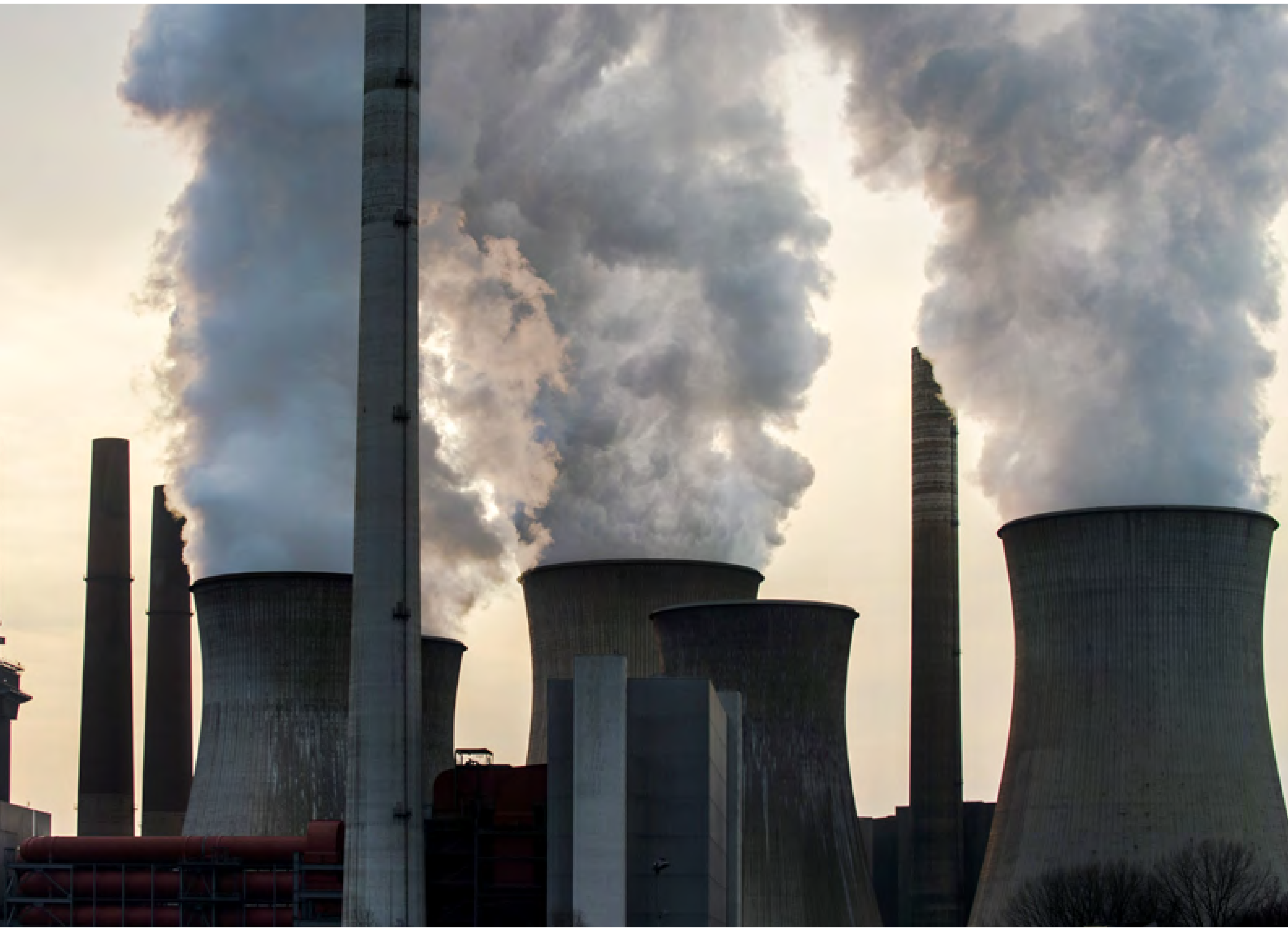
HEALTH AND ECONOMIC IMPLICATIONS OF ALTERNATIVE EMISSION LIMITS

FOR COAL-FIRED POWER PLANTS IN THE EU



EUROPEAN ENVIRONMENTAL BUREAU

GREENPEACE

Toxic coal - counting the cost of weak EU air pollution limits

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CONTENT

1. INTRODUCTION

1.1 OBJECTIVES

The purpose of this paper is to quantify the damage to health, crops and materials associated with emissions from 290 large combustion plant in Europe, burning fossil fuels, and then to compare the results for two scenarios:

- **Draft BREF:** Emissions in line with the upper end AELs of the draft BAT Reference (BREF) Note for large combustion plant (draft, April 2015)[1].
- **BAT:** Emissions under best available techniques (BAT), taken as the lower end of the AEL ranges given in the draft LCP BREF, supplemented by performance data for operating power plants in China, Japan and the U.S.[2]

As noted below, there are significant differences in emission limits under the draft BREF. It is therefore informative to understand what the consequences of these differences are, particularly for health impacts.

It has not been possible to take account of the exclusion of levels for peak load plants (1,500 hours averaged over 5 years) and emergency boilers (<500 hours per year).

1.2 EMISSION LIMITS

Emission limits under the Draft BREF and BAT (as adopted in this report), are shown in Table 1. The draft BREF provides BAT-AELs as a range, and it is immediately clear that for SO_2, PM and mercury there are order of magnitude differences across this range. For NOx the difference is smaller, but still substantial at about a factor 3. The BAT levels in the table are at or around the lower end of the BREF AELs.

	MWth, >	SO_2	NOx	dust	Hg
Draft BREF	50	360	270	20	9[a] , 10[b]
	100	200	180	20	9[a] , 10[b]
	300	130	150[a] , 180[b]	15	4[a] , 10[b]
	1000	130	150[a] , 180[b]	10	4[a] , 10[b]
BAT	50	70	100	2	1[a] , 2[b]
	100	70	100	2	1[a] , 2[b]
	300	10	65[a] , 50[b]	1	1
	1000	10	65[a] , 50[b]	1	1

Notes: (a) coal, (b) lignite
Table 1. Emission limits for existing facilities under the draft BREF and BAT scenarios, mg/m3 except for Hg, µg/m3.

1 Best Available Techniques (BAT) Conclusions for Large Combustion Plant, TL/JFF/EIPPCB/Revised LCP_Draft 1 , April 2015

2 Greenpeace 2015: Smoke & Mirrors: How Europe's biggest polluter became their own regulators.

2. METHODS

2.1 HEALTH IMPACT ASSESSMENT

The health impact assessment provided here is based on methods used in evaluation of proposals made by the European Commission for advancing air quality policy, and methods used by the European Environment Agency for characterisation of the impacts and economic damage associated with all plant reporting emissions to the E-PRTR (European - Pollutant Release and Transfer Register). Key references are:

- WHO-Europe (2013a): Review of Evidence on Health Aspects of Air Pollutants (REVIHAAP)[3]
- WHO-Europe (2013b): Recommendations on response functions for air pollutant impacts on health through the 'Health Risks of Air Pollution in Europe' (HRAPIE) study[4]
- European Commission (2013): The proposal for the Clean Air Policy Package[5]
- Holland (2014a): Development of methods for health impact assessment using the HRAPIE recommendations[6]
- Holland (2014b): The cost benefit analysis of the European Commission's Clean Air Policy Package[7]
- European Environment Agency (2014): Study of the costs of air pollution from European industrial facilities, 2008-2012[8].

2.2 OVERVIEW OF METHODS

The basis for the methods used here is the impact pathway approach developed under the ExternE project (ExternE, 1995, 1999, 2005) and the CBA for the Clean Air For Europe (CAFE) Programme, and illustrated in Figure 1. This approach follows a logical progression from emission, through dispersion and exposure to quantification of impacts and their valuation.

3 http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2013/review-of-evidence-on-health-aspects-of-air-pollution-revihaap-project-final-technical-report

4 http://www.euro.who.int/__data/assets/pdf_file/0006/238956/Health-risks-of-air-pollution-in-Europe-HRAPIE-project,-Recommendations-for-concentrationresponse-functions-for-costbenefit-analysis-of-particulate-matter,-ozone-and-nitrogen-dioxide.pdf

5 http://ec.europa.eu/environment/air/clean_air_policy.htm

6 http://ec.europa.eu/environment/air/pdf/CBA%20HRAPIE%20implement.pdf

7 http://ec.europa.eu/environment/air/pdf/TSAP%20CBA.pdf

8 http://www.eea.europa.eu/publications/costs-of-air-pollution-2008-2012

Emission
(NH_3, NOx, $PM_{2.5}$, SO_2, VOCs)

▼

Dispersion, atmospheric chemistry
(primary and secondary particles, ozone, NO_2)

▼

Exposure
(people, crops, buildings, etc.)

▼

Impact
(mortality, morbidity, crop loss, materials damage, etc.)

▼

Economic value

Figure 1.

Impact Pathway Approach, tracing the consequences of pollutant release from emission to impact and economic value.

The general form of the equation for the calculation of impacts is:

Impact = Pollution level x Stock at risk x Response function

Pollution may be expressed in terms of:

- Concentration, for example in the case of impacts to human health impacts where exposure to the pollutants of interest in this study occurs through inhalation, or
- Deposition, for example in the case of damage to building materials where damage is related to the amount of pollutant deposited on the surface.

The term 'stock at risk' relates to the amount of sensitive material (people, ecosystems, materials, etc.) present in the modelled domain. For the health impact assessment, account is taken of the distribution of population and of effects on demographics within the population, such as children, the elderly, or those of working age. Incidence rates considered representative of the rate of occurrence of different health conditions across Europe (by country to the extent that data permit) are used to modify the stock at risk for each type of impact quantified.

Analysis for the European Commission is based around detailed pan-European modelling of pollution control measures. For each scenario models are run to describe the concentration field across Europe for fine particles and ozone (the two pollutants most associated with health impact) and other pollutant species. The modelling works accounts for both the spread of pollutants from source, and their chemical reaction in the atmosphere, leading to the formation of ozone from NOx and VOC emissions, and 'secondary' particles from reactions involving, for example, NH_3, NOx and SO_2.

A simplified approach has been developed for work by the European Environment Agency in quantifying damage on a plant by plant basis using data from the European-Pollutant Release and

Transfer Register (E-PRTR) (EEA, 2014). This utilises the same pollutant transfer matrices generated using outputs from the EMEP model that are used in the full scenario analysis for the European Commission. Here, they are applied, in combination with the recommendations of WHO (2013b) and Holland (2014) to generate estimates of average damage per unit emission for each country (reproduced in Appendix 1). Once emissions are known for a plant, these damage per tonne estimates can be applied to provide an indication of the broad magnitude of damage associated with that plant. It is acknowledged that the use of data averaged at the national level can lead to significant error for individual facilities. However, when applied to a number of facilities within any country these errors are likely to average out.

EEA (2014) also includes in Annex 3 damage estimates for toxic metals and other substances (arsenic, cadmium, chromium, lead, mercury, nickel, 1,3 buta-diene, benzene, PAHs, formaldehyde and dioxins and furans. Whilst analysis of the effects of releases of NH_3, NOx and the other pollutants considered above considers only exposure through inhalation, analysis of a number of these trace pollutants requires consideration also of exposure through consumption of food and water. The analysis therefore accounts for transfer of pollutants through the food chain, as well as dispersion in the atmosphere.

For some of these trace pollutants country-specific estimates of damage per tonne are provided, whilst for others (including mercury), results are provided for analysis at European and global scales. This distinction recognises that damage associated with some pollutants is unlikely to be affected greatly by the site of release. Mercury, for example, travels widely once released. When taken up by fish it enters what is now a global food chain. At each step of this pathway analysis becomes less and less specific to the site of release.

2.3 EMISSIONS DATA

Identification of large coal-fired facilities was performed for the Greenpeace Silent Killers report in 2013[9], and that list is used. The main fuel type for each facility was taken from Platts World Electric Power Plants (WEPP) database, March 2014 version[10]. Emissions data for the Current Scenario are taken from information reported by operators to the E-PRTR[11].

Table 1 (above) shows that emissions under the draft BREF and BAT are both a function of the size of plant: Due to economies of scale, more advanced technologies may be fitted to larger plant than smaller facilities. The E-PRTR does not contain information on the thermal capacity of facilities, so maximum reported CO_2 emissions are used in this analysis to approximate thermal capacity in order to estimate what emissions would be under the Draft BREF and BAT scenarios. CO_2 emissions from a reference facility operating with 75% load factor and firing bituminous hard coal were used as the threshold. This assumption has been tested over a wide range (0 to 100% load factor; CO_2 emission factors ranging from sub-bituminous to lignite coal) and is found to have negligible impact on the overall results. CO_2 data were missing for 9 of the 290 facilities considered, and so no further account could be taken of these plants.

Emissions under the Draft BREF Scenario were calculated assuming that regulators would apply the upper end of the emission limit range proposed in the draft BREF: clearly, operators can argue that they are compliant with the BREF so long as emissions are within the AEL range, so the presence

9 http://www.greenpeace.org/international/en/publications/Campaign-reports/Climate-Reports/Silent-Killers/

10 http://www.platts.com/products/world-electric-power-plants-database

11 http://prtr.ec.europa.eu/

of a lower bound does not provide added requirement for controls under most circumstances[12]. The BAT Scenario emissions were based on the lower end of the AELs from the draft BREF and Chinese operating data.

Stack concentrations were estimated from annual emission rates using CO_2 emissions as an indicator of total flue gas volume, assuming 3,563 Nm^3/tCO_2, calculated from EEA technical report 4/2008[13]. This ratio applies to both lignite and hard coal.

Annual average dust emission concentrations at or below 5 mg/Nm^3 are assumed to imply the use of fabric filters; above that, the use of electrostatic precipitators is assumed. This influences the PM_{10} fraction of total particulate matter emissions, which is taken from U.S. EPA AP-42[14] for these two technologies.

Many coal-burning facilities do not report mercury emissions, possibly from a view that they are unlikely to exceed reporting threshold of 10 kg/yr[15]. For these, a figure of 5 kg/yr has been taken as an estimate of emissions, corresponding to half of the E-PRTR reporting threshold. The logic used was that the most these plant could emit would be 10 kg/yr (otherwise they would report emissions) and the theoretical least, 0 kg/yr, with 5 kg/yr being taken as the midpoint of the extremes. In reality of course, no coal burning plant will have zero mercury emission, and some of those that do not report emissions may exceed the reporting threshold.

2.4 DAMAGE DATA

Damage data per tonne of emission are taken from the EEA report on the costs of air pollution from industrial plant in Europe for the period 2008-2012, expressed as €/tonne emission, and estimated using the impact pathway approach. Results are given for 36 European countries for NOx, SO_2 and PM (also NH_3 and VOCs, though these are not considered here). They are dominated by health impacts, but for NOx and SO2 also include damage to building materials and crops. Data are reproduced in Appendix 1.

Following the recommendations of the WHO's HRAPIE study and numerous other research, the effects of SO_2 and NOx are estimated as mediated through the formation of secondary pollutants, sulphate and nitrate aerosols (both treated as PM2.5 in the impact assessment) and NO_2. The assessment of NO_2 health effects, however, is limited, and no account has been taken of impacts on ecosystems.

The damage per tonne estimates given in the EEA paper are based on modelling of changes in emissions from each country from all sources. As such, they indicate the change in damage per tonne of emission averaged over transport, industry, the domestic sector and so on. They do not account for the fact that exposure (and hence impact) per unit emission will vary between sources. This can be most clearly illustrated with reference to emissions of fine particles, for which emissions close to ground level from traffic in a city will lead to a much higher population exposure than emissions 100 metres or more in the air from a large combustion plant in a rural location. The EEA paper sought to make results more applicable to industrial facilities by accounting for this variability

12 One situation where the lower bound would be useful is the case where there are exceedances of ambient air quality limit values and the facility concerned was a significant contributor to exceedance.

13 www.eea.europa.eu/publications/technical_report_2008_4/download

14 http://www.epa.gov/ttnchie1/ap42/

15 http://prtr.ec.europa.eu/docs/Summary_pollutant.pdf.

using results from the Eurodelta II study[16]. This compared the exposure to fine particles linked to emission of NOx, PM and SO_2 from different types of source relative to averaged emissions. Results are shown in Table 2 for the four countries considered. Limitations of the Eurodelta II exercise are noted in Annex 4 of the EEA report, for example the limited number of countries investigated and the restricted European area covered by the analysis. However, in the absence of further information this was accepted in the EEA report and also here, as useful for converting average damage costs to figures more representative of the large combustion sector. The general pattern in the results, with the most significant correction factors being for primary PM emissions, are logical, given that the source/site specificity for NOx and SO_2 is reduced by the time taken for these pollutants to convert to secondary aerosol. National data are used where available, and where unavailable, average data are adopted.

	NOx	PM	SO_2
France	0.91	0.64	0.74
Germany	0.80	0.51	0.86
Spain	0.65	0.39	1.01
UK	0.74	0.47	0.86
Average	0.78	0.50	0.87

Table 2. Efficiency of reductions of NOx, PM and SO_2 emissions for $PM_{2.5}$ exposure from European power plants relative to average emissions.

The EEA report provides estimates for damage associated with mercury emissions ranging from €910/kg for effects on the European population only, to €2,860 for the global population (bearing in mind that mercury is a persistent pollutant that disperses widely after release). These impacts are associated only with neurodevelopmental impacts reflected through lost earnings potential from reduced IQ. Other impacts associated with exposure to mercury are not quantified.

The economic assessment inflates the published estimates given in 2005 prices to 2015, using a factor of 1.177 from Eurostat. Valuation of mercury related damage takes the world, rather than European estimate: there is no reason why damage outside of Europe should not be considered relevant. Valuation of damage linked to emissions of NOx, PM and SO_2 uses the lower bound figures published by EEA as these are the results most prominent in policy related work, such as on the European Commission's Clean Air Policy Package.

16 http://bookshop.europa.eu/en/eurodelta-ii-pbLBNA23444/?CatalogCategoryID=r2AKABstX7kAAAEjp-pEY4e5L

3. RESULTS

The major result from this analysis concerns the overall difference in effects between the Draft BREF and BAT scenarios. These are most easily illustrated through the results of the full economic analysis, and are shown in Table 3, with results demonstrating the benefit of additional emission savings by each country wherever in Europe they occur. It is clear from this table that a substantial societal benefit (€6.36 billion, annually) would arise if emissions were reduced from the Draft BREF scenario to the BAT scenario considered here. It should be noted that the results shown in this section are all based on the most conservative estimate of the benefits shown for each pollutant in Appendix 1. Results would increase by roughly a factor 3 if the upper bound for economic impacts was adopted.

	Draft BREF	BAT	BAT/draft BREF
Belgium	40	7	18%
Bulgaria	142	26	19%
Czech Republic	492	103	21%
Denmark	17	6	34%
Finland	49	12	24%
France	183	35	19%
Germany	2,856	555	19%
Greece	123	17	14%
Hungary	76	13	17%
Ireland	33	6	17%
Italy	397	93	23%
Netherlands	205	43	21%
Poland	1,283	230	18%
Portugal	30	5	17%
Romania	247	51	21%
Slovakia	43	10	23%
Slovenia	80	14	17%
Spain	199	30	15%
Sweden	5	2	34%
United Kingdom	867	129	15%
Grand Total	**7,370**	**1,386**	**19%**

Table 3. Annual damage by country for the 281 facilities included in the analysis under the Draft BREF and BAT scenarios. Units: Million €.

These results can be broken down by pollutant as shown in Table 4, which demonstrates that the largest benefits would arise through reduction of SO_2 emissions.

	NOx	PM	SO2	Hg-world
Belgium	5	2	26	0.0
Bulgaria	45	5	66	0.0
Czech Republic	90	18	280	1.6
Denmark	2	1	9	0.1
Finland	7	1	29	0.3
France	32	6	108	0.5
Germany	629	66	1,595	10
Greece	24	6	72	3.5
Hungary	24	1	39	0.0
Ireland	5	1	22	0.0
Italy	72	10	222	0.1
Netherlands	13	7	141	0.1
Poland	249	50	748	5.6
Portugal	4	1	19	0.3
Romania	66	8	121	1.6
Slovakia	11	2	21	0.0
Slovenia	22	2	42	0.1
Spain	19	6	143	0.8
Sweden	0	0	3	0.0
United Kingdom	93	24	619	2.9
Grand Total	**1,412**	**218**	**4,326**	**28**

Table 4. Annual benefit of moving from the Draft BREF scenario to the BAT scenario by country and pollutant. Units: Million €/year.

These results are disaggregated by type of impact in Table 5.

	NOx	PM	SO_2	Hg	Total
Ozone					
Acute Mortality (All ages) median VOLY	13		-3.4		**9**
Respiratory hospital admissions (>64)	0.5		-0.1		**0.4**
Cardiovascular hospital admissions (>64)	2.4		-0.7		**1.8**
Minor Restricted Activity Days (MRADs all ages)	57.9		-16		**42**
PM					**-**
Chronic Mortality (All ages) LYL median VOLY	1,009	164	3,277		**4,450**
Infant Mortality (0-1yr) median VSL	5.5	0.9	18		**24**
Chronic Bronchitis (27yr +)	74	12	239		**325**
Bronchitis in children aged 6 to 12	2.7	0.4	8.9		**12**
Respiratory Hospital Admissions (All ages)	1.4	0.2	4.4		**6.0**
Cardiac Hospital Admissions (>18 years)	1.1	0.2	3.4		**4.6**
Restricted Activity Days (all ages)	174	28	566		**768**
Asthma symptom days (children 5-19yr)	2.1	0.3	6.7		**9.1**
Lost working days (15-64 years)	68	11	222		**302**
Hg					**-**
IQ loss				28	**28**
Totals	**1,412**	**217**	**4,325**	**28**	**5,982**

Table 5. Monetary value of specific health impacts under the Draft BREF and BAT scenarios. Units: Million €/year.

Of course, the monetised estimates of benefit provide only part of the results. It is also useful to know how large the underlying health impacts are (leaving aside damage to crops and materials as these account for only a small part of overall impact). These are shown in Table 6.

	Units	NOx	PM	SO_2	Hg	Total
Ozone						
Acute Mortality (All ages)	Life years	219	-	-59	-	**159**
Acute Mortality (All ages)	Deaths	219	-	-59	-	**159**
Respiratory hospital admissions (>64)	Admissions	242	-	-66	-	**176.7**
Cardiovascular hospital admissions (>64)	Admissions	1,094	-	-296	-	**797.6**
Minor Restricted Activity Days (MRADs all ages)	Days	1,379,715	-	-373,562	-	**1,006,153**
PM						
Chronic Mortality (30yr+)	Life years	17,493	2,836	56,787	-	**77,116**
Chronic Mortality (30yr+)	Deaths	1,579	256	5,125	-	**6,960**
Infant Mortality (0-1yr)	Deaths	3	1	11	-	**15**
Chronic Bronchitis (27yr +)	Cases	1,374	223	4,462	-	**6,059**
Bronchitis in children aged 6 to 12	Cases	4,640	752	15,061	-	**20,452**
Respiratory Hospital Admissions (All ages)	Admissions	617	100	2,004	-	**2,721.5**
Cardiac Hospital Admissions (>18 years)	Admissions	473	77	1,536	-	**2,085.2**
Restricted Activity Days (all ages)	Days	1,893,817	307,034	6,147,624	-	**8,348,475**
Asthma symptom days (children 5-19yr)	Days	49,003	7,945	159,071	-	**216,018.2**
Lost working days (15-64 years)	Days	526,797	85,407	1,710,066	-	**2,322,269**
Hg						
IQ loss	IQ points				2,957	**2,957**

Table 6. Health impacts under the Draft BREF and BAT scenarios. Note: estimates of adult life years lost and deaths are alternative metrics for the same impact and are not additive.

4. APPENDIX 1 DAMAGE PER TONNE ESTIMATES FOR NH_3, NOx, $PM_{2.5}$, SO_2 AND VOCs.

The results presented in this appendix are taken from Appendix 2 of EEA (2014). Whilst results are presented only in terms of monetised damage per tonne, the calculation process includes full assessment of mortality and morbidity effects (hospital admissions, chronic bronchitis, work loss days, etc.), and also estimates of damage to building materials and crops.

€/tonne, 2005 prices	NH3		NOx	
	Low	High	Low	High
Albania	4,794	10,768	4,082	8,308
Austria	9,914	29,615	8,681	24,442
Belgium	19,223	57,437	4,152	12,227
Bulgaria	10,166	33,489	4,588	12,581
Denmark	4,693	13,944	3,092	8,515
Finland	2,912	8,408	1,481	3,780
France	6,258	18,149	5,463	13,951
Greece	5,085	15,632	1,390	3,142
Hungary	17,191	51,980	7,502	20,354
Ireland	1,692	5,034	3,736	9,785
Italy	11,221	35,689	7,798	23,029
Luxembourg	16,125	48,130	6,468	17,974
Netherlands	12,199	35,859	4,854	14,770
Norway	2,507	7,048	1,675	4,081
Poland	13,435	38,240	5,131	13,840
Portugal	4,018	11,921	1,805	4,367
Romania	11,418	33,832	7,507	20,361
Spain	4,345	12,224	2,241	5,183
Sweden	4,017	12,152	2,197	5,662
Switzerland	6,422	18,856	11,997	33,635
UK	9,503	27,790	3,558	9,948
Belarus	7,703	22,479	4,033	10,691
Ukraine	16,780	51,145	3,800	10,079
Moldova	13,517	38,902	5,516	14,667
Estonia	5,017	14,664	2,159	5,566
Latvia	5,195	15,651	3,021	7,851
Lithuania	4,914	14,479	3,778	9,935

Czech Republic	19,318	56,460	6,420	17,663
Slovakia	20,436	57,719	6,729	17,936
Slovenia	14,343	43,277	9,127	25,992
Croatia	10,477	31,786	6,802	18,433
Bosnia and Herzegovina	8,651	24,282	5,511	14,031
Serbia and Montenegro	12,133	35,776	6,039	15,869
FYR Macedonia	9,125	24,294	3,449	8,349
Cyprus	2,194	4,668	593	1,196
Malta	4,893	12,756	736	1,696
Germany	13,617	41,798	6,817	19,059
Russia	14,145	39,221	2,264	5,530
North Atlantic			1,032	2,535
Atlantic (Faroes & Azores)			628	1,526
Gibraltar			292	761
Irish Sea & Bay of Biscay	1,694	4,951	928	2,433
Black Sea	2,641	8,143	1,560	4,328
Baltic Sea	6,126	18,084	2,416	6,858
Mediterranean (North Africa)	479	1,455	273	733
Mediterranean (Europe)	3,428	10,271	826	2,301
North Sea	11,723	34,159	3,558	10,372
In Port Emissions (Europe)	12,230	36,387	1,978	5,769

€/tonne, 2005 prices	$PM_{2.5}$		SO_2	
	Low	High	Low	High
Albania	26,582	55,439	8,822	20,069
Austria	38,300	113,642	19,651	58,494
Belgium	57,327	170,702	22,591	66,516
Bulgaria	24,186	80,806	6,238	19,696
Denmark	16,074	48,050	11,209	33,200
Finland	5,942	17,139	4,117	11,867
France	33,751	96,917	15,875	45,909
Greece	18,669	56,883	4,000	11,671
Hungary	38,433	118,336	11,821	35,479
Ireland	13,461	40,315	11,011	32,378
Italy	48,288	154,289	14,729	46,150
Luxembourg	36,007	105,895	18,763	55,912
Netherlands	54,535	154,240	25,269	74,414
Norway	5,638	15,846	3,878	11,168

Poland	42,153	117,344	11,802	33,613
Portugal	21,129	62,483	5,216	14,949
Romania	35,666	105,101	10,668	31,439
Spain	26,595	74,455	7,520	21,120
Sweden	7,644	23,204	5,209	15,438
Switzerland	55,427	160,225	30,800	90,337
UK	38,393	111,766	14,425	41,861
Belarus	20,200	59,335	11,052	32,206
Ukraine	29,670	91,284	7,029	20,832
Moldova	29,935	85,455	10,602	30,622
Estonia	9,418	27,684	5,826	16,692
Latvia	12,412	37,736	8,770	26,175
Lithuania	15,979	47,453	10,106	29,748
Czech Republic	39,882	115,146	12,483	36,491
Slovakia	32,503	92,299	10,411	30,093
Slovenia	33,836	101,827	15,774	47,749
Croatia	21,353	65,336	10,348	31,348
Bosnia and Herzegovina	20,720	58,677	7,601	21,941
Serbia and Montenegro	29,458	86,361	9,042	26,275
FYR Macedonia	19,978	52,814	6,197	16,862
Cyprus	7,015	14,917	1,052	2,270
Malta	5,625	15,338	2,302	6,895
Germany	47,310	147,553	18,956	57,524
Russia	42,317	116,796	6,974	19,369
North Atlantic	768	2,235	828	2,421
Atlantic (Faroes & Azores)	233	671	284	834
Gibraltar	2,966	8,370	1,851	5,266
Irish Sea & Bay of Biscay	3,838	11,124	3,019	8,782
Black Sea	6,351	19,330	3,022	9,144
Baltic Sea	11,281	33,471	7,223	21,480
Mediterranean (North Africa)	1,387	4,079	1,070	3,162
Mediterranean (Europe)	6,322	18,773	2,982	8,957
North Sea	18,797	54,972	12,286	36,206
In Port Emissions (Europe)	21,164	62,274	6,528	19,407

€/tonne, 2005 prices	VOC	
	Low	High
Albania	839	2,088
Austria	2,248	6,184
Belgium	2,368	5,750
Bulgaria	912	2,554
Denmark	1,156	2,756
Finland	599	1,544
France	1,616	4,087
Greece	911	2,386
Hungary	1,751	4,830
Ireland	1,046	2,647
Italy	3,179	8,968
Luxembourg	2,355	5,891
Netherlands	2,364	5,722
Norway	478	1,145
Poland	1,610	4,194
Portugal	628	1,534
Romania	1,159	3,148
Spain	1,074	2,690
Sweden	797	2,038
Switzerland	2,946	7,855
UK	1,450	3,468
Belarus	844	2,174
Ukraine	1,069	2,859
Moldova	967	2,627
Estonia	670	1,723
Latvia	866	2,252
Lithuania	794	2,066
Czech Republic	2,075	5,518
Slovakia	1,442	3,838
Slovenia	2,809	7,882
Croatia	1,542	4,159
Bosnia and Herzegovina	1,077	2,840
Serbia and Montenegro	1,322	3,490
FYR Macedonia	990	2,587
Cyprus	105	237
Malta	674	1,651
Germany	1,891	4,772

Russia	851	2,164
North Atlantic	384	1,085
Atlantic (Faroes & Azores)	104	280
Gibraltar	591	1,556
Irish Sea & Bay of Biscay	749	2,010
Black Sea	729	2,050
Baltic Sea	1,353	3,643
Mediterranean (North Africa)	481	1,308
Mediterranean (Europe)	921	2,522
North Sea	2,272	6,097
In Port Emissions (Europe)	1,659	4,467