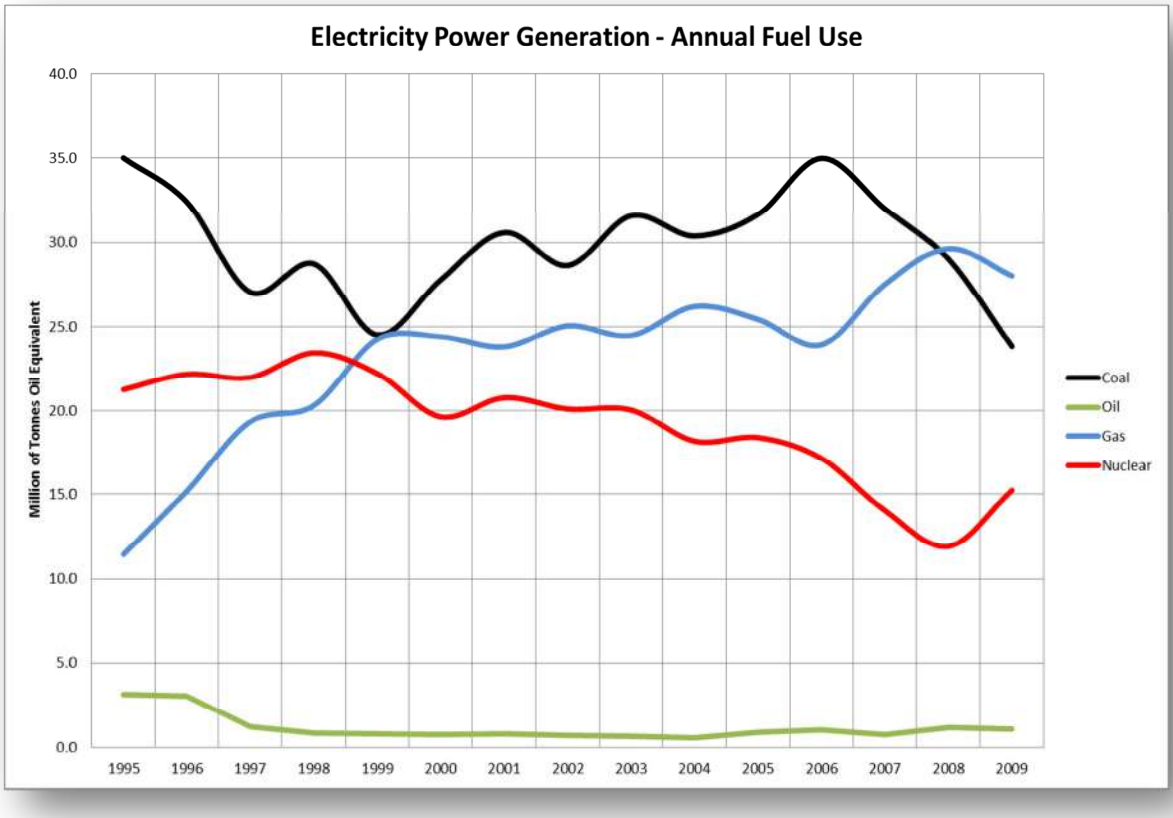
The future for PFA

There are a considerable number of EU directives affecting the coal fired power generation industry that are impacting the production, quality and availability of Pulverised Fuel Ash (PFA)/fly ash into the UK market. The UK operates old and relatively inefficient stations which need updating in order to reduce CO_2 emissions and improve efficiency. However, UK Government energy policy is inconsistent which has resulted in the many of the operators not being prepared to invest in modern plant, carbon capture, etc due to the uncertainty of the future of coal fired power generation!

The power generation industry's fuel mix is changing as a result of cheaper gas prices and more expensive coal. The UK nuclear power stations are all coming to the end of their lifespan and will increasingly generate less in future years. This scenario is added to the continual pressure to reduce CO_2 emissions and the lack of viable carbon capture technologies has resulted in a considerable reduction in coal fired generation and the availability of higher quality PFA. Additionally, the recession has further reduced the power demand during the summer months which has resulted in more double shifting of coal fired stations.

Ash production in recent times

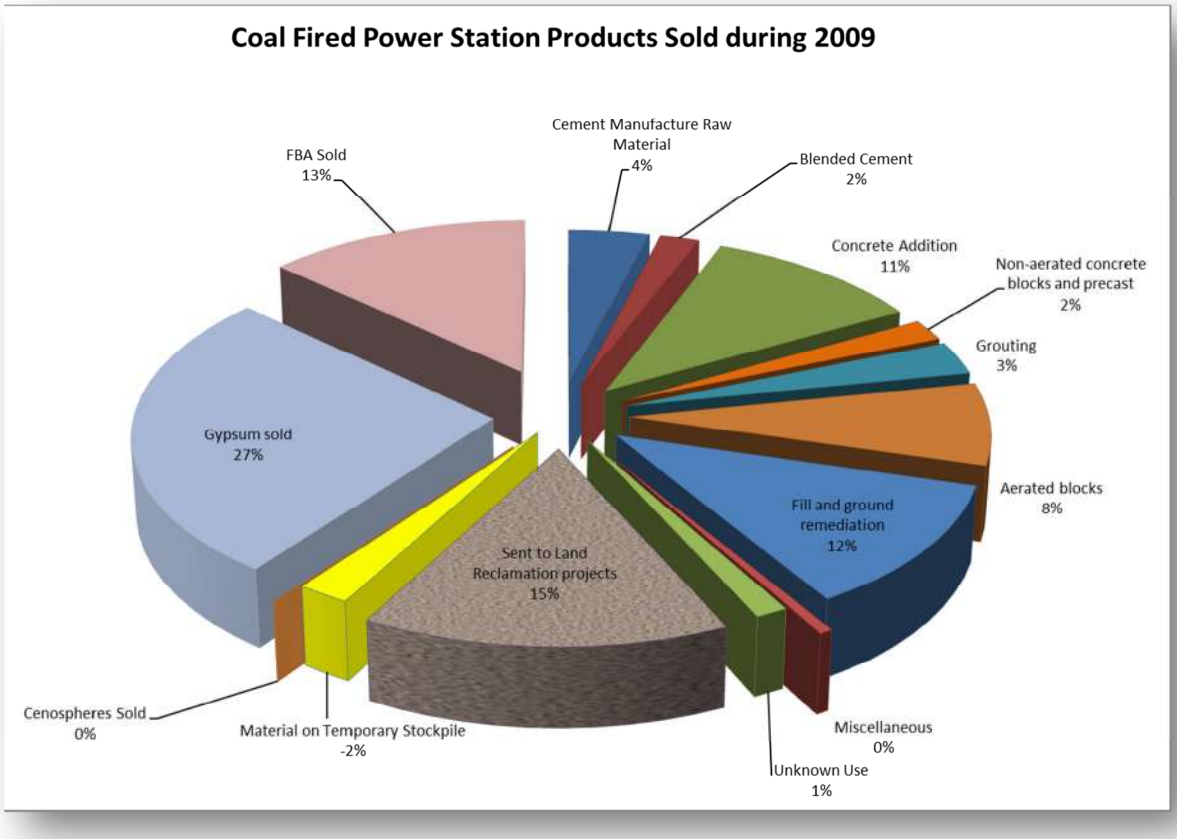
As a result of these pressures, ash production in the UK is falling overall. The UK produced about 5,300,000 tonnes of PFA and 800,000 tonnes of Furnace Bottom Ash per annum plus an additional 1,500,000 tonnes of gypsum per annum from the fuel gas desulphurisation (FGD) systems. This level of production had been fairly consistent for a number of years but has significantly reduced in the last two years. However, the Large Combustion Plant Directive (LCPD) means that a number of stations are due to close by 2015. These have opted out of compliance with LCPD and therefore operating under a 20,000 hours limit. The variation in coal fired power production is making it difficult to predict when stations will actually close. This is due to the availability of gas fired generation; its price fluctuations and the reduction in operational nuclear stations are all having a variable demand on coal fired stations.

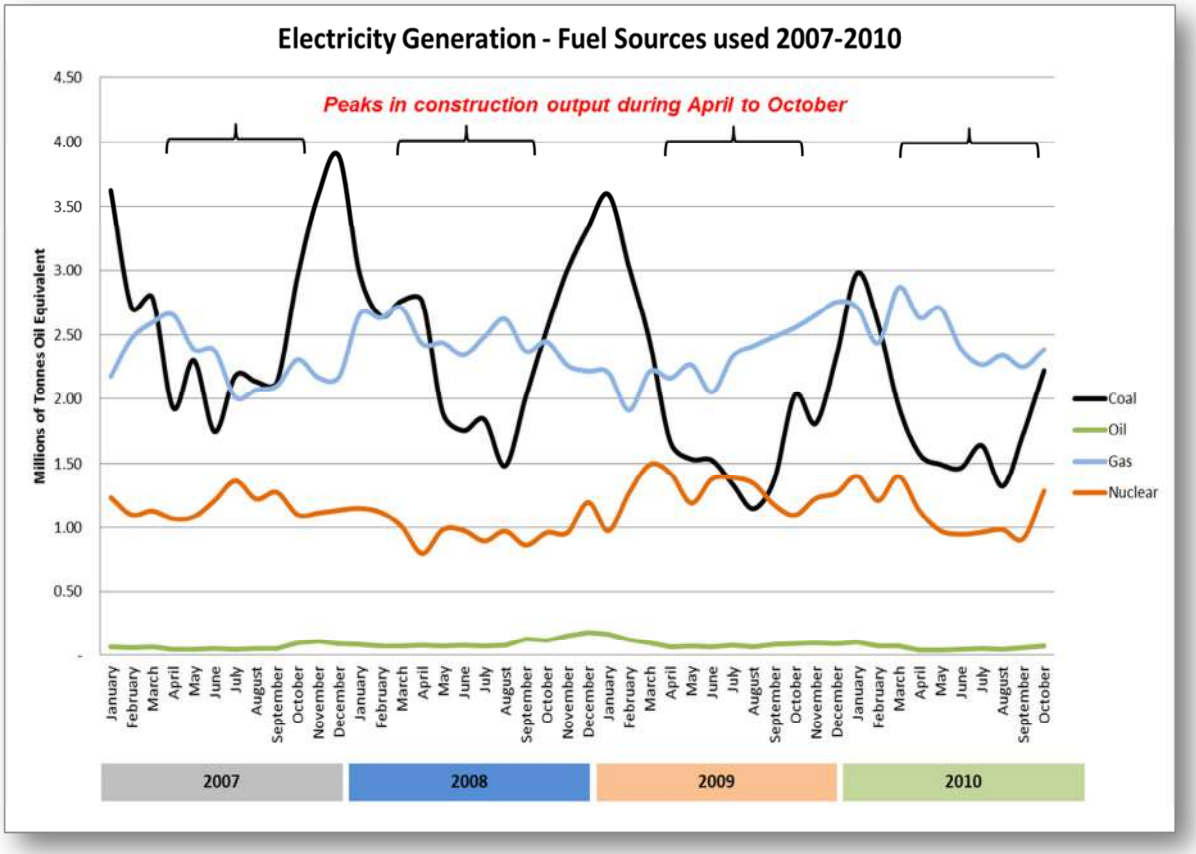


The two recent cold winters though have resulted in a sudden increase in electricity demand and therefore fly ash output during the worst weather – just when it's not needed for construction purposes. However, in the summer months, many coal fired generators tend to be restricted to double shifting, e.g. at breakfast and evening meal times, in order to satisfy peak demand, which reduces the quality of the ash produced, e.g. higher Loss On Ignition (LOI). This timing is exactly the converse of the construction industry's demand for the material.

The following figures are typical uses for PFA within the UK in the last two years.

Application for PFA – recent typical annual PFA production	~Tonnes
Cement raw material	200,000
Blended Cement	100,000
Concrete Addition	550,000
Non-aerated concrete blocks and precast	100,000
Grouting	150,000
Aerated blocks	400,000
Fill, ground remediation and other uses	650,000
Sent to Land Reclamation projects	750,000
Land filled material	1,600,000
Totals	4,400,000





It must also be remembered that materials other than PFA are important to other industries.

Furnace Bottom Ash is important to block makers and also in short supply due to the reduction in coal fired power generation. There is no other cheap source of consistent lightweight aggregate material available in the UK for the manufacture of lightweight concrete blocks. This has resulted in imports of FBA from coal fired power stations across the EU, where their material is not fully utilised. Another product is gypsum, which is important in plasterboard production. FGD gypsum is ideal for plasterboard manufacturers as it is purer gypsum than natural material, has a reduced cost to both environment and producer and requires no mining and associated processing and handling.

As more power stations fit FGD systems there is a risk that supply may exceed demand in the future, but there are a number of markets currently using mined gypsum that could use FGD gypsum, for example in the manufacture of cement.

Regulatory issues – a brief overview…

Large Combustion Plant Directive

A number of stations are due to close by 2015 under the LCPD as tighter emissions controls are enforced. Plants that opt out of compliance can only operate for 20,000 hours up to 2015. The variation in usage as described above is making it difficult to predict when stations will actually close and how much ash will be available!

The Quality Protocol

This Environment Agency document defines when ash ceases to be a waste. In summary it requires that PFA be supplied to recognised standards. So the term 'Run of Station' used for many applications will cease to exist. This system will be effective from January 2011. It however, does not cover the use in 'unbound' applications, such as embankment fill, but this is being addressed and it is hoped this can be finalised by the end of 2011. In the interim there is an Environment Agency Position Statement in effect for unbound uses.

Regulated Dangerous Substances

Requirements for 'Essential Requirement 3' in respect of Regulated Dangerous Substances will begin to appear in product standards from 2017 onwards. Work is on-going to produce harmonised test methods for assessing the leaching characteristics of products, including validation and robustness of these tests methods. In the UK the limit values are likely to be as those required within the Quality Protocol for PFA and FBA.

REACH

The consequence of PFA and FBA not being classified as a waste but a product, means PFA and FBA then has to comply with the REACH regulations for substances. Some €350,000 spent on testing and registration in the EU for PFA alone!

Construction Product Regulations

These are likely to be implemented ~June 2015 (or later) and means that supply of products to recognised standards will be a legal requirement if a harmonised CE marked standard exists. As a result, CE Marking becomes compulsory.

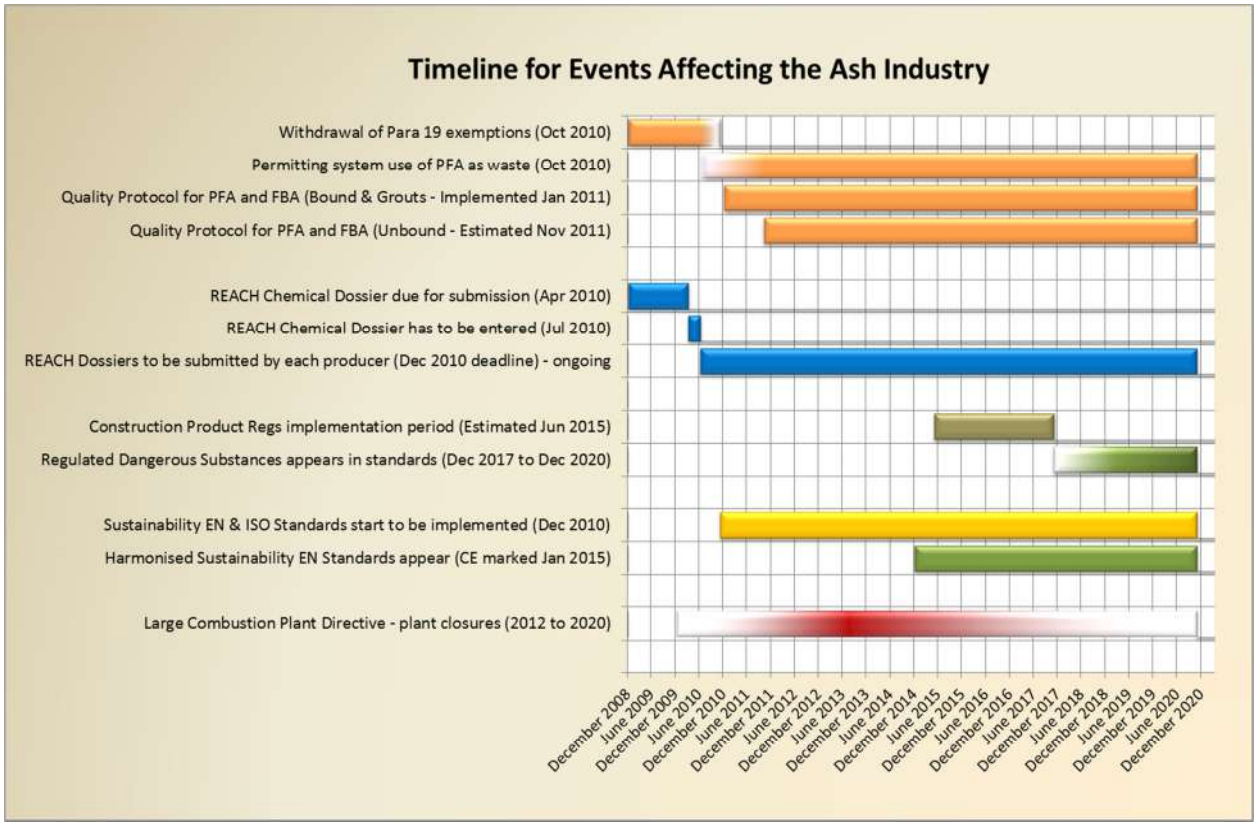
Sustainable Construction standards

These are being worked at currently at an alarming rate. They are a series of standards that define a common set of rules for assessing environmental impacts and sustainability issues. Environmental Product Declarations will have to be done in a standardised way so that they are comparable with similar/alternative products. These standards will start to become 'harmonised' in 2015. In addition there is increasing pressure on materials suppliers to comply with Quality Management and Sustainability schemes

Do NOT believe this is all of the regulation emanating from the EU!

Timeline of future regulatory events

As will be observed many of these initiatives are coinciding, resulting in a great deal of uncertainty for the producers and users over the future!



Some of the general issues for the industry to address…

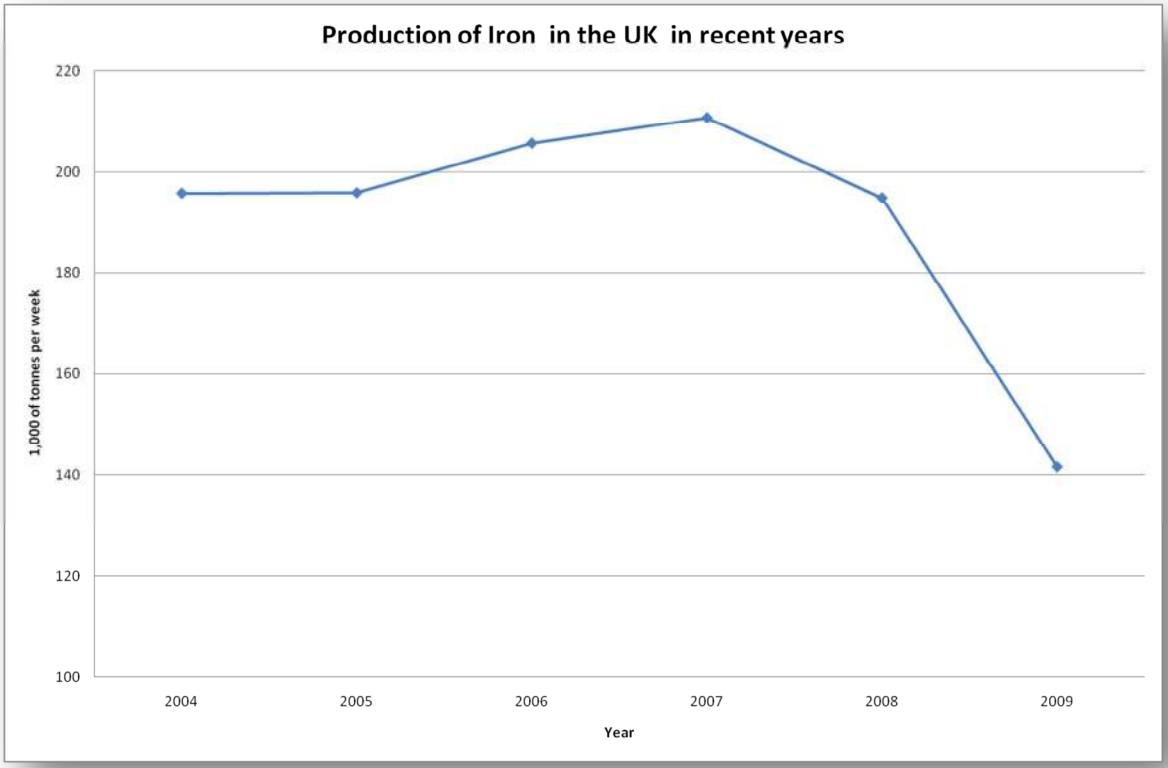
Lower LOI PFA is required if the cement, concrete and aircrete block industries are to continue to be supplied. Ammonia slip needs to be addressed by either processing the ash to remove the ammonia or by very careful control of the SCR and injection

of the ammonia. The UKQAA's role is to inform customers of future scenarios for PFA and FBA availability, so that they are aware and can make contingency plans.

Issues that occurred during 2008 to 2010

Some users, such as the Aircrete block makers have found difficulties in finding suitable quality ash. Aircrete blocks rely on consistent chemistry, which is important in the quality control of blocks. Their only other option is to use ground sand, e.g. revert to using virgin aggregate and grinding it to a high fineness. As many of the block plants were designed to use PFA, they do not have the appropriate grinding equipment. The effects of double shifting and deteriorating quality issues during 2009 resulted in some Aircrete producers running out of suitable ash and having to halt production on occasion!

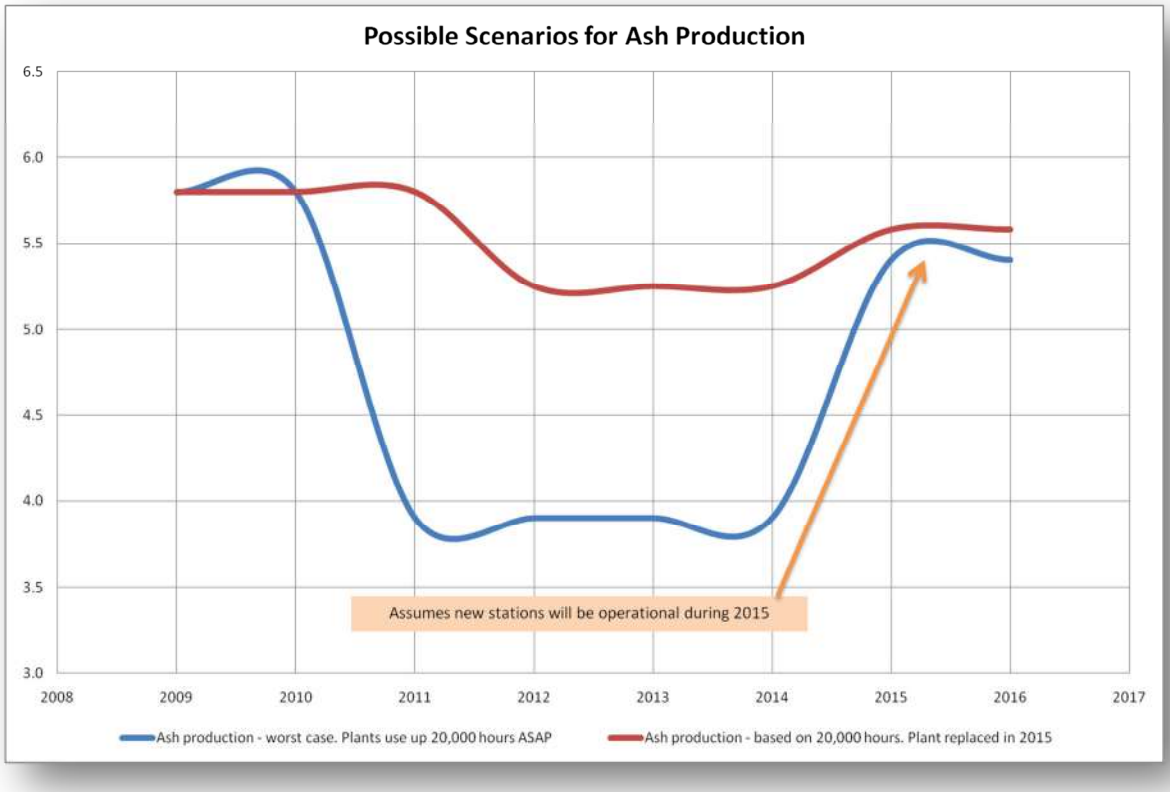
To add to these pressures, the reduced availability of Ground Granulated Blastfurnace Slag (GGBS) in the UK when the Teeside blast furnaces closed in February 2010 lead to an increased demand for higher quality ash. As would be expected the reduced GGBS production resulted in its price increasing significantly to almost that of CEM I.



The result of all these factors was demand outstripped supply – even during a recession. The recession seriously affected the concrete and cement industries which had a 25% downturn in production and many precast concrete factories were closed/mothballed, etc. Many concrete producers prefer classified ash, but the effect of the increased market demand was such that even when the ash was available for processing, insufficient material could be processed to satisfy that demand. In these circumstances this resulted in low LOI ash being diverted to less critical applications, e.g. fill, grout, etc.

Future scenarios

It is clear there will be less coal fired generation in future years and production will tend to be concentrated in the winter months. As no company is building new, more efficient stations with integrated Low NO_x burners, Selective Catalytic Reduction (SCR), Carbon Capture (CCS), etc this situation is not likely to improve in the foreseeable future. Low NOx burners have already been fitted to all stations and there are some retro-fits of SCR to older stations. The low NOx burners plus SCR will inevitably lead to higher LOIs, reducing the availability of suitable ash for the aircrete block, cement and concrete industries.



Both old and new power stations will, in most cases, require ammonium injection by 2015 in order to reduce NO_x emissions to the tighter limit values being imposed. The consequence is the danger of excess ammonia ending up in the PFA. Though ammonia does not result in a technical issue in cementitious systems, when ammoniated ash makes contact with the alkaline cement and water, the ammonia is immediately given off as gas. This becomes a smell and health and safety problem. To prevent this very careful control of furnace and SCR units or processing of the ash with ammonia removal systems will be needed!

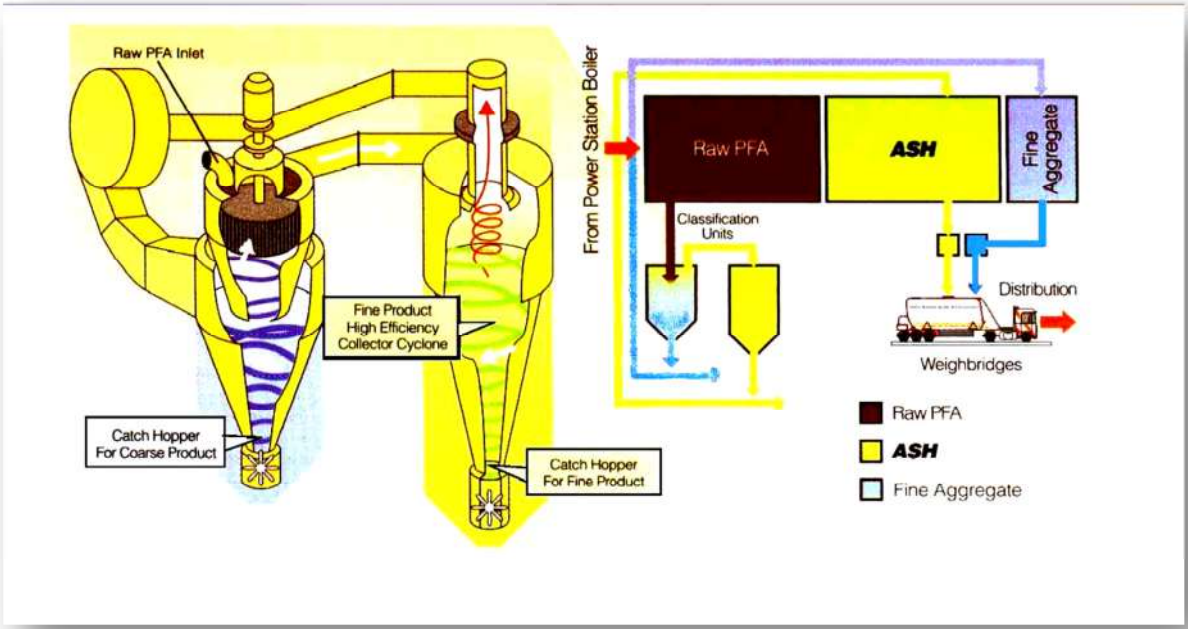
Possible solutions to the many problems?

Increased use of processing the ash by classification, carbon reduction plants, improved selection from station precipitators, etc will result in an increased supply of low LOI ash to the markets. More dry storage where low LOI ash is stored in the winter for supply in the summer months will help, but this is a high capital expenditure option. An alternative is to use wet stored ash. Conditioned ash, ash to which ~12% water is added is routinely stored at power stations prior to sale for

embankment fill or grouting applications. This material is chemically the same as dry ash, so if subsequently dried could be used successfully in cement and concrete applications, as has been done for a number of years in France. It is estimated about 200,000 tonnes of low LOI ash is landfilled p.a.

Making more fly ash available…

Classification



This has been carried out in the UK since the late 1970's and is well established. The air swept classifiers remove coarser ash particles to produce a finer product thereby improving the reactivity in concrete/cement. An alternative or supplement to classification is selection, where ashes are preferentially extracted from the banks of precipitators or the ash output is continually monitored for LOI and when within pre-set parameters is diverted to a low LOI silo.

Dry storage

This is a simple idea, but expensive to implement in providing sufficient dry ash storage facilities for large amounts of ash in order to supply summer demand. In general the quality of ash produced during the winter is better when not double shifting, e.g. lower LOI. Usually an excess of low LOI is available and a proportion of good material therefore goes to disposal or less demanding applications. Storage overcomes the peaks and troughs.

Some German coal fired power stations have storage facilities that can hold up to 100,000 tonnes of ash, with 30 to 50,000 tonnes being quite common. However, it is only in recent years that the UK storage capacities have begun to be extended.

Carbon reduction plants

These remove excess carbon from the fly ash using electrostatic systems. LOIs as low as 1.5% are possible, but a greater throughput is achievable at higher LOIs values, which are still compliant with the upper limit of 7.0% LOI.

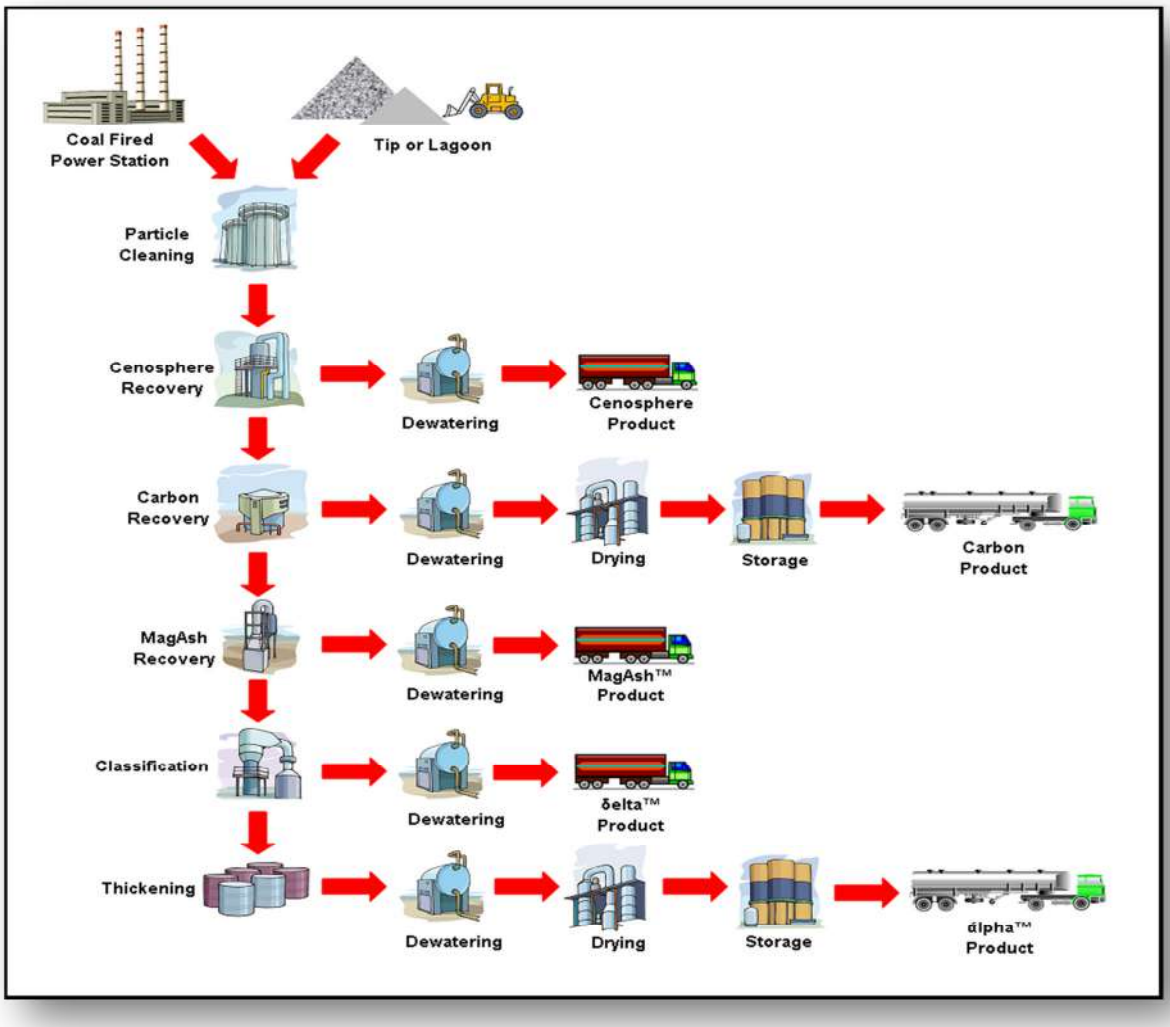

Sustainable Success

ScotAsh's ash recycling and blending plant is designed not only to recycle ash from the Longannet Power Station, helping to avoid disposal costs, but also to reduce the dependency of the construction industry on raw primary materials. A major investment programme has recently been completed, and Claire Hunt visited the plant on the occasion of its official opening by Lewis Macdonald, MSP.

Some previously unusable ashes may become available and these ashes may be surprisingly reactive. Colour may or may not be lighter with carbon reduction plants, even though the carbon content is reduced. This relates to the particle shape and type of carbon in the ash. Most carbon reduction plants in the UK are the electrostatic STI units and one station has an ammonium reduction system. However, there is one water based ash processing system operational in the UK;

Rocktron

The Rocktron system is based on wet processing of ash. It is a patented process. This system can use stockpile ash and therefore not dependant on stations being operational. In fact stockpile material has been found easier to process and is readily available throughout the year. The PFA can be processed in a number of products, including a fine ash, coarse ash magnetite, cenospheres, low LOI, etc. The drawback to wet handling is drying the material post processing as the energy and cost of drying increases material cost.

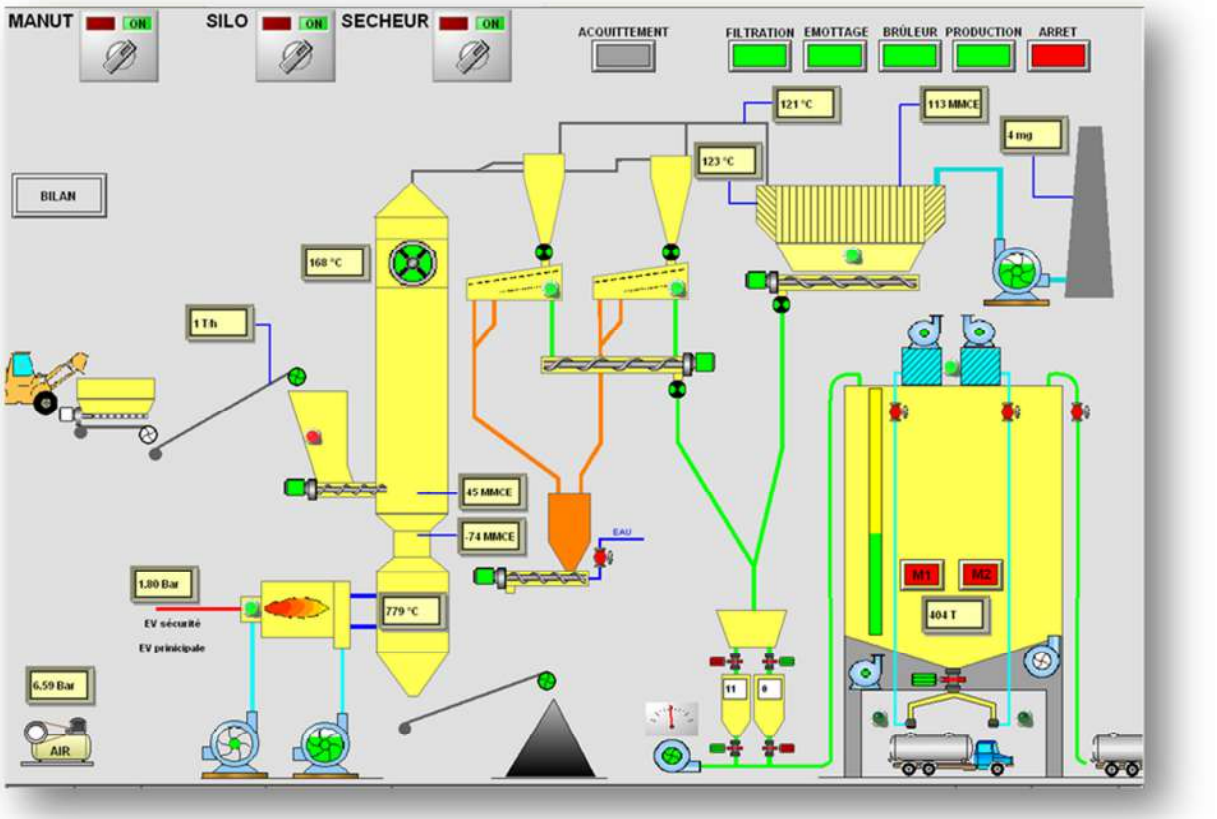


Storing conditioned ash

Conditioned ash is widely used in fill for embankments and grouting and for disposal mounds. Most UK power stations have conditioning equipment and can produce large quantities of such ash quickly and efficiently. In order to recover this ash for use in cement and concrete it has to be dried and this is usually done using gas. However, gas drying plant involves some further grading and selection and consumes energy. Therefore, the cost of the ash will increase and to some extent its excellent low embodied CO_2 is degraded.

Whatever system of storage is used, there is a considerable capital cost in building and operating these plants. The power station operators are reluctant to invest when the future for coal fired generation is uncertain and government policy is vague.

To give one an idea of the complexity of drying ash the following diagram is the French system, currently being used:



Conclusions

There are difficult times ahead for the ash industry with a reduction in ash production and the resulting quality issues. In addition there are ever increasing regulatory burdens. There are solutions to many of these problems in order to continue to satisfy supply and demand, but they require capitalisation for these to work. Storage and increased processing will provide the solution, but ultimately at an increased cost to the user.

The future for the UKQAA; the trade association promoting the use of ash from coal fired power stations, we will continue to work at solving some of these problems and try to ensure a realistic message gets across to the producers and users.