Transactions on Ecology and the Environment vol 6, © 1995 WIT Press, www.witpress.com, ISSN 1743-3541

Acid dispersion abatement: the use of flur gas desulphurisation in the UK

J.W.S. Longhurst,[a] B.A. Heath,[b] D.C. Gibbs[c]
[a]Atmospheric Research and Information Centre, Department of Environmental and Geographical Sciences, Manchester Metropolitan University, Chester Street, Manchester, M1 5GD, UK
[b]Division of Environmental Sciences, Crewe and Alsager Faculty, Manchester Metropolitan University, Crewe Green Road, Crewe, Cheshire, CW1 1DU, UK
[c]Socio-Economic Research Group, Department of Environmental and Geographical Sciences, Manchester Metropolitan University, Chester Street, Manchester, M1 5GD, UK

Abstract

This paper will review and evaluate the development of the UK flue gas desulphurisation (FGD) programme. This programme on establishment in 1986 represented a planned and coherent approach to acid deposition abatement which would progressively reduce emissions whilst maintaining the UK's coal fired power generation capacity. It was anticipated that at least 12000 MW of electricity generating plant would be retrofitted with FGD. The programme has effectively been abandoned in favour of a market based approach to emission control which sets the targets to be achieved but not the means. As a consequence the retrofitted capacity in 1995 is just 6000 MW.

Introduction

FGD is a long established and trusted technology for the effective removal of sulphur from the waste gases of a power station. During the 1980s it became a widely used abatement technology in North America, Japan and Europe [1,2,3] but the technology has its roots in British efforts to control sulphur emissions in the inter-war years. The technology was applied to Battersea power station as early as 1933 and was in use at Bankside power station until 1981 [4]. The early FGD stations used a river water scrubbing method with the

Transactions on Ecology and the Environment vol 6, © 1995 WIT Press, www.witpress.com, ISSN 1743-3541

purpose of limiting ground level concentrations of sulphur rather than to limit long range transport. Indeed the response to the London smog of 1952 and the Clean Air Act of 1956 was to construct new power stations on green field sites equipped with tall chimneys to ensure dilution and dispersion. With the adoption of this strategy the UK technological lead in FGD was lost and no FGD installations followed for more than 30 years. By the mid 1980s the UK was under increasingly severe international pressure, particularly from Scandinavia, to control sulphur emissions from power plants so as reduce the contribution to acid deposition [3,5,6,7] In parallel with this the EC was also seeking to limit sulphur emissions to atmosphere from member states.

In 1986 the Secretary of State authorised the Central Electricity Generating Board to retrofit 6000 MW of existing capacity with FGD in a planned and coherent response to reducing acid deposition. This action was anticipated to reduce UK emissions of sulphur by 14%. Beginning with a retrofit of Units 4, 5 and 6 at Drax power station, the programme was costed at £600 million (1986 prices) with £180 million set aside to replace lost generating capacity as the FGD units would reduce efficiency of the power plants by 2-4% [2,8]. Shortly after this the CEGB announced it would build a set of new coal fired stations fitted with FGD to the satisfaction of Her Majesty's Inspectorate of Pollution. These were anticipated to be at Fawley, West Burton, Kingsnorth and one other site. The combined total of 8000 MW would replace old inefficient generating capacity. The proposed FGD programme at this time can be seen in Table 1.

In 1988, with the adoption of the EC Large Combustion Plant Directive, commonly referred to as the LCPD, the UK was required to reduce SO_2 emissions relative to 1980 levels by 20%, 40% and 60% by the years 1993, 1998 and 2003 respectively. In order to comply with the LCPD requirements it was expected that the then Central Electricity Generating Board would need to retrofit some 8000 - 12000 MW of existing coal fired power plant with FGD. Additional stations were added to the FGD retrofit list including Ratcliffe and Ferrybridge [2,8]. These stations were expected to be retrofitted and in service by the mid 1990s. At this stage FGD was unarguably the most appropriate technology offering fixed levels of emission abatement with out the need to switch to fuels with lower reserves or imported stocks of low sulphur coal.

Table 1. Anticipated FGD Programme.

Station	Status	Station Commissioning Date	FGD Commissioning Date	Output MW
Drax 4-6	1st retrofit	1986	1993	1980
West Burton B	New	1994/5	1994/5	1800
Fawley B	New	1996/6	1995/6	1800
Drax 1-3	2nd Retrofit	1974	1995	1980
Fiddlers Ferry	3rd Retrofit	1971	1997	1880
Kingsnorth	New	1998	1999	1800
?	New	1998	1999	1800

Source: [2]

FGD Technology for Control of Acid Deposition Precursors

Traditionally sulphur dioxide has been removed from large combustion plants by FGD. The choice has primarily been between a limestone-gypsum method and the regenerable Wellman-Lord method [3]. The UK programme was anticipated to use a mixture of these two technologies. The Wellman-Lord FGD process was expected to be retrofitted onto Fiddler's Ferry power station [8] with a limestone-gypsum system on the rest of the stations.

Broadly speaking FGD processes can be divided into two categories, regenerable and non-regenerable, the distinction being made according to what happens to the sorbent after the SO_2 has been absorbed. In regenerable systems, after the absorption or adsorption reaction the sorbent is regenerated to release SO_2 and the original sorbent. The sorbent is recycled into the absorption tower, whilst the SO_2 meanwhile can be converted into elemental sulphur, sulphuric acid or liquid SO_2, and sold as a raw material. In non-regenerable systems the sorbent, having reacted with the SO_2, either becomes a waste product, or in some cases can be a useful by-product e.g. gypsum [9,10]. Regenerable systems are less widely used than non-regenerable systems owing partly to their greater complexity and therefore increased capital costs. However,

Transactions on Ecology and the Environment vol 6, © 1995 WIT Press, www.witpress.com, ISSN 1743-3541

environmentally they are more favourable since, unlike many non-regenerable processes, they result in the production of very small quantities of waste [3].

Wet Lime/Limestone Gypsum System

The most widely used FGD system is a non-regenerable process involving wet scrubbing of gases with lime or limestone as the alkaline sorbent. The system is relatively simple; crushed lime or limestone is mixed with water to form a slurry which is then sprayed into an absorption tower where it comes into contact with the flue gases. Here the alkaline sorbent reacts with the SO_2 to form aqueous calcium sulphite which is then oxidised to calcium sulphate, i.e. gypsum. Gypsum is a useful by-product with applications in the construction industry [3]. The UK FGD programme selected the limestone gypsum system because it is tried and tested technology, producing a useful by-product with sulphur removal efficiency in excess of 90%. Disadvantages include the large quantities of high purity limestone required relative to other systems and the requirement for liquid effluent disposal. Additionally there is the risk that much of the gypsum produced may have to be disposed of, depending on market conditions.

Wellman - Lord Process

Operation of this process can be divided into absorption and regeneration stages. Absorption is achieved by wet scrubbing the flue gases with a saturated solution of sodium sulphite. Reaction of the sorbent with the SO_2 yields sodium bisulphite and the concentrated bisulphite solution is collected at the bottom of the absorption tower and passed to an evaporation system for regeneration [3]. Regeneration by thermal decomposition results in the production of sodium sulphite, the original sorbent, which is then recycled back to the absorption tower. The other products of regeneration are SO_2 and water, condensation of the latter results in the production of a highly concentrated stream of gas, in the order of 94 - 95% SO_2 [3]. This product can then be converted into elemental sulphur, sulphuric acid or liquid SO_2 and sold to the chemical industry as a valuable raw material [3]. Because of the regeneration stage the system is more complex than many alternatives and this means that capital costs are about 20% higher than for the limestone gypsum process.The process has the advantages of low raw material requirements, low operational costs, high value product, high SO_2 removal efficiency and low levels of waste [3].

Privatisation of the Electricity Supply Industry

It is evident that in the mid-late 1980s FGD was being presented as the technology which would form the basis of the UK's national acid deposition abatement programme. FGD's advantages included: tried and tested technology with guaranteed high SO_2 removal efficiencies, largely predictable capital and operating costs and potentially marketable by-products. Consequently FGD represented an effective and reliable abatement technology, for use on coal fired power stations. This last fact was of particular importance given the UK's traditional dependence on coal for power generation. One major policy initiative of government, the privatisation of the Electricity Supply Industry (ESI) has had a significant effect on the UK FGD programme and also on the UK coal industry, resulting in significant changes to the previous emission abatement strategy.

At about the same time that the UK was involved in discussions about emission targets to be allocated by the LCPD, developments were also being made in relation to the future of the UK ESI. Traditionally a nationalised industry strongly integrated with its major fuel supplier, the UK government intended to privatise the CEGB. Official privatisation of the ESI in England and Wales came about on 31st March 1990, whilst in Scotland it came a little later. The former CEGB has now had its assets divided between a number of separate generating, transmission and distribution companies. National Power and PowerGen, received a roughly 60:40 share of the generating capacity operational at that time.

Privatisation of the ESI has resulted in a major re-organisation of the industry and the prime concern of the future will be profit making. In contrast to the old system, the generators are no longer under any obligation to supply electricity. This switch in emphasis away from supplying electricity to meet demand, towards generating a profit, has had significant impacts on both the FGD programme, reducing it in scale dramatically, and also on the fuel base of the ESI. Other economic and strategic effects may become apparent in future.

Selling Electricity to the Pool
In addition to PowerGen and National Power, there are a number of other independent, small scale, generating companies, who compete to supply electricity. Under privatisation, generating companies bid daily to supply electricity to the Pool. National Grid, the independent operator of the transmission system, reviews the prices submitted by the generators for electricity from each of their plants and selects the lowest bids to supply power to the Pool the following day.

This system is designed to achieve minimum prices for electricity users by encouraging maximum efficiency from electricity suppliers. The effect that the Pool system has is to favour those plants with the

Transactions on Ecology and the Environment vol 6, © 1995 WIT Press, www.witpress.com, ISSN 1743-3541

lowest operating costs and restrict the ability of higher cost stations to sell their electricity. Clear evidence of this is demonstrated by the fact that Drax power station at times operates without using its FGD plant, in order to make it more competitive and so ensure sales of its electricity to the Pool [11]. Such a situation is clearly a nonsense with regard to the UK's environmental commitments to reduce SO_2 emissions.

Effects of Privatisation on the Coal Industry
The pressure for private generators to minimise their costs, to increase sales and therefore increase profits has had a knock on effect on the UK coal industry. Privatisation has resulted in a move away from base-load power stations burning a total of up to 80 million tonnes of UK coal per annum, towards gas fired stations and low sulphur coal imports. Together these factors have effectively halved the market for UK coal for power generation to some 40 million tonnes [12] and this market is continuing to contract. Pit closures and job losses have inevitably accompanied this change in policy.

Current Acid Deposition Abatement Programme

The current position is that all new build coal-fired power stations planned at the end of the 1980s have been abandoned and plans for FGD retrofits on existing coal stations have been scaled down. Units 4, 5 and 6 of Drax and part of Ratcliffe have been retrofitted and are operational. Fiddlers Ferry was initially identified as a Wellman-Lord retrofit station but difficulties with the projected sales of its sulphuric acid product led to the technology being withdrawn from the programme and ultimately Fiddler's Ferry being removed from the retrofit programme. No new coal fired stations are anticipated to be ordered in the 1990s. Ferrybridge C has been identified for retrofit but no progress has been made despite permission being granted in 1993 [13]. The station had £250 million set aside at privatisation to ensure the retrofit would take place [14]. Work is unlikely to begin in the foreseeable future.

Despite this poor performance the 1993 emission of sulphur from the UK LCP sources was only 76% of their quota under the national plan for sulphur emissions [15]. The success in achieving these reductions is not primarily due to FGD but rather to the closure of old stations, an enhanced market share for nuclear electricity sources and the growth of the gas fired generating sector. This can not be taken as evidence of a coherent policy successfully implemented.

Recently new sulphur targets have been agreed as part of the UNECE sulphur protocol [16]. For the UK reductions of 50% in 1980 emissions are required by 2000, rising to 70% in 2005 and 80% in 2010. These targets are likely to be met by means other than FGD as the use of existing FGD units is very limited [11,14,17]. The additional cost of FGD is quoted as 30% on generation and hence mitigates against the use of power stations fitted with such technology.

Conclusion

The UK FGD programme was conceived of as an effective response to acid deposition commensurate with the needs of the UK energy industries. It was amended by the EC LCPD and was intended to progressively convert a proportion of modern coal fired generating sets to FGD by means of retrofits. Where plants were too old for retrofitting they would be closed and replaced by new modern FGD equipped stations.

Of those stations initially identified for new build or retrofit action only Drax and Ratcliffe have FGD units operating. However, the operation of these units is severely constrained by the operation of the electricity market which mitigates against coal fired, FGD equipped stations. Paradoxically, the UK is on target to meet its Large Combustion Plant targets but at the cost of a major run down of the UK deep coal mining capability, the early closure of coal fired plant and the adoption of combined cycle gas fired plant as the favoured generating technology. These costly actions would not have been necessary had the UK's initial FGD programme been implemented as anticipated.

The events of the past decade as described here, have important implications for emission abatement policy in the future. It is clear that by creating a market system for electricity, driven by profit making not simply meeting a demand, privatisation of the ESI has forced electricity generators to adopt short term, low cost, emission control options. The full costs of this strategy have fallen heavily upon the coal industry and in future, further environmental, economic and strategic impacts are likely once gas reserves and low sulphur coal reserves decline. As a means of limiting such impacts it is regrettable that long term strategic assessment was not carried out and greater attention paid to the undoubted benefits of FGD as a long term abatement technology.

References

1. Longhurst, J.W.S. Some observations on the environmental implications of the U.K. flue gas desulphurisation programme. *Environmentalist* 1988, 8 (2) 115-121.

2. Gibbs, D.C. & Longhurst J.W.S. Acid deposition abatement: assessing the economic and environmental impact of the UK FGD programme, *Acid Deposition: Sources, Effects and Controls* ed J.W.S. Longhurst, pp 309 - 327, British Library, London and Technical Communications, Letchworth, 1989.
3. Longhurst, J.W.S., Raper, D., Lee, D., Heath, B., Conlan, D.E. & King, H. Acid deposition: a select review 1852 - 1990. Part 2. *Fuel* 1993, 72 (10) 1363 -1380.
4. Bettelheim, J., Kyte, W.S., Littler, A. 50 years experience of flue gas desulphurisation at power stations in the United Kingdom. *Chemical Engineer*, 1981, 369, 275 - 284.
5. Longhurst, J.W.S. Acid Deposition, *Longmans World Guide to Environmental Issues and Organisations*, ed P. Buckley, pp 3 - 23 Longmans, London, 1990.
6. Longhurst, J.W.S., Raper, D., Lee, D.,. Heath, B., Conlan, D.E. & King, H. Acid deposition: a select review 1852 - 1990. Part 1. *Fuel* 1993 72 (9) 1261 -1280.
7. Longhurst, J.W.S., Owen, P.S., Watson, A.F.R., Conlan, D.E., & Raper, D.W. (1995) Air pollution: components, mechanisms, control and remediation. *Clean Technology and the Environment.* eds R. Kirkwood & A. Longley, pp 32 - 86, Blackie Academic, Glasgow. 1995.
8. Reid, R. & Longhurst, J.W.S. Siting and systems options in the UK FGD programme. *Environmentalist* 1990, 10 (3) 177 - 188.
9. Reiling, W. Technologies for controlling acid deposition precursor emissions from large power plants, *Acid Deposition: Sources, Effects and Controls* ed J.W.S. Longhurst, pp 301 - 308, British Library, London and Technical Communications, Letchworth, 1989.
10. Vernon, J. Technologies for control of sulphur dioxide emissions, *Acid Deposition: Sources, Effects and Controls* ed J.W.S. Longhurst, pp 287 - 299, British Library, London and Technical Communications, Letchworth, 1989.
11. Clover, C. Coal fired power plant switches off acid rain control *Guardian*, 18 November 1994.
12. British Coal Corporation, Annual Report 1993/94., British Coal, London, 1994.
13. ENDS, PowerGen's go-slow on FGD, *ENDS Report* 236, London, 1994
14. ENDS, Power generators' FGD go-slow, *ENDS Report* 238, London, 1994.
15. ENDS, Acid emissions on downward trend, *ENDS Report* 237, London, 1994.
16. ENDS, UK gets away with SO_2 abatement on the cheap, *ENDS Report* 223, London, 1994.
17. ENDS, Generators' switched off FGD units, *ENDS Report* 240, London, 1995.