Review of IPPC Improvement Condition 6

Joint Environmental Permit Support working group

March 2016

Summary

IPPC Improvement Condition 6 applies to all coal power station installations in England and Wales that have not 'opted-out' of the Large Combustion Plant Directive (LCPD):

Improvement Condition 6:
Provide a written plan of how this installation will contribute to total emissions of SO_2 from existing major coal-fired power stations in England and Wales being minimised and in any case not exceeding 70 kt/y by 2020. The report should consider scenarios for electricity demand in 2020 and give the planned arrangements for SO_2 emissions control at this installation. (Existing coal-fired stations comprise LCP that might still be operating in 2020. These are at Aberthaw, Cottam, Drax, Eggborough, Ferrybridge, Fiddlers Ferry, Ratcliffe, Rugeley, Uskmouth and West Burton). The plan should be implemented after approval by the Environment Agency.

Due date - 1st April 2008.
With updated versions by 1st April 2012 & 1st April 2016

This report is written to provide the required update of the assessment of compliance with IC6. The structure of the report follows that of the first and second response to the condition, which were sent to the Environment Agency by all relevant Operators in March 2008 and March 2012, respectively.

This study demonstrates that taking account of the uncertainties in emission projections, the SO_2 emissions in 2020 from England and Wales coal plant can be managed below 70 kilotonnes, even under extreme assumptions in the scenarios with higher generation from coal stations which reflect the uncertainties in the pathway to decarbonisation.

1 Introduction

This updated response to improvement condition 6 is a common document that has been prepared collectively by all the coal station operators in England and Wales operating plant that had not 'opted-out' of the Large Combustion Plant Directive (LCPD). The common response reflects the collective nature of the improvement condition requirement and the potential variability with respect to individual stations investment decisions that will determine their detailed operation and emissions in 2020.

Since the publication of the original IC6 response in 2008, and the 2012 update, there have been a number of significant changes, the implications of which are assessed:

- There have been significant changes to the economic outlook for the UK to 2020
- There have been significant changes to DECC energy projections reflecting significant shifts in government energy policy
- The Industrial Emissions Directive came into effect for the coal stations from 1st Jan 2016, and as a consequence plants opted for either the Transitional National Plan or the Limited Life Derogation
- Introduction of Carbon Price Floor increasing the cost of carbon within the UK
- There have been announcements of a significant generation capacity closure in 2016
- The commercialisation competition for large-scale power CCS has been withdrawn by Government.

At the present time it remains possible to provide a high level of confidence that the coal stations in England and Wales can and will, in aggregate, ensure that the total SO_2 emissions do not exceed 70 kilotonnes per annum from 2020 onwards, under a realistic range of possible future scenarios.

This conclusion is based on an analysis of both the DECC updated view of energy projections to 2020 published in November 2015 (DECC 2015), as well as the latest Future Energy Scenarios released by National Grid also in 2015 (NG 2015).

This assessment of the further reduction in SO_2 emissions from existing coal plant to 2020 should be seen against the backdrop of the process of decarbonisation of the UK electricity sector. The Committee on Climate Change report on the Fifth Carbon Budget identifies the need for investment in up to 200 TWh of new generation in the decade from 2020 to replace generation from retiring coal and nuclear capacity and to meet possible increases in demand, which would drive average CO_2 emissions intensity from of the UK power sector down to around 50-100 gCO_2/kWh in 2030, from the present values of around 450 gCO_2/kWh (CCC 2015). This substantial investment in low-carbon forms of generation and resulting displacement of coal generation output would result in significant further SO_2 emission reductions.

2 Market and regulatory context for future coal-fired generation & key decisions for operators

The Industrial Emissions Directive sets out the requirements for emission limit values for large combustion plant in the period post 2015. Coal plants have now made decisions on IED compliance routes from the available options:

1) compliance with the ELVs (including the 1,500 hour derogation which allows less onerous emission limits for plant with limited operational hours)
2) taking the limited life derogation (LLD) of 17,500 operating hours between 1/1/2016 and 31/12/2023 after which plant must close
3) entering the Transitional National Plan (TNP) between 1/1/2016 and 30/6/2020 after which plant must comply with the IED ELVs (or close)
4) close

The options selected by coal-fired plant operators in England & Wales, together with recent announcements of intention to close in 2016, are summarized in Table 1 (the stated capacities are from DUKES, 2015).

Power Station	Location	Installed Capacity [MW]	IED Decision	Announced intention / potential to close in 2016
Cottam	England	2,008	TNP	
Drax	England	3,870	TNP	
Eggborough	England	1,960	LLD	✓
Ferrybridge C	England	980	LLD	✓
Fiddler's Ferry	England	1,961	TNP	✓
Lynemouth	England	420	TNP	
Ratcliffe on Soar	England	2,000	TNP	
Rugeley	England	1,006	TNP	✓
West Burton A	England	2,012	TNP	
Wilton	England	280	TNP	
Aberthaw	Wales	1,586	TNP	
Uskmouth	Wales	363	TNP	
Kilroot	Northern Ireland	520	TNP	
Longannet	Scotland	2,260	TNP	✓

Table 1: Coal capacity, IED decisions (TNP = Transitional National Plan, LLD=Limited Life Derogation) and announcements of intention to close in 2016.

As can be seen from the table, coal capacity in the UK will substantially decrease before 2020: the newly announced closures of coal plant at Fiddler's Ferry (potential for three of the four units) and Rugeley, in addition to the previous announcements from Eggborough, Ferrybridge C and Longannet, brings the potential total loss of coal plant in 2016 to nearly 8GW. All closing plant cited the challenging market conditions for coal at present as reasons for closing earlier than previously scheduled.

Some of the plant that announced closure in 2016, might however tender for alternative grid support contracts including (but not limited to) the National Grid's SBR (Supplemental Balancing Reserve: a new service designed to support National Grid in balancing the system in the unlikely event that there is insufficient capacity in the market to meet demand). SBR is targeted at generators who would otherwise be closed, mothballed or generally unavailable to the market, and would only be used as a last resort by the system operator after all commercial balancing actions have been taken. Consequently, if securing an SBR contract, plant might still remain

operational, ready to be called to boost supply margins in times of very high system stress. SBR contracts are only effective for a four month winter period (between November and end of February), therefore operation for this type of contract would be time limited. For winter 2016/17 SBR contracts have been signed with Fiddler's Ferry (422 MW de-rated capacity) and Eggborough (681MW), as noted in National Grid (2016). It is worth noting that the contribution to annual SO_2 emissions from plant under the SBR might be expected to be very minor (due to the low number of running hours, if any at all). Furthermore, the SBR is an annual service and there is no guarantee on its continuity. National Grid has indicated that SBR will end once the new Capacity Mechanism is implemented, which mean SBR is discontinued before 2020.

All LCP permits required review as part of the IED implementation process and plant under the Limited Life Derogation and Transitional National Plan were required to have SO_2, NOx and dust ELVs as permitted on 31/12/15 at least maintained. These reviews are necessary to ensure that permit conditions deliver IED requirements and continue to reflect BAT in the period between 2016 until the new BAT AELs must be complied with i.e. 4 years from the date of publication of the BAT conclusions by the Commission.

At the end of the TNP (on 30/6/2020), emissions from plant that entered the TNP will be regulated under Annex V of the IED and operators might opt to achieve compliance with the stringent emission limit values imposed by the IED (for NOx, SO_2 and dust; the ELV for SO_2 is set to 200mg/Nm^3) or opt to move to the 1,500 hour derogation. This choice will be driven to a significant extent by operator choices for compliance with the IED NOx limits. This is because any plant intending to comply with the Annex V ELVs from 2016 onwards will need to reduce daily NOx emission rates to at least 200mg/Nm^3 or to 450 mg/Nm^3 if operating for less than 1500 hours pa (as a five year average). BAT requirements based on the revised LCP BREF may require further reductions. One possibility of achieving this reduction is by installing selective catalytic reduction (SCR), although a combination of other technologies may also provide the necessary level of performance, particularly if plant opt for the limited hours (1500 hour) derogation.

For coal-fired power stations both future generation levels and investment decisions depend fundamentally on the factors below:

- The future design of the UK electricity market and Government decisions on the phase out of coal-fired power stations
- The efficiency and condition of the station and the expected remaining life of key components
- Future fuel prices
- Future electricity price and volume demands
- Future carbon price support rate of the Climate Change Levy
- Future of the Capacity Market (or similar measures such as National Grid tenders for Supplementary Balancing Reserve)
- Prospect of subsidy for biomass conversion (or co-firing)
- Future environmental constraints

There are major uncertainties in all these factors. However, for the current purposes the following broad assumptions can be made for operation at the end of 2020:

- Plant that invests in NOx reduction will not be subject to restricted running hours and, under favourable market conditions, would have the flexibility to run at a reasonably high load factor in order to recover the investment. This includes plant that moves from a TNP to an ELV compliance regime before

30/6/2020. All such plant will be equipped with FGD as the principal means of lowering SO_2 emissions.

- Plant that does not invest in NOx reduction will close or operate in a low load peaking to mid-merit role. This includes:
  - the 17,500 hour derogation (with plant closing by 31/12/2023) or
  - the 1,500hr derogation.

  All such plant will be equipped with FGD as the principal means of lowering SO_2 emissions, in line with the 'no backsliding' approach to BAT.

Emissions up to the end of the TNP (on 30/6/2020) are examined in the following Section, while a set of scenarios for emissions after the closure of the TNP is analysed in Section 7.

In order to take account of possible coal to biomass conversions for the stations subject to this collective improvement condition, the scenarios consider future energy projections for biomass and coal in combination.

3 Transitional National Plan

Through the operation of a Transitional National Plan (TNP), the Industrial Emissions Directive (IED) allows certain large combustion plants (LCPs) an additional four and a half years in which to make the necessary investments in emissions abatement technology, whilst continuing to operate to ensure security of energy supply, to achieve compliance with the stringent IED emission limits for three key pollutants (nitrogen dioxides, sulphur dioxide, and dust). Following a full impact assessment undertaken by DEFRA, the implementation of the TNP in the UK is expected to allow a reduction in emissions of air pollutants, in a more cost-beneficial manner, see Defra (2015).

The option to participate in the plan was available to combustion plants which were granted their first permit before 27 November 2002, or the operators of which had submitted a complete application for a permit before that date, provided the plant was put into operation no later than 27 November 2003. All UK coal-fired power stations fall in this category and the majority of operators to which this improvement condition applies decided to include their units into the TNP (see Table 1).

The TNP operates on the basis that each plant within the plan contributes to a total annual emissions ceiling for one or more of the pollutants (NOx, SO_2, and dust), based, in 2016, on the actual operation of each plant between 2001 and 2010 and the ELVs which applied to those plants under the Large Combustion Plants Directive (LCPD). Together, these contributions create an overall cap within the TNP that is reduced, year on year, on a linear basis. In 2019 and 2020, the cap is based on the ELVs set out in Annex V of the IED.

Each plant within the TNP is allocated a total allowance of annual emissions which they must stay within based on their contribution to the overall ceiling. However, in order to allow plants to invest in technologies to reduce their emissions in the most cost-effective way, a cap and trade scheme has been included in the UK TNP Regulations. This cap and trade system will enable plants which invest early to sell, if they so choose, an unused part of their annual allowance to other plants which have not yet made the investment. Overall, the total maximum amount of emissions from plants within the TNP in a given year will be the same.

The contribution of coal-fired plant in the TNP to the SO_2 TNP Emission Ceiling are reported in Table 2 (Annex B of Defra, 2015). It is worth noting that the values reported for 2020 only refer to the first 6 months of this year, as the TNP comes to an end on 30 June 2020.

Power Station	Installed Capacity [MW]	Contribution to SO_2 Emission Ceilings (tonnes per annum)				
		2016	2017	2018	2019	2020 (6 months)
Aberthaw	1,586	9,444	7,870	6,296	4,722	2,361
Cottam	2,008	13,742	11,452	9,161	6,871	3,435
Drax	3,870	33,035	27,529	22,023	16,517	8,259
Fiddler's Ferry	1,961	9,934	8,278	6,623	4,967	2,484
Lynemouth	420	4,319	3,599	2,879	2,159	1,080
Ratcliffe on Soar	2,000	14,208	11,840	9,472	7,104	3,552
Rugeley Power	1,006	7,036	5,863	4,691	3,518	1,759
Uskmouth Power	363	1,446	1,205	964	723	362
West Burton A LCP1	2,012	6,336	5,280	4,224	3,168	1,584
West Burton A LCP2		6,240	5,200	4,160	3,120	1,560
Wilton	280	1,510	1,097	683	270	135
TNP: England and Wales (2020 6 months only)	15,506	**107,250**	**89,213**	**71,176**	**53,139**	**26,571**
Kilroot	520	3,616	3,014	2,411	1,808	904
Longannet	2,260	13,440	11,210	8,980	6,750	3,375
TNP: UK (2020 6 months only)	18,286	124,306	103,437	82,567	61,697	30,850

Table 2: contribution of coal-fired plant to the SO_2 TNP Emission Ceiling - from Defra, (2015) – Annex B. It should be noted that the emissions ceiling for 2020 covers only the period 1 January - 30 June 2020 (this is because the TNP will finish on 30 June 2020). Additional contributions to annual SO_2 emissions from coal-fired plants in England and Wales could come from Eggborough and Ferrybridge C, which opted for the Limited Life Derogation and do not operate within the TNP (see Table 1).

As can be seen from Table 2, the total allowance of annual SO_2 emissions assigned to the fleet of coal plant within the TNP in England and Wales is, by 2020, around 53 $ktSO_2$, well below the 70 kilotonnes of the Improvement Conditions. Additional contributions from Eggborough and Ferrybridge C (which do not operate within the TNP, but under the Limited Life Derogation and announced intention to close in 2016) should be added to this value, but they might be expected to be well within the substantial headroom for compliance with the Improvement Condition.

If plants that announced intention to close in 2016 were to be excluded, all the coal-fired plant operational in 2020 would be regulated under the TNP, and their contribution to the SO_2 emission Ceiling will be below $45ktSO_2$.

This evidence although compelling is not conclusive, due to the unquantified contribution from the two plants under LLD and as the UK TNP Regulations includes a cap and trade scheme, so that emissions from coal-fired plant might, in principle, exceed their assigned quotas by purchasing spare allowances from plants outside the power sector (however, given the low projections for coal generation discussed in the sections below, this is unlikely).

The aim of the rest of this study is to demonstrate a very high level of confidence that the SO_2 emissions in 2020 from England and Wales coal plant will be below 70 kilotonnes, even under extreme scenarios, with high generation from coal stations (to reflect uncertainties in the pathway to decarbonisation) and extreme assumptions for future SO_2 emission levels.

4 Future demand for electricity and coal/biomass-fired generation

4.1 DECC Projections

Two scenarios for 2020 emissions from Major Power Producers have been derived, according to the latest DECC projections released in November 2015 (DECC 2015). The DECC projections take account of 'planned' policies, where decisions on policy design are sufficiently advanced to allow robust estimates of policy impacts to be made. As in previous years, the DECC Projections consist of a:

- *Reference Scenario*, based on central estimates of economic growth and fossil fuel prices.

and a range of alternative scenarios, modelled to indicate the sensitivity of the outputs to key model assumptions, more specifically:

- *Low prices scenario,* assumptions similar to reference scenario but with lower projected fossil fuel prices
- *High prices scenario,* assumptions similar to reference scenario but with higher projected fossil fuel prices
- *Low growth scenario*, assumptions similar to reference scenario but with lower projected economic growth
- *High growth scenario*, assumptions similar to reference scenario but with higher projected economic growth

The 2020 activity rates projected by DECC for Major Power Producers' coal-fired plant are summarized in Table 3:

Scenario coal DECC 2020	Capacity [GW]	Load Factor [%]	Generation [TWh]
'Reference'	10.9	47.0%	44.7
'Low Prices'	6.0	1.0%	0.5
'High Prices'	12.9	44.8%	50.8
'Low Growth'	10.9	46.6%	44.4
'High Growth'	10.9	47.4%	45.1

Table 3: activity rates in 2020, as derived under the 'reference' and the four DECC 'sensitivity' Scenarios. Electricity generation is defined here as 'Supplied (gross)', i.e. gross generation less the amount of electricity used on station sites (own use).

It is worth noting that the DECC Projections refers to the whole United Kingdom, the values reported in Table 3 therefore also includes contributions from Scotland (Longannet) and Northern Ireland (Kilroot).

It is also worth noting that DECC projects 0.6 GW of '*Coal and natural gas CCS*' capacity in 2020. However, after the projections were released by DECC, Government announced that the 'up to £1 billion' of support for large-scale power CCS (as part of 'Phase 1' of CCS commercialisation programme) would no longer be available. With the commercialisation competition no longer in place, the 0.6 GW of '*Coal and natural gas CCS*' capacity projected by DECC for 2020 appear most unlikely and is therefore not further considered in this work (their eventual inclusion would not alter the conclusion of the assessment).

Projected activity rates for biomass conversion or co-firing are not disclosed by DECC (2105). The most recent DECC projected values in public domain are those released by DECC in November 2013 (in response to a request under the Freedom of Information Act, see DECC, 2013). The 'Biomass Conversion' rates projected for 2020 are reported in Table 4.

Scenario DECC 2020 biomass	Capacity [GW]	Load Factor [%]	Generation [TWh]
'Reference'	2.6	74.6%	17.3
'Low Prices'	2.6	74.3%	17.2
'High Prices'	2.6	74.5%	17.3
'Low Growth'	2.6	74.5%	17.3
'High Growth'	2.6	74.6%	17.3

Table 4: activity rates for 'biomass conversion' projected for 2020 under the DECC Projections released in 2013 (the latest of this kind of data in public domain).

Table 4 suggests that the activity rates for biomass conversion are insensitive to the underlying assumptions.

4.2 National Grid Scenarios

Instead of the DECC approach, which consists in a 'reference' central scenario and a range of 'sensitivity' scenarios, National Grid aim at the identification of four 'extreme' scenarios that should establish a plausible envelope for the actual development of future generation. This set of four scenarios might consequently be used to test options for future electricity markets, see NG (2015).

The four 'extreme' scenarios presented by National Grid in 2015 were derived under different narrative and assumptions and were labelled: '*Gone Green*', '*Slow Progression*', '*No Progression*' and '*Consumer Power*', see NG (2015).

2020 activity rates for Major Power Producers' coal-fired plant, under the four scenarios are reported in Table 5:

Scenario NG 2020 coal	Capacity [GW]	Load Factor [%]	Generation [TWh]
'Gone Green'	8.7	33.6%	25.5
'Slow Progression'	9.9	41.6%	36.2
'No Progression'	10.4	41.4%	37.8
'Consumer Power'	9.4	15.3%	12.6

Table 5: activity rates in 2020 for Major Power Producers' coal-fired plant, derived under the four 'extreme' scenarios analysed by National Grid.

Similarly to the DECC Projections, the National Grid scenarios refers to the whole United Kingdom, the values reported in Table 5 therefore also includes contributions from Scotland (Longannet) and Northern Ireland (Kilroot).

No coal CCS by 2020 is projected by National Grid under their four scenarios.

In case of biomass conversion or co-firing, only estimates for future installed capacity are reported by National Grid. Their values in 2020 (for biomass plants connected to the transmission grid) are shown in Table 6.

Scenario NG 2020 biomass	Capacity [GW]
'Gone Green'	3.2
'Slow Progression'	2.5
'No Progression'	2.5
'Consumer Power'	2.5

Table 6: capacity of biomass-firing plants connected to the transmission grid, under the four 'extreme' scenarios analysed by National Grid (corresponding values for generation are not available).

Their values are relatively similar to the ones projected by DECC (see Table 4), apart from the 'Gone Green' scenario where presumably some additional coal-fired capacity is converted to biomass (compare Table 5 and Table 6).

4.3 Emission Scenarios

Based on the DECC and the National Grid studies, three 2020 emission scenarios are further investigated in this work:

- a '*central view*', which reflects the SO_2 emissions associated with the DECC 'reference' scenario;
- two '*upper case*' scenarios for SO_2 emissions,
  - the first based on the DECC projections, but in association with the 'high prices' scenario: the DECC sensitivity scenario that, as can be seen from Table 3 and 4, is characterized by the highest generation by coal- and biomass-fired plant.
  - the second based on the latest National Grid Scenarios, but in association with the 'no progression' scenario: the National Grid pathway that, as can be seen Table 5 and 6, is characterized by the highest generation by coal- and biomass-fired plant.

The main properties of the three selected scenarios are summarized below:

Scenario	fuel	[GW]	Load Factor [%]	Generation [TWh]
DECC 'central view'	coal	10.9	47.0%	44.7
	biomass	2.6	74.6%	17.3
DECC 'upper case'	coal	12.9	44.8%	50.8
	biomass	2.6	74.5%	17.3
NG 'upper case'	coal	10.4	41.4%	37.8
	biomass	2.5	75.0%	16.7

Table 7: activity rates in 2020, under the three scenarios analysed in this work.

Biomass annual generation under the National Grid 'upper case' scenario has been derived under the assumption of an annual load factor of 75%. This is in line with the 74.6% projected by DECC (see Table 4) and more optimistic than the 70% 'average availability' suggested by National Grid for (transmission connected) biomass, in NG (2015).

5 Reduction of SO_2 emissions

Historic emission trends

Figure 1 shows the trend of annual total SO_2 emissions from England and Wales coal power stations from 1997 to 2014 (excluding opted out plant). The picture is one of a significant reduction in emissions over this period, with a levelling out of the trend over the last 7 years as compliance with LCPD using FGD is achieved by these stations (variations in emission over this period are mainly a consequence of market-driven variations in the contribution by coal-fired plant to electricity generation).

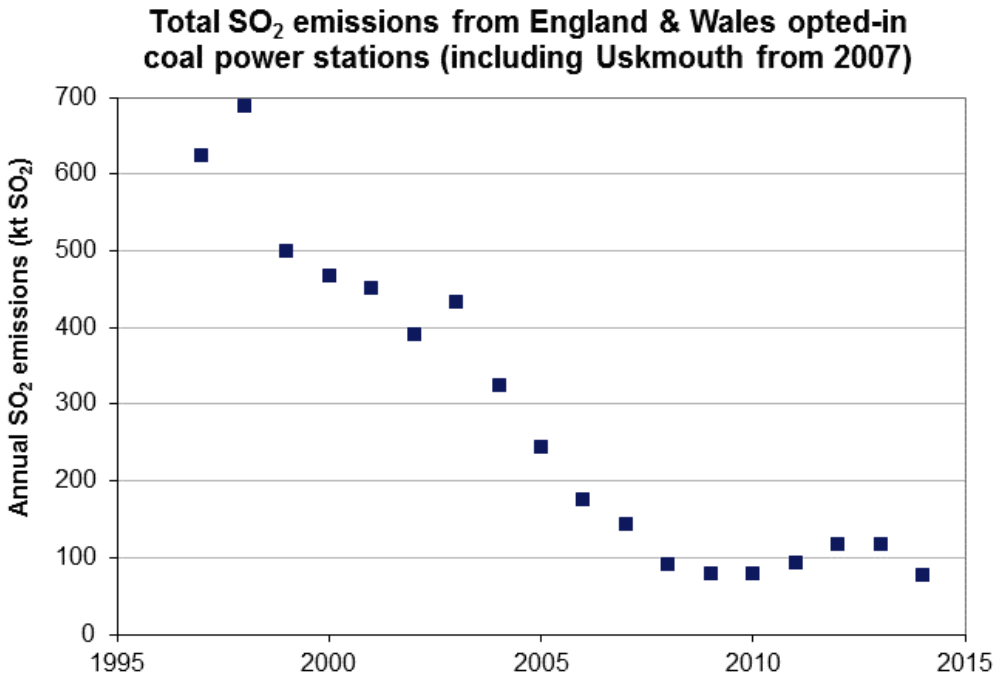

Figure 1: total SO_2 emissions between 1997 and 2014 from England and Wales coal-fired power stations (excluding those opted out under the LCPD)

The trend of emissions per unit of generation for each power station is shown in Figure 2. It is evident that there has been a dramatic reduction over the period in both the emissions per GWh at station level, and also in the range of emission factors across this group of coal-fired power stations.

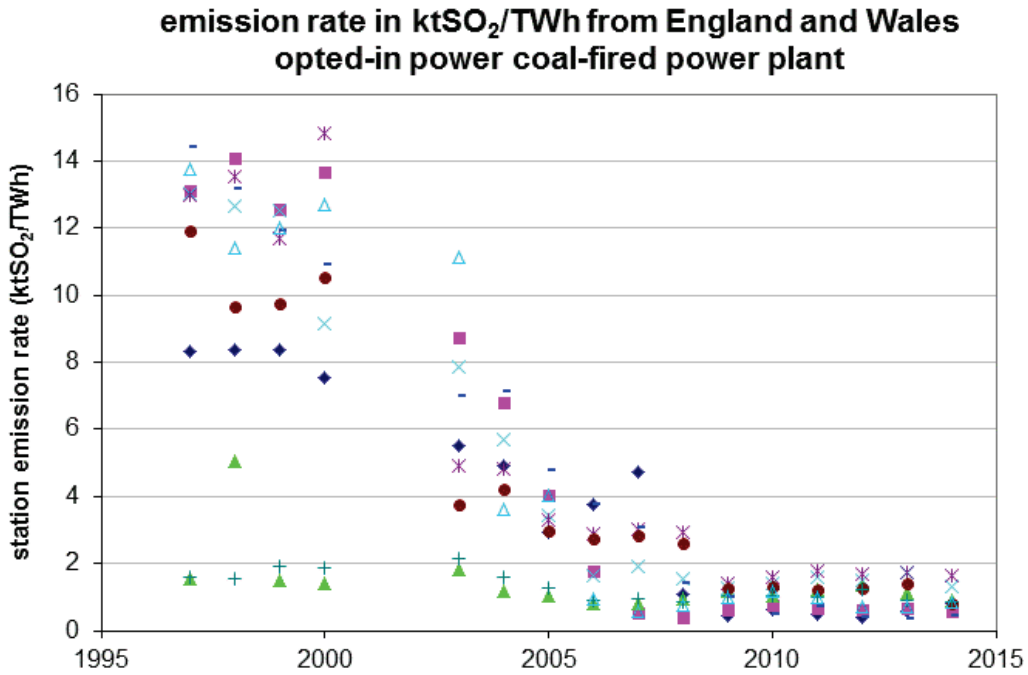

Figure 2: individual station SO_2 emissions/TWh between 1997 and 2014 from England and Wales coal-fired power stations (excluding those opted out under the LCPD, and Uskmouth)

6 Post TNP emission levels

From the 1st of July 2020, coal-fired and biomass-converted Large Combustion Plants (LCPs) under the Transitional National Plan will operate either under:

- the IED Emission Limit Values (ELV) or
- the Limited Hours Derogation (<1,500 operating hours per year)

while, plant that opted for:

- the Limited Life Derogation (17,500 operating hours between 1/1/2016 and 31/12/2023)

will continue to operate under this regime.

The associated annual emissions can then be estimated by multiplying annual generation (in TWh) for each of these three classes by corresponding 'emission rates' (expressed as $ktSO_2$/TWh):

$$\underset{[kt]}{Emission} = \underset{[TWh]}{Gen_{ELV}} \cdot \underset{[kt/TWh]}{Em\,Rate_{ELV}} + \underset{[TWh]}{Gen_{LHD}} \cdot \underset{[kt/TWh]}{Em\,Rate_{LHD}} + \underset{[TWh]}{Gen_{LLD}} \cdot \underset{[kt/TWh]}{Em\,Rate_{LLD}}$$

where Gen_{ELV}, Gen_{LHD} and Gen_{LLD} are the generation associated with plant operating under the IED ELVs, the Limited Hour Derogation (LHD) and the Limited Life Derogation (LLD), respectively and $Em\ Rate_{ELV}$, $Em\ Rate_{LHD}$ and $Em\ Rate_{LLD}$ are the corresponding emission rates.

Maximum SO_2 emissions in 2020 have then been estimated under the following assumptions:

- Consistent with the aim of estimating maximum emissions (and consistent with the DECC and National Grid Scenarios), all the considered LCPs are assumed to be existing plants (ELVs for existing plants are higher than those for new plants)
- Following EA (2014), emission rates of 300mg/Nm^3 and 350mg/Nm^3 for SO_2 are assumed in estimating emissions from 'baseload'[1] and 'mid-merit'[2] plant, respectively, under Limited Life Derogation or Limited Hours Derogation (this choice is consistent with the aim of estimating maximum annual emissions, as there is the potential under the IED for tighter emission standards to be specified through the revision of the LCP BAT Reference Document).
- Consistent with the DECC Projections (all of them assigning a load factor >70% to biomass-converted plants) biomass-fired plants are assumed not to opt for LLD and therefore, over the period of interest, to be compliant with the IED ELVs (for existing biomass-fired plants);
- When opting for the Limited Life Derogation, the operator of the LCP makes the commitment not to operate the plant for more than 17,500 operating hours, starting 01/01/16 and ending no later than 31/12/23, it is however not known how these 17,500 hours will be distributed over this time period. Due to this flexibility, in the present assessment, the number of hours run by LCPs that opted for the Limited Life Derogation has not been constrained; the only requirement is that, for commercial reasons, the load factor of plants running under these derogations should not be higher than those of plants compliant with the IED ELVs. In the results reported in the next section (aiming at identifying maximum emissions associated with the DECC Projections and the National Grid future scenarios) the most conservative assumption is made: that coal-fired plant under the IED ELVs and LLD run at the same load factor.

[1] 'baseload' is defined as: >4000 operating hours per annum

[2] 'mid merit' is defined as: 1500-4000 operating hours per annum

- Similarly, the operational constraint under the Limited Hours Derogation (1,500 operating hours per year) is defined as a rolling average over a period of 5 years (starting from the date the derogation is taken). Also in this case it is not known in advance how the permitted operating hours is going to be distributed in time. A protocol was however recently agreed between Operators and Regulators, see Energy-UK (2015). The protocol, which applies in England and Wales requires, among others, that operation in any individual year should not exceed 2,250 hours. In the results reported in the next section (aiming at identifying maximum levels of SO_2 emissions) the most conservative assumption is made: that all coal-fired plant under the LHD run for 2,250 hours in 2020 (i.e. at an annual load factor of 25.7%).

The emissions rates used in the estimation of maximum emissions in 2020 (consistent with EA, 2014) are summarized in Table 8:

	SO_2	
	mg/Nm^3	kt/TWh
Coal – Emission Limit Values (existing plant)	200	0.73
Coal – Limited Life Derogations (baseload[1])	300	1.10
Coal – Limited Hours or Limited Life Derogations (mid-merit[2])	350	1.28
Biomass – Emission Limit Values (existing plant)	200	0.73

Table 8: assumed emission factors for SO_2 in mg/Nm^3 and kt/TWh.

7 Maximum SO_2 emissions in 2020

Following the assumptions developed in the previous Section, maximum plausible levels of SO_2 emissions in 2020 can be calculated, under each of the three scenarios in Table 7, by implementing the following approach:

- assume that 2.94GW of coal-fired capacity (Eggborough and Ferrybridge C) operates under the Limited Life Derogation (this is a conservatively high emissions assumption as these stations are very likely to have closed by 2020, based on announcements by their operators);
- the additional capacity projected by DECC or National Grid in 2020 has to be split between plant operating under the IED ELVs and plant operating under the Limited Hours Derogation. The split ratio is selected in such a way that SO_2 emissions in 2020 are maximized, under the assumptions that:
  - plant under the LHD run for a maximum of 2,250 hours in 2020;
  - the load factor of plant operating under ELVs (and assumed to be matched by those operating under the Limited Life Derogations) should not exceed 90%.
- as the DECC and National Grid scenarios were developed before the recent announcements of plant closures (and only results aggregated at UK level have been disclosed), the resulting UK maximum annual emissions are then re-distributed across England, Wales, Scotland and Northern Ireland, using the simplifying assumption of a proportionality between emission levels and installed capacities. The shares of installed capacity (derived by Table 1) are:

	England	Wales	Scotland	Northern Ireland
Capacity [GW]	16.5	1.9	2.3	0.5
Capacity [%]	77.7%	9.2%	10.6%	2.4%

The obtained results, under each of the three scenarios, are summarized below.

7.1 'central scenario' - DECC

Following Table 7, under this scenario, the UK fleet in 2020 is characterized by a (coal-fired, biomass-converted) capacity of 13.5 GW and an annual generation of 62.0 TWh. Maximum annual SO_2 emissions are obtained under a scenario where only around 5% of the available UK capacity opts for compliance with the IED ELVs at the end of the TNP and all plant run at maximum allowable load factor (90% for ELVs compliant and those under LLD, 2,250 hours for those under LHD). The results are summarized in Table 9 below.

Category	Capacity	Load Factor	Generation	2020 Annual Emissions
	[GW]	[-]	[TWh]	$ktSO_2$
existing coal ELVs	0.7	90.0%	5.2	3.8
existing coal LLD	2.9	90.0%	23.2	25.5
existing coal LHD	7.3	25.7%	16.3	20.9
biomass	2.6	74.6%	17.3	12.7
Total UK	13.5		62.0	**62.9**
Total England & Wales	11.7		54.1	**54.7**

Table 9: Estimation of the maximum SO_2 annual emissions in 2020, compatible with the DECC 'central view' in Table 7

The estimated maximum SO_2 emissions of 54.7 $ktSO_2$ (for England and Wales) are well below the 70 $ktSO_2$ of the IPPC Improvement Condition 6.

7.2 'upper scenario' - DECC

Following Table 7, the UK fleet in 2020 under the DECC 'upper case' scenario is characterized by a (coal-fired, biomass-converted) capacity of 15.6 GW and an annual generation of 68.1 TWh. Maximum annual SO_2 emissions are obtained under a scenario where only around 6% of the available UK capacity opts for operating under ELVs and, as before, all plant run at maximum allowable load factor.

Category	Capacity	Load Factor	Generation	2020 Annual Emissions
	[GW]	[-]	[TWh]	$ktSO_2$
existing coal ELVs	0.9	90.0%	7.2	5.3
existing coal LLD	2.9	90.0%	23.2	25.5
existing coal LHD	9.1	25.7%	20.4	26.2
Biomass	2.6	74.5%	17.3	12.6
Total UK	15.6		68.1	**69.6**
Total England & Wales	13.5		59.2	**60.5**

Table 10: Estimation of the maximum SO_2 annual emissions in 2020, associated with the DECC 'upper case' scenario in Table 7

Even under the most unfavourable DECC projection and extreme assumptions for the composition and running schedule of the coal-fired fleet in 2020, the estimated maximum SO_2 emissions of 60.5 $ktSO_2$ (for England and Wales) are below the 70 $ktSO_2$ of the IPPC Improvement Condition 6.

7.3 'upper scenario' – National Grid

Under this scenario, the UK fleet in 2020 is characterized by a (coal-fired, biomass-converted) capacity of 13.0 GW and an annual generation of 54.5 TWh. An implementation of the procedure outlined at the beginning of this Section results in maximum annual SO_2 emissions of 56.9ktSO_2 (for the whole UK). This are associated with a scenario where no coal-fired plant opts for operating under the IED ELVs, but all capacity adopts the Limited Hours Derogation at the end of the TNP, see Table 11.

Category	Capacity	Load Factor	Generation	2020 Annual Emissions
	[GW]	[-]	[TWh]	ktSO_2
existing coal ELVs	0	-	0	0
existing coal LLD	2.9	81.5%	21.0	23.1
existing coal LHD	7.5	25.7%	16.8	21.5
biomass	2.5	75.0%	16.7	12.3
Total UK	13.0		54.5	**56.9**
Total England & Wales	11.3		47.4	**49.4**

Table 11: Estimation of the maximum SO_2 annual emissions in 2020, associated with the National Grid 'upper case' scenario in Table 7

The maximum SO_2 emissions of 49.4 ktSO_2 (for England and Wales) estimated under the National Grid scenarios are well below the 70 ktSO_2 of the IPPC Improvement Condition 6.

8 Conclusions and future actions

This study has shown that, taking account of the uncertainties in emission projections to 2020, the SO_2 emissions from relevant England and Wales coal plant will be less than 70 kilotonnes, even under the DECC projections and National Grid scenarios with higher coal-fired generation (which reflect the uncertainties in the pathway to decarbonisation) and under most extreme assumptions on the running schedule of plant under the IED Derogations (Limited Life Derogation or Limited Hours Derogation) in 2020.

For this reason it is concluded that no specific actions are justified as a result of this updated assessment.

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