# Reducing air pollution from electricity-generating large combustion plants in the European Union

## An assessment of potential emission reductions of $NO_X$, $SO_2$ and dust

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European Environment Agency

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# Executive summary

## Background

In 2008, the European Environment Agency (EEA) published a first assessment of the theoretical potential to reduce emissions of nitrogen oxides ($NO_X$) and sulphur dioxide ($SO_2$) from electricity-generating large combustion plants (LCPs) (EEA, 2008). That earlier study showed that improving the environmental performance of existing LCPs by applying best available techniques potentially could have reduced $NO_X$ emissions by up to 59 %, and $SO_2$ emissions by as much as 80 % in the year 2004. These earlier emission reduction estimates were based on data from 450 electricity-generating LCPs in the then EU-25 that had been included in the now-discontinued European Pollutant Emission Register (EPER).

Since 2004, data reported by Member States shows that emissions of $NO_X$, $SO_2$ and dust from all LCPs have fallen. More specifically, between 2004 and 2009, EU-27 total emissions of $NO_X$ from the sector decreased by 30 %, of $SO_2$ by 53 % and of dust by 58 % (AMEC, 2012). It is important to note that not all this reduction has occurred solely due to a further implementation of best available techniques (BAT), but rather by a combination of factors also including, for example, the economic recession and its subsequent impacts on energy demand, increased uptake of renewable energy and the closure of certain power plants.

This report presents results from an updated assessment of the hypothetical emission reduction potential of $NO_X$, $SO_2$ and dust from European LCPs for the year 2009. This new assessment is based upon improved statistics increasing the accuracy of the analysis compared to the earlier report, notably the latest available emission and fuel-use data from 2009 reported by Member States under the Large Combustion Plant Directive (2001/80/EC) (LCPD; EU, 2001).

The European Commission has proposed an enhanced focus on implementation in the context of the 7th Environment Action Programme. Filling gaps in the knowledge base in order to optimise policy responses will become increasingly important in the face of the challenges and opportunities to enhance cross-cutting policy coherence. Compared with the existing situation, emissions from LCPs are expected to further decrease in the future with the implementation of the Industrial Emission Directive (2010/75/EU) (IED; EU, 2010) and its more stringent emission limit values (ELVs) that are to be met by 2016 for existing plants. The publication of the latest 2009 LCPD dataset has therefore provided an opportunity to assess the magnitude of the difference between actual emissions reported for that year and the level of emissions that would theoretically occur were the same set of plants to achieve emission levels corresponding with the IED ELVs. For comparative purposes, the report also presents a comparison of the reported 2009 emissions with the LCPD ELVs and the lower BAT associated emission levels (BAT AELs) — the latter to serve as a proxy for a potential 'maximum feasible' emission reduction.

The LCP pollutants $NO_X$ and $SO_2$ are major contributors to acid deposition, leading to soil and freshwater acidification, which damages plants and aquatic habitats and can corrode building materials. Both pollutants also contribute to the formation of secondary particulate matter (PM) in the atmosphere following their release, while $NO_X$ also react with volatile organic compounds (VOCs) in the presence of sunlight to form ground-level ozone ($O_3$). At present, primary and secondary PM and $O_3$ are Europe's most problematic pollutants in terms of harm to human health (EEA, 2012a). $NO_X$, $SO_2$ and dust adversely affect local air quality, but also contribute to transboundary pollution causing harm to health and environment even at distant locations.

## Approach

This report presents an estimation of the theoretical emission reduction potential from Europe's largest thermal power plants and compares the 2009 emissions data reported under the LCPD (EEA, 2012b) with the future applicable ELVs as defined in the IED, excluding all exempted circumstances.

**Box ES.1 Legislative context**

Large combustion plants are defined in the EU LCP Directive (2001/80/EC) as those plants having a rated thermal input of 50 MW or greater. Emissions of three pollutants ($SO_2$, $NO_X$ and dust) are regulated by the directive. According to the directive's Annex VIII(B), Member States must establish a plant-by-plant inventory of the total annual $SO_2$, $NO_X$ and dust emissions and total annual energy input by fuel type (i.e. biomass, other solid fuels, liquid fuels, natural gas or other gases). A summary of this information must be reported to the Commission every three years; the latest available data covers 2007–2009. In addition, the Commission has asked for the plant-by-plant data to be made available. Large combustion plants are also regulated under the Integrated Pollution Prevention and Control (IPPC) Directive (consolidated version: EU, 2008) which may lead to stricter and/or additional obligations on the plants than those required under the LCPD itself.

In particular, the IPPC Directive requires installations operating activities within its scope to apply the best available techniques (BAT), i.e. the most effective and advanced stage of operations considered technically and economically viable for the sector for controlling and reducing pollution. The emission limit values in the permits have to be based on BAT, taking into account local considerations. In order to describe and define the BAT at the EU level, the European Commission develops and adopts the BAT reference documents (BREF), which serve as guidance for competent authorities when defining permit conditions.

In 2006 the European Commission adopted the large combustion plant BREF (LCP BREF) which describes the BAT as well as the range of emission levels achievable by applying BAT — the so-called Associated Emission Levels (AEL) with the lower end (lower BAT-AEL) being the most stringent and the upper end the least stringent.

The IPPC Directive and the LCPD were superseded by the Industrial Emissions Directive (IED) (2010/75/EU) which entered into force on 6 January 2011 and which had to be transposed into national legislation by 7 January 2013. The IED regulates the emissions from LCPs by requiring the application of BAT and the BAT-AELs, set out in BAT conclusions which have a legal effect, as well as by setting mandatory 'minimum' emission limit values (ELVs) for $SO_2$, $NO_X$ and dust. These limit values will apply for existing combustion plants from 2016 onward, with some longer transitional periods for particular groups of plants. The European Commission is presently revising the LCP BREF, with the aim of establishing BAT conclusions, to be adopted in the course of 2014.

This report does not assess the compliance of individual plants or Member States under these directives. Neither does it evaluate the implementation of the IPPC, LCPD or IED through national regulations.

A comparison of the reported 2009 emissions with the LCPD ELVs and the BREF lower AELs is also provided. The 2009 LCPD dataset used is the most recent emissions dataset available for LCPs, and it also contains information on the thermal capacity of each facility, its fuel types and fuel use. Of the 3 310 plants in the dataset, 1 595 (48 %) met the criteria for further analysis by being identifiable as an Electricity Supply Industry (ESI) or Combined Heat and Power (CHP) plant and being operational. Of these 1 595 plants, most (1 592) reported $NO_X$ emissions, 1 119 reported $SO_2$ and 1 173 reported dust.

The remaining 1 715 plants were not considered in the scope of this report. The LCPD covers other types of industrial combustion plants beyond ESI and CHP plants such as refineries, and iron and steel facilities. Such facilities were not included in the study. Further, 'opt-out' plants which have elected to manage their emissions via other permissible LCPD methods such as closing down after a set period were excluded, as were those where there was insufficient information to allow their classification.

The 2009 LCP dataset was supplemented by data from the Platts European Energy Power Plants (EEPP) dataset (Platts, 2011) that contains technical information on most electric power plants in Europe. The Platts dataset was used to distinguish between ESI and CHP plants when sector code information was not reported in the LCP dataset, and also to improve the level of detail concerning use of 'other solid fuels' and 'biomass' at Member State level.

Four main steps were performed in the assessment:

i. determination of the thermal capacity, and fuel use per fuel type at each plant;
ii. estimation of flue gas volumes;
iii. calculation of the theoretical $NO_X$, $SO_2$ and dust emissions for three cases:
   – assuming that all plants have emissions not exceeding the LCPD ELVs;
   – assuming that all plants have emissions not exceeding the IED ELVs;
   – assuming that all plants have emissions not exceeding the BREF lower AELs;
iv. comparison of the pollutant emissions calculated for each of the three cases aggregated by Member State with the reported emissions for the year 2009.

The robustness of the updated assessment compared to the earlier EEA 2008 report is notably improved in two main respects:

- the number of plants considered in this report (1 595) is greater than the number (450) upon which the findings of the earlier report were based, which strengthens the applicability of the analysis;
- actual fuel-use data from the LCPD reporting is used in this study. Such data was not available when the previous reporting was performed, which meant a number of assumptions had to be made concerning the fuel type and fuel consumption at the individual plant level. The accuracy of results in the current study is therefore significantly improved.

It is important to note the theoretical nature of this study. It assumes the same application of the IED ELVs (and the LCPD ELVs and the BREF lower AELs) across all plants covered, and does not consider derogations or the detailed flexibilities (temporary and permanent) that are included in the scope of the IED. For example, no differentiation was made for ESI and CHP plants addressed in National Emission Reduction Plans (NERPs) or under Member State Accession Treaty derogations. Thus, the study does not provide a detailed modelling of IED implementation. The report also does not take into account any changes that may have occurred since 2009 — for example, reduced industrial activity because of the economic recession, plant closures, replacement of old plants with newer, more efficient and cleaner technologies, changes in fuel mixes, operational/management changes and evolution of abatement equipment.

## Results and key findings

A small number of large-scale coal plants and plants co-combusting coal with other fuels dominate the reported emissions for all three pollutants. Just 50 plants (i.e. 3 % of the 1 595 plants addressed in this report) contribute 50 % of $NO_X$ emissions, with 454 (28 %) responsible for 90 % of emissions. The situation is more striking for $SO_2$ with only 20 plants (1 %) responsible for 50 % of total emissions and 165 (10 %) contributing 90 %. For dust, just 21 plants (1 %) contribute 50 % and 175 (11 %) contribute 90 % of the total reported emissions. In general, a good correlation is noted at the Member State level between the 2009 emissions reported under the LCPD for the electricity generation sector and those reported under the European Pollutant Release and Transfer Register (E-PRTR) ([1]), although some potential errors in official reporting were identified and are described. Unfortunately, a detailed plant-by-plant comparison is not possible because there is no direct link established between the two datasets ([2]).

The results of the present study clearly indicate that EU-27 emissions of the air pollutants $NO_X$, $SO_2$ and dust from the selected LCPs could potentially be significantly lower if all plants operating in 2009 were to meet the ELVs set out in the IED (Table ES.1 and Figure ES.1).

Specific findings of the report are listed below.

- EU-27 $NO_X$ emissions from LCPs considered in this study have the potential to be 36 % lower than in 2009 if all plants meet the IED ELVs and 69 % lower if plants achieve the more stringent BAT AEL. For $SO_2$, the potential emission reductions are 66 % and 94 %, respectively, and 64 % and 79 %, respectively, for dust.
- Most of the potential reduction can be achieved from just a relatively few very large coal and coal co-combustion plants.
- Several Member States already report emissions from LCPs below the level of the IED emission limits that have to be achieved by 2016. However, in some of the newer Member States, emissions are still significantly above the IED levels.

([1]) European Pollutant Release and Transfer Register (http://prtr.ec.europa.eu/).
([2]) Under future reporting by Member States concerning their implementation of the IED, establishing such a link should be facilitated.

- At the Member State level, most of the reported 2009 emissions are consistent with, or below, the LCPD ELVs. There are a number of derogations (exemptions) granted under the LCPD that are not taken into account in this analysis, such a plants granted longer transitional periods and/or which rely on derogations such as controls on desulphurisation rates being implemented in place of attaining ELVs.

It is clear that meeting the ELVs of the IED would reduce emissions of $SO_2$ and dust from these LCPs by more than 60 % compared to 2009 emission levels. Such reduction of emissions would obviously deliver substantial benefits in terms of improvements to human health and the environment. A recent assessment from the EEA showed that the estimated damage costs to health and the environment caused by air pollution from the energy-generating sector (excluding carbon dioxide ($CO_2$)) in 2009 was EUR 26–71 billion (EEA, 2011). An assessment of the costs to industry and consumers to achieve such lower emissions is beyond the scope of this report.

In the following figures comparisons are made by Member State between reported emissions for 2009 and the theoretical application of ELVs for $NO_X$ (Figure ES.2), $SO_2$ (Figure ES.3) and dust (Figure ES.4).

### *$NO_X$*

Germany, Poland and the United Kingdom report the highest 2009 $NO_X$ emissions from LCPs (Figure ES.2). However, emissions from Germany are already largely consistent with the IED ELVs, while some scope exists to reduce emissions further to the levels of the lower BAT AELs values. Greece, Poland, Spain and the United Kingdom have the largest absolute differences in terms of tonnes of $NO_X$ from 2009 emissions to the IED ELVs.

### *$SO_2$*

Bulgaria, Greece, Poland and Romania have the highest reported 2009 $SO_2$ emissions of the EU-27 Member States (Figure ES.3), and together account for the largest difference between 2009 emission levels and the IED ELVs. In particular, Bulgaria and Romania together, contribute almost 40 % to the total $SO_2$ emissions for the EU-27 and, similarly, account for a large fraction of the EU-27 $SO_2$ emissions that in 2009 lay above the IED ELVs.

### *Dust*

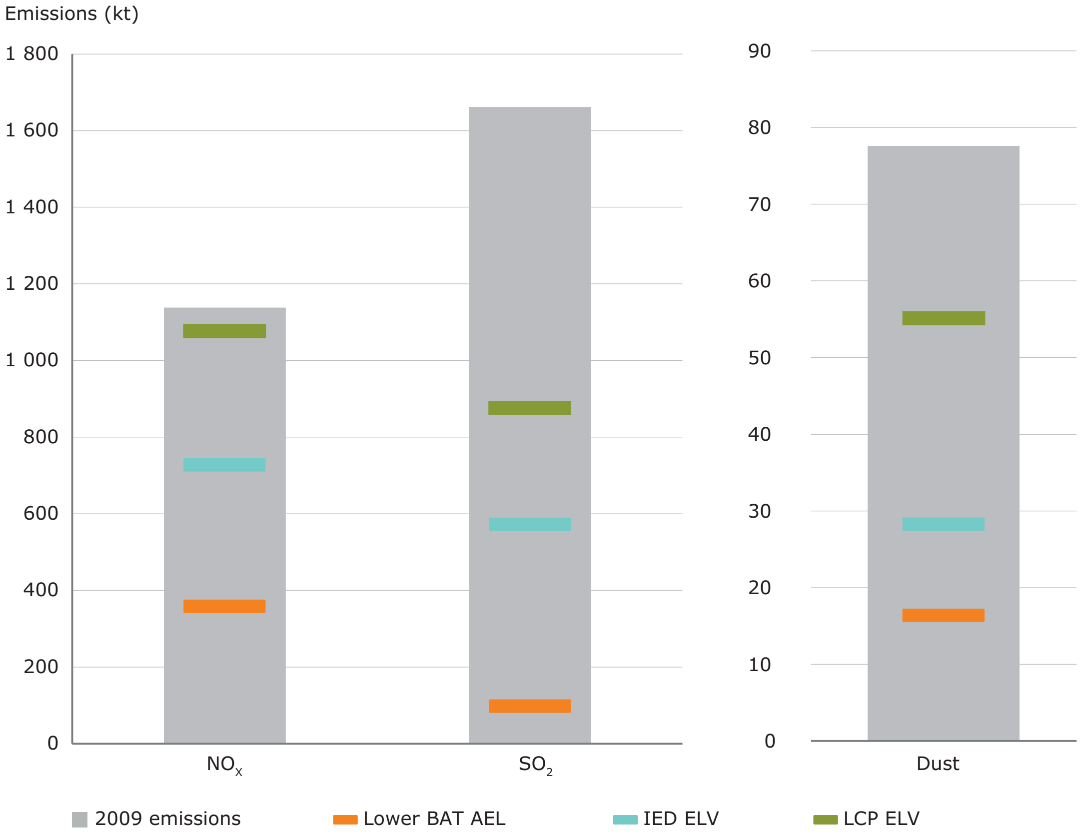
The same four Member States (i.e. Bulgaria, Greece, Poland and Romania) also reported the highest 2009 dust emissions, significantly above emission levels that would be consistent with the IED ELVs (Figure ES.4).

**Table ES.1 Gap between 2009 emissions and emissions based on the LCP emission limits, the IED emission limits, and the lower BAT AELs, by pollutant for the 1 595 plants assessed in this report (*)**

| | Reported emissions 2009 | Potential emissions based on LCPD ELVs | | Potential emissions based on IED ELVs | | Potential emissions based on lower BAT AELs | |
|---|---|---|---|---|---|---|---|
| | Emissions (kt) | Emissions (kt) | % reduction compared to 2009 emissions | Emissions (kt) | % reduction compared to 2009 emissions | Emissions (kt) | % reduction compared to 2009 emissions |
| $NO_X$ | 1 138 | 1 077 | – 5 % | 728 | – 36 % | 358 | – 69 % |
| $SO_2$ | 1 662 | 876 | – 47 % | 572 | – 66 % | 98 | – 94 % |
| Dust | 77.6 | 55.1 | – 29 % | 28.2 | – 64 % | 16.4 | – 79 % |

**Note:** * Care is needed when interpreting the values in Table ES.1 as there are uncertainties inherent in the estimation of the flue gas volumes. The estimates are based on Member State averages and do not reflect individual plants; existing LCP derogations have not been taken into account.

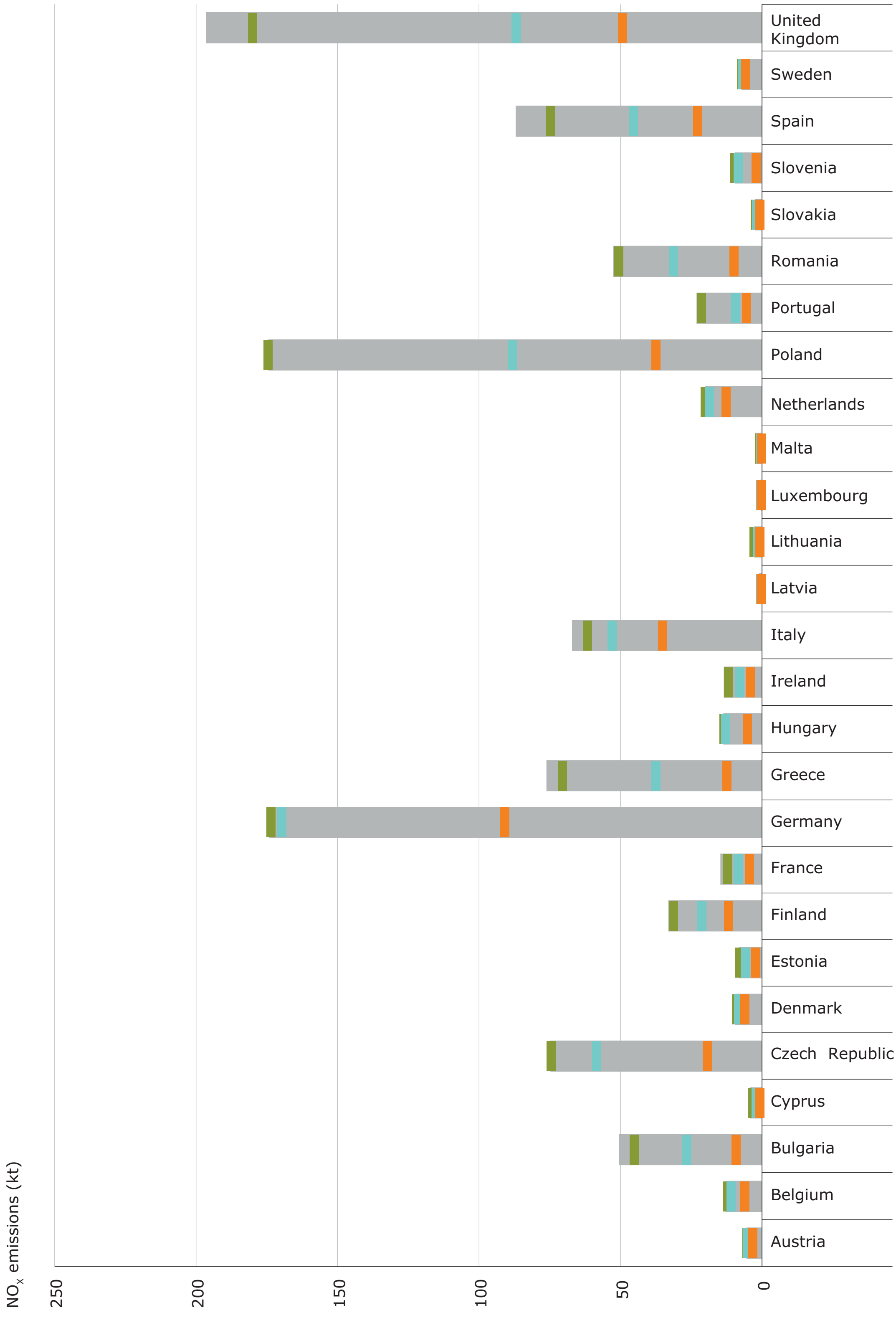
**Figure ES.1 Reported 2009 EU-27 LCP emissions compared with the future emission limit values of the IED, the existing LCPD emission limit values and the LCP BREF lower AEL**




### *Uncertainties*

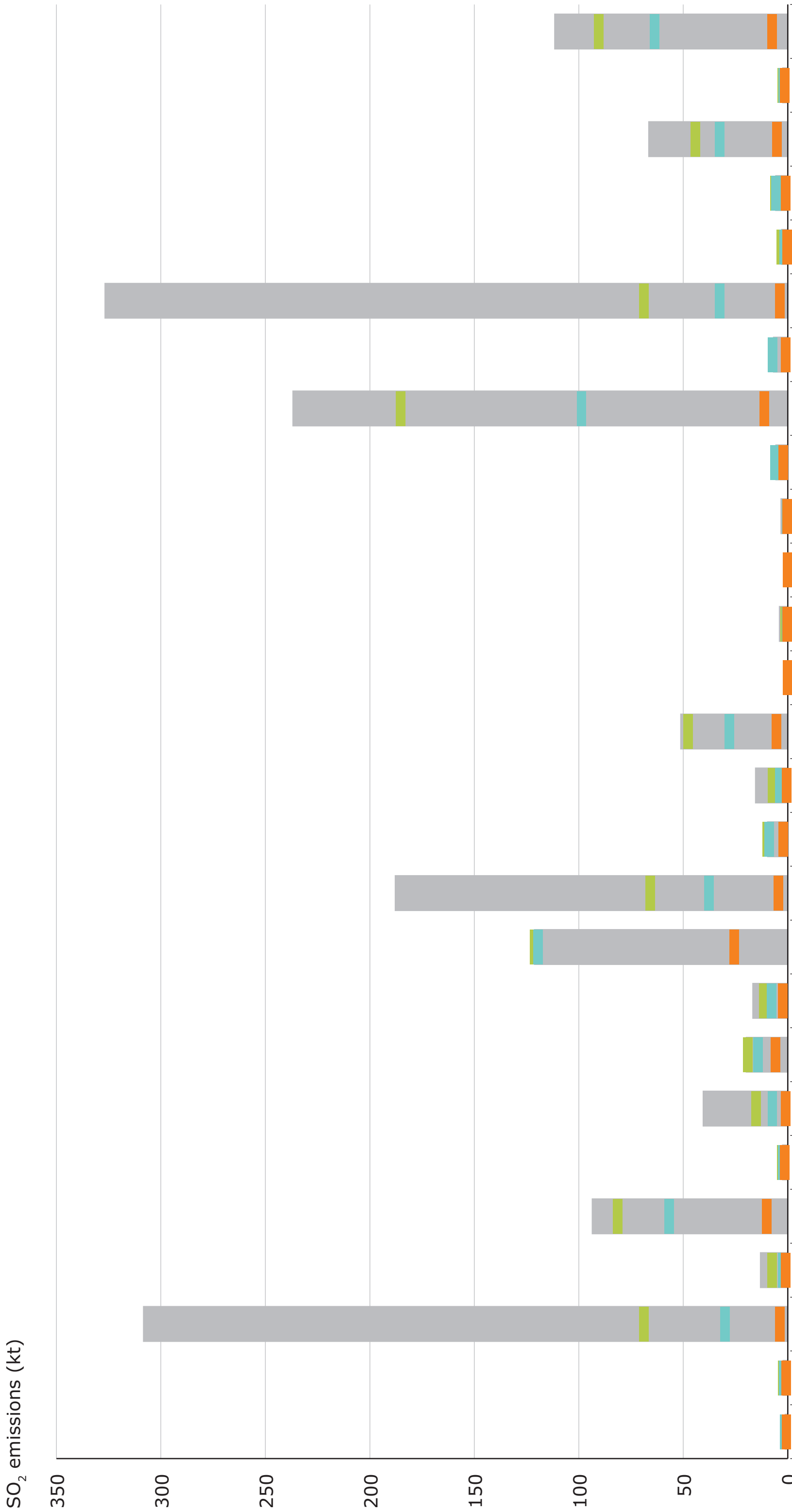
Due caution is also needed when interpreting the figures since there are uncertainties inherent in the estimation of the flue gas volumes, and the estimates are averaged for each Member State thus not reflecting individual plants. Recognising the uncertainty inherent in the assessment, a sensitivity analysis was performed concerning the influence of the fuel calorific values used to estimate the flue gas volumes and, hence, ultimately the emissions. The analysis showed that the highest impact on the certainty of the study results is related to lignite and its wide range of possible calorific values. In order to raise the overall certainty for future assessments and to assist in the verification of plant emissions, it would be beneficial if plant-specific information on the calorific value of fuels used were made publicly available.

**Figure ES.2 2009 $NO_x$ emissions (kt) compared with LCP and IED emission limits, and the lower BAT AELs (1 595 plants)**



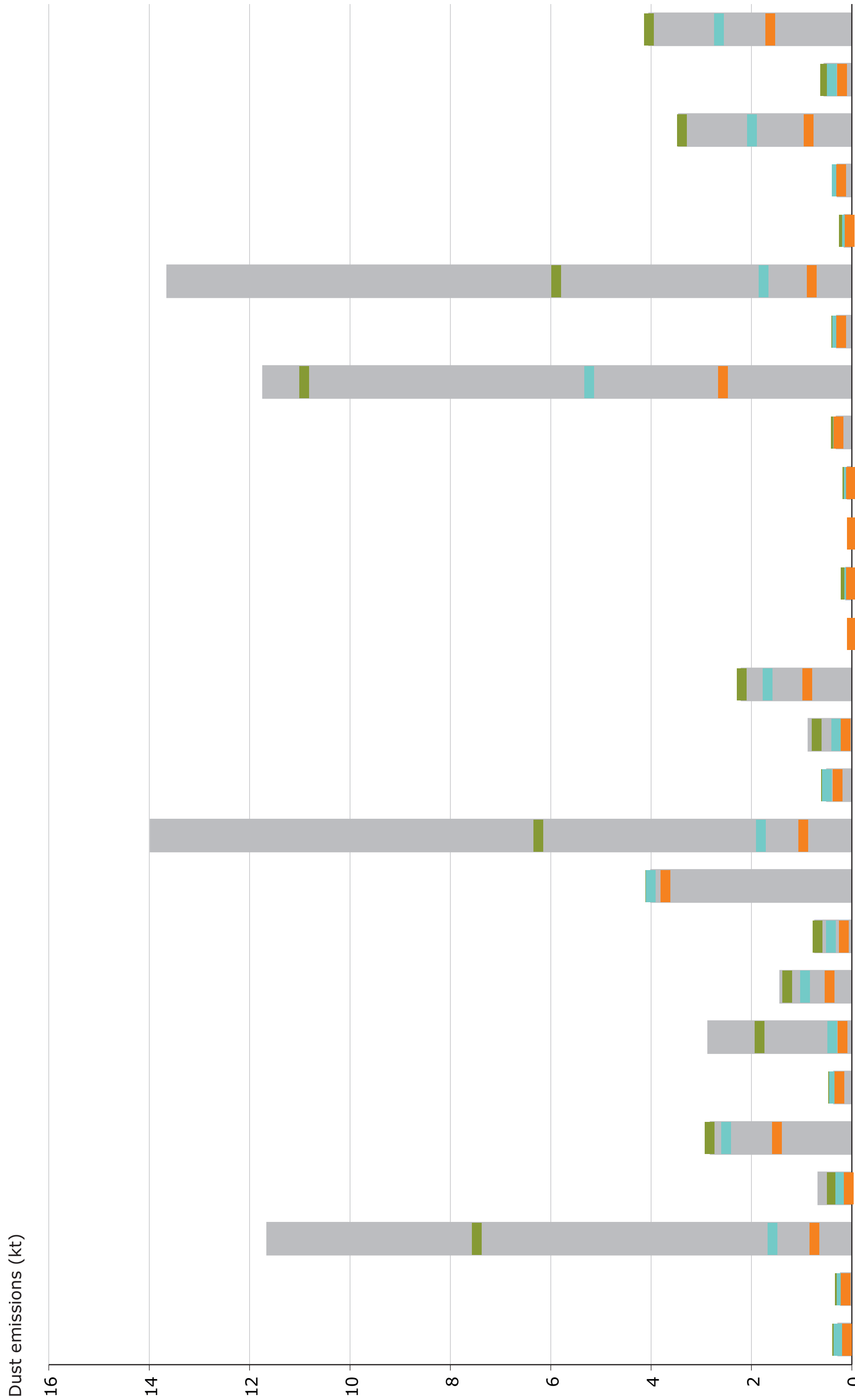

| Country | 2009 | LCP ELV | IED ELV | Lower BAT AEL |
|---|---|---|---|---|
| Austria | 5.6 | 5.2 | 5.0 | 3.2 |
| Belgium | 12.9 | 12.1 | 10.9 | 6.0 |
| Bulgaria | 50.6 | 45.1 | 26.6 | 9.1 |
| Cyprus | 4.2 | 3.3 | 2.0 | 0.7 |
| Czech Republic | 74.8 | 74.5 | 58.4 | 19.3 |
| Denmark | 9.5 | 8.9 | 8.2 | 6.1 |
| Estonia | 8.0 | 8.0 | 5.9 | 2.2 |
| Finland | 33.1 | 31.4 | 21.2 | 11.8 |
| France | 14.8 | 12.1 | 8.4 | 4.4 |
| Germany | 174.1 | 173.5 | 169.7 | 90.9 |
| Greece | 76.2 | 70.5 | 37.6 | 12.4 |
| Hungary | 13.7 | 13.4 | 12.8 | 5.2 |
| Ireland | 13.6 | 11.8 | 7.9 | 4.1 |
| Italy | 67.2 | 61.6 | 53.0 | 35.2 |
| Latvia | 1.0 | 0.6 | 0.5 | 0.3 |
| Lithuania | 2.8 | 2.8 | 1.5 | 0.7 |
| Luxembourg | 0.5 | 0.5 | 0.5 | 0.3 |
| Malta | 2.5 | 0.7 | 0.6 | 0.2 |
| Netherlands | 20.1 | 20.1 | 18.4 | 12.7 |
| Poland | 174.6 | 174.6 | 88.2 | 37.5 |
| Portugal | 23.1 | 21.4 | 9.5 | 5.5 |
| Romania | 52.6 | 50.5 | 31.4 | 9.9 |
| Slovakia | 2.5 | 2.4 | 1.9 | 0.8 |
| Slovenia | 9.7 | 9.7 | 8.5 | 2.1 |
| Spain | 87.1 | 74.7 | 45.5 | 22.7 |
| Sweden | 7.3 | 7.2 | 6.8 | 5.7 |
| United Kingdom | 196.4 | 180.0 | 86.9 | 49.3 |

**Figure ES.3 2009 $SO_2$ emissions (kt) compared with LCP and IED emission limits, and the lower BAT AELs (1 595 plants)**




| | 2009 | LCP ELV | IED ELV | Lower BAT AEL |
|---|---|---|---|---|
| United Kingdom | 111.8 | 90.5 | 63.8 | 7.5 |
| Sweden | 2.6 | 2.6 | 2.0 | 1.4 |
| Spain | 66.8 | 44.1 | 32.4 | 5.1 |
| Slovenia | 6.0 | 6.0 | 5.6 | 0.9 |
| Slovakia | 3.2 | 3.0 | 1.7 | 0.3 |
| Romania | 327.0 | 68.7 | 32.6 | 3.7 |
| Portugal | 7.1 | 7.1 | 7.1 | 0.9 |
| Poland | 237.0 | 185.2 | 98.7 | 11.1 |
| Netherlands | 5.9 | 5.9 | 5.9 | 2.1 |
| Malta | 3.5 | 0.6 | 0.6 | 0.2 |
| Luxem-bourg | 0.0 | 0.0 | 0.0 | 0.0 |
| Lithuania | 4.2 | 1.1 | 0.6 | 0.3 |
| Latvia | 0.0 | 0.0 | 0.0 | 0.0 |
| Italy | 51.5 | 47.7 | 27.8 | 5.5 |
| Ireland | 15.7 | 7.4 | 3.7 | 0.5 |
| Hungary | 9.8 | 9.8 | 9.0 | 2.1 |
| Greece | 188.1 | 65.7 | 37.6 | 4.5 |
| Germany | 121.5 | 121.1 | 119.4 | 25.6 |
| France | 16.9 | 11.3 | 7.6 | 2.3 |
| Finland | 20.1 | 19.1 | 14.1 | 5.7 |
| Estonia | 40.7 | 15.2 | 7.4 | 0.9 |
| Denmark | 2.7 | 2.7 | 2.4 | 1.5 |
| Czech Republic | 93.8 | 81.2 | 56.6 | 9.9 |
| Cyprus | 13.3 | 7.5 | 2.4 | 1.0 |
| Bulgaria | 308.5 | 68.9 | 30.1 | 3.7 |
| Belgium | 2.5 | 2.3 | 1.9 | 0.6 |
| Austria | 1.4 | 1.3 | 1.4 | 0.7 |

**Figure ES.4 2009 dust emissions (kt) compared with LCP and IED emission limits, and the lower BAT AELs (1 595 plants)**




| | 2009 | LCP ELV | IED ELV | Lower BAT AEL |
|---|---|---|---|---|
| United Kingdom | 4.1 | 4.0 | 2.6 | 1.6 |
| Sweden | 0.6 | 0.5 | 0.4 | 0.2 |
| Spain | 3.5 | 3.4 | 2.0 | 0.9 |
| Slovenia | 0.3 | 0.3 | 0.3 | 0.2 |
| Slovakia | 0.2 | 0.2 | 0.1 | 0.0 |
| Romania | 13.7 | 5.9 | 1.8 | 0.8 |
| Portugal | 0.3 | 0.3 | 0.3 | 0.2 |
| Poland | 11.7 | 10.9 | 5.2 | 2.6 |
| Netherlands | 0.3 | 0.3 | 0.3 | 0.3 |
| Malta | 0.1 | 0.1 | 0.1 | 0.0 |
| Luxembourg | 0.0 | 0.0 | 0.0 | 0.0 |
| Lithuania | 0.1 | 0.1 | 0.1 | 0.0 |
| Latvia | 0.0 | 0.0 | 0.0 | 0.0 |
| Italy | 2.2 | 2.2 | 1.7 | 0.9 |
| Ireland | 0.9 | 0.7 | 0.3 | 0.1 |
| Hungary | 0.5 | 0.5 | 0.5 | 0.3 |
| Greece | 14.0 | 6.2 | 1.8 | 1.0 |
| Germany | 4.0 | 4.0 | 4.0 | 3.7 |
| France | 0.7 | 0.7 | 0.4 | 0.2 |
| Finland | 1.4 | 1.3 | 0.9 | 0.4 |
| Estonia | 2.9 | 1.8 | 0.4 | 0.2 |
| Denmark | 0.4 | 0.4 | 0.3 | 0.3 |
| Czech Republic | 2.8 | 2.8 | 2.5 | 1.5 |
| Cyprus | 0.7 | 0.4 | 0.2 | 0.1 |
| Bulgaria | 11.7 | 7.5 | 1.6 | 0.7 |
| Belgium | 0.2 | 0.2 | 0.2 | 0.1 |
| Austria | 0.3 | 0.3 | 0.3 | 0.1 |

# 1 Introduction

## 1.1 Background

LCPs are a significant source of emissions of the air pollutants $NO_X$, $SO_2$ and dust (particulate matter) as well as other pollutants such as greenhouse gases, heavy metals and certain persistent organic pollutants. The pollutants $NO_X$ and $SO_2$ are major contributors to acid deposition, leading to soil and freshwater acidification, which damages plants and aquatic habitats, and can corrode building materials. Both pollutants also contribute to the formation of secondary PM in the atmosphere following their release, while $NO_X$ also react with VOCs in the presence of sunlight to form ground-level $O_3$. At present, primary and secondary PM and $O_3$ are Europe's most problematic pollutants in terms of harm to human health (EEA, 2012b). $NO_X$, $SO_2$ and dust adversely affect local air quality, but also contribute to transboundary pollution causing harm to health and environment even at distant locations.

The introduction of air pollution legislation over the past decades and the subsequent implementation of emission prevention and abatement measures in the power plant sector has led to a significant reduction in the level of emissions from LCPs. Since 2004, data reported by Member States shows that emissions of $NO_X$, $SO_2$ and dust from plants covered by the LCP Directive have fallen significantly. More specifically, between 2004 and 2009, EU-27 emissions of $NO_X$ from the sector decreased by 30 %, of $SO_2$ by 53 % and of dust by 58 % (AMEC, 2012).

However, despite the reductions in emissions that have occurred, the electricity and heat production sector still remains an important source of key air pollutants that contribute to poor air quality in Europe (EEA, 2012a).

### 1.1.1 *EU legislation concerning large combustion plants*

The LCPD (2001/80/EC) covers combustion plants with a rated thermal input equal to or exceeding 50 MW which are operated for power and/or heat generation purposes as well as certain industrial plants. It entered into force on 27 November 2001. The directive sets specific ELVs for the pollutants $SO_2$, $NO_X$ and dust (PM). The directive distinguishes between new plants (licensed after 1 July 1987), which had to meet the LCPD ELVs immediately, and existing plants (licensed before 1 July 1987), which could choose, by 1 January 2008, to:

- meet the LCPD ELVs, or
- implement a national emission reduction plan (NERP), which sets an annual maximum level of emissions for the plants covered by it.

A NERP has been implemented by 8 Member States ([3]) for part or all of their existing LCPs.

In addition, existing plants can be exempted from compliance with the emission limits and from inclusion in the NERP on condition that the operator undertook not to operate the plant for more than 20 000 hours between 1 January 2008 and 31 December 2015. In 2009, there were approximately 239 such plants, and these are referred to as 'opted out' plants.

The IPPC Directive (originally 96/61/EC, but consolidated in 2008 as Directive 2008/1/EC) covers a number of industrial activities (including combustion plants with a rated thermal input exceeding 50 MW) and aims to reduce their overall environmental impact through a process of integrated permitting. Emission limit values set in those permits have to be based on best available techniques (BAT), taking into account certain local considerations. The interaction between the IPPC Directive and the LCPD is such that the latter sets

([3]) These Member States are Czech Republic, France, Finland, Greece, Ireland, Portugal, Spain and the United Kingdom.

minimum obligations which are not necessarily sufficient to comply with the IPPC Directive.

The IPPC Directive and the LCPD are being replaced by the IED (2010/75/EU) is a recast of seven existing directives. The IED entered into force on 6 January 2011 and had to be transposed into national legislation by Member States by 7 January 2013.

The IED aims to achieve further benefits to the environment and human health by reducing harmful industrial emissions through the better application of BAT. Amongst the key changes is a stricter definition of BAT, leaving less flexibility for competent authorities to set ELVs outside the BAT ranges. The IED also has tighter minimum ELVs for LCPs to be applied from 1 January 2016 for existing plants. There is also the possibility under the IED of using minimum desulphurisation rates or less strict ELVs in case of plants having a limited number of operating hours. These options are not considered for the purposes of the hypothetical assessment described in this report.

#### *1.1.2 Best available techniques and emission limits*

The present LCP BREF was adopted in 2006 following an exchange of information between the European Commission, the Member States, industry and environmental NGOs (European Commission, 2006).

The BAT associated emission levels (BAT-AELs) given in the BREF are expressed as a range of values taking into consideration factors such as the age of the plants, process management and the range of techniques considered to be BAT. The BAT-AELs range from the lower BAT (most stringent) to the upper BAT (least stringent). The BAT AELs are expressed as flue gas pollutant concentrations. While not legally binding under the IPPC Directive, the BAT AELs provide information on the best environmental performance associated with technically and economically viable techniques.

A revision of the LCP BREF started in October 2011, a process which is expected to lead to new LCP BAT conclusions to be adopted under the IED in the course of 2014. These BAT conclusions will have a much more binding role under the IED than was previously the case under the IPPC Directive.

## 1.2 Objectives of this report

Emissions from existing LCPs are expected to decrease in the future with the implementation of the IED and its more stringent ELVs that are to be met by 2016. The publication of the latest 2009 LCPD dataset provided an opportunity to assess the difference between actual emissions reported for that year and the level of emissions that would hypothetically occur were all LCPs to achieve the default IED ELVs. The report also presents a comparison of the reported 2009 emissions with the LCPD ELVs and the BREF lower AELs.

It is important to note the theoretical nature of this study. It assumes the same application of the IED ELVs (and the LCPD ELVs and the BREF lower AELs) across all plants covered, and does not consider derogation or the detailed flexibilities (temporary and permanent) that are included in the IED. Thus, the study does not provide a detailed modelling of future IED implementation. The report also does not take into account any changes that may have occurred since 2009 — for example, reduced industrial activity because of the economic recession, plant closures, replacement of old plants with newer, more efficient and cleaner technologies, changes in fuel mixes, operational/management changes and evolution of abatement equipment.

# 2 Data and methods

## 2.1 Datasets used in this study

The latest available LCP (2009) dataset (EEA, 2012b) was used as the main data source for the purposes of this report. However, not all required data are available from this source and thus the methodology developed also required certain assumptions and approximations. The Platts EEPP dataset (Platts, 2011) was used to provide more detailed technical information on coal and biomass type used on a Member State basis. The E-PRTR was used for cross-checking emissions from the LCP dataset.

Each of these datasets has its own terminology, and each also represents a different scale of the emissions sources. At the most detailed scale is the Platts EEPP dataset, in which information is provided for individual units (i.e. boilers, turbines, etc.). One or more units that discharge waste gases through a common stack form a LCP. One or more plants on the same site comprise a 'facility' under the E-PRTR Regulation. These datasets are discussed in further detail below.

### 2.1.1 *Large combustion plant inventory dataset*

Starting in 2004, Member States were required to establish an inventory of annual $SO_2$, $NO_X$ and dust emissions from plants under the LCPD (Annex VIII(B)) requirements. The inventory contains information on a plant-by-plant basis including the amount of fuel used per category of fuel (biomass, other solid fuels, liquid fuels, natural gas, other gases). In addition, the Commission has asked Member States to also report for each plant, sometimes on a voluntary basis, information on the rated thermal input, the plant type or sector in which it is operated and its age category. Information on whether the plant has opted-out of the LCPD is also reported. Of the 3 310 plants in the dataset for 2009, 1 595 (48 %) met the criteria for further analysis by being identifiable as an ESI or CHP plant and being operational. Of these 1 595 plants, most (1 592) reported $NO_X$ emissions, 1 119 reported $SO_2$ and 1 173 reported dust.

The remaining 1 715 plants were not considered in the scope of this report. The LCPD covers other types of industrial combustion plants beyond ESI and CHP plants such as refineries, and iron and steel facilities. Such facilities were not included in the study. Further, 'opt-out' plants which have elected to manage their emissions via other permissible LCPD methods such as closing down after a set period were excluded, as were those where there was insufficient information to allow their classification.

Only the electricity-producing plants, ESI and CHP sectors, are used in this report. Most Member States voluntarily provided the sector codes but a few did not — for example, Germany, the Netherlands and Sweden, while Italy only distinguishes between 'refinery' and 'non-refinery'. For these plants it was necessary to use other sources of information to distinguish between a plant producing only electricity (ESI) or also heat (CHP) or only heat (others like refinery or district heating, etc.).

The main shortcoming of the LCP dataset for the purpose of comparing emissions with applicable emission limit values or BAT levels (expressed as concentrations) is that the fuel type grouping is not detailed enough to calculate flue gas volumes with a sufficient degree of certainty, especially for 'biomass' and 'other solid fuels'. More specifically, biomass can be solid, liquid or gaseous, and 'other solid fuels' can be (sub)bituminous coal, anthracite or lignite. Each of these fuel types produces a different specific flue gas volume when combusted. The LCP data was therefore complemented by using data from the Platts EEPP dataset at a Member State level to improve the assessment's certainty. The EEPP dataset was used to distinguish between ESI and CHP by assuming all LCPs with gas turbines produce electricity and for all others to determine if the plant was producing only heat or also electricity. Where it was not possible to identify the sector activity of a LCP using this approach — for example, industrial parks with several LCPs on the same site — the LCPs were excluded from the study.

### 2.1.2 European Pollutant Release and Transfer Register 2009 dataset

The E-PRTR ([4]) 2009 dataset (v4.1) ([5]) was used to cross-check the LCP emissions data for consistency. The E-PRTR provides annual $NO_X$, $SO_X$ and $PM_{10}$ emissions from industrial facilities covering 65 activities. In 2009, 2 252 E-PRTR facilities reported being 'Thermal power stations and other combustion installations', of which 1 732 facilities reported it as their main activity, which is considered equivalent to the LCP ESI and CHP sectors. One or more pollutants were reported by 1 288 facilities above the E-PRTR reporting thresholds for $NO_X$, $SO_X$ and $PM_{10}$.

### 2.1.3 Platts European Energy Power Plants dataset (Platts, 2011)

The EEPP (version Dec. 2011) (Platts, 2011) is a commercial dataset containing information on most European power plants. The data is available at unit level, which represents a set, block, aggregate or section of power generation equipment. Information on unit name, geographic location, operating status, electrical capacity ($MW_e$), primary and alternate fuel type (but not fuel use), equipment vendors for the boiler (or reactor), turbine and/or engine, as well as generator/alternator, steam conditions, pollution control equipment and cooling system data are included in the dataset.

The dataset contains more detail on the biomass (wood, peat, bio-derived liquid fuel) and coal (anthracite, (sub)bituminous coal, lignite) fuel types compared to that provided in the LCP dataset. Therefore, for the purposes of this study, the EEPP dataset was linked to the LCP dataset and used at an aggregated Member State level to complement the LCP dataset. The chemical composition of the fuels was used to calculate the flue gas volume with higher accuracy. The following section and Annex I provide further details of the calculations for the different fuel types.

In most cases, individual units contained in the Platts dataset cannot be matched with LCP plants and therefore information was aggregated by Member States. The sector code information was used to distinguish between ESI and CHP sectors for Italy, the Netherlands and Sweden. In some cases, the EEPP was not up to date so further information was gathered via publicly available sources.

## 2.2 Methodology

The LCP dataset is the only official dataset available at EU level that contains both emissions and information on the fuel consumption at individual plant level. The Platts dataset was used for increasing the level of detail concerning the coal and biomass fuel types. Together, these datasets provide the necessary parameters to calculate emission levels (based upon ELVs) and make the comparison with actual emissions.

Four main steps were performed in the assessment:

1. determination of the thermal capacity, and fuel use per fuel type at each plant;
2. estimation of flue gas volumes;
3. calculation of the theoretical annual $NO_X$, $SO_2$ and dust (and also $PM_{10}$ and $PM_{2.5}$) emissions when:
   – assuming that all plants have emissions not exceeding the LCPD ELVs;
   – assuming that all plants have emissions not exceeding the IED ELVs;
   – assuming that all plants have emissions not exceeding the BREF lower AELs;
4. comparison of the pollutant emissions calculated for each of the three cases aggregated by Member State with the reported emissions for the year 2009.

Each step is described in more detail below.

### *Step 1: Thermal capacity per plant — fuel use per fuel type*

To calculate the progress of Member States towards the LCPD and IED ELVs and the lower BAT AELs, knowledge of the thermal capacity at each plant is needed. The LCP dataset contains data on the total thermal input capacity per plant and provides fuel use broken down into five categories: biomass, other solid fuels, liquid fuels, natural gas and other gases.

([4]) See http://prtr.ec.europa.eu.
([5]) The E-PRTR dataset (v4.1) represents the status of the E-PRTR dataset as on 9 June 2012. It contains 2009 data reported in 2011 that has subsequently been corrected by reporting countries. See http://www.eea.europa.eu/data-and-maps/data/E-PRTR4.1.

*Step 2: Estimation of flue gas volumes*

To calculate the level of expected emissions consistent with LCPD and IED ELVs and the lower BAT AELs, estimates of flue gas volumes were calculated based on fuel type and fuel use information.

The calculations start with the estimation of the stoichiometric volumes of flue gases due to the combustion of different fuel types. The combustible components of fuels are principally carbon (C) and hydrogen (H), and in lesser quantity sulphur (S). Complete combustion of a fuel is possible only in the presence of an adequate supply of oxygen (O) usually in the form of air (Box 2.1).

Ambient air contains 21 % oxygen, 78 % nitrogen ($N_2$) and 1 % other gases (for example, argon (Ar), $CO_2$ and water vapour). The products of a stoichiometric combustion with oxygen from the air are $CO_2$, $H_2O$ (water) and $SO_2$, which pass through the chimney along with the $N_2$ in the air. $N_2$ and the other gases do not take part in the combustion process, but some $N_2$ reacts with oxygen to form NO and $NO_2$ (reported as $NO_X$).

As an example, the flue gas volume in the combustion of 1 kg of light fuel oil is illustrated in Figure 2.1. Annex I provides details of the calculation of the flue gas volume of other fuels (based upon Babcock & Wilcox Co., 2007). For the ideal combustion of 1 kg of light fuel oil containing 86 % carbon, 14 % hydrogen and 0.05 % sulphur, theoretically about 14 kg of air is required. This is the minimum air that would be required if the mixing of fuel and air by the burner and combustion is perfect.

The flue gas volume is calculated by taking the molecular weight (m) of the combustible components and air combined in the volume of 1 molecule (mol) of the ideal gas at normalised (N) gas conditions (1 013.25 mbar, 0 °C). This equates to 22.4 L. Using the values in Figure 2.1, the combustion of 1 kg of light fuel oil therefore leads to a net flue gas volume of 12.1 Nm³:

| | | |
|---|---|---|
| $CO_2$-gas: | 22.4 L * 3.161 kg/44 m | = 1.6092 Nm³ |
| $SO_2$-gas: | 22.4 L * 0.001 kg/64 m | = 0.0004 Nm³ |
| $N_2$-gas: | 22.4 L * 11.188 kg/28 m | = 8.9504 Nm³ |
| Water vapour: | 22.4 L * 1.238 kg/18 m | = 1.5406 Nm³ |
| | | = 12.1006 Nm³ (wet flue gas) |
| | | = 10.5600 Nm³ (dry flue gas) |

The dry flue gas volume per unit energy produced (MJ) in a stoichiometric combustion process using 1 kg of light fuel oil is therefore 0.281 Nm³/MJ using the default net calorific value (43.0 MJ/kg) (IPCC, 2006). Since the LCPD and IED ELVs and the BAT AELs are also expressed as an emission factor per Nm³, the flue gas volumes can be directly used to calculate emissions.

In reality, unlike the theoretical example above, combustion works with a surplus of oxygen. The LCPD requirements state that the amount of surplus oxygen depends on fuel type and the technology used (e.g. gas turbine). The following excess oxygen values are used for the flue gas calculations in this report:

**Box 2.1 Theoretical combustion**

*[C + H (fuel)] + [$O_2$ + $N_2$ (Air)] à (Combustion Process) à [$CO_2$ + $H_2O$ + $N_2$ (Heat)]*

Considering:

*1 mol C + 1 mol $O_2$ = 1 mol $CO_2$ à 12 kg C + (2 x 16/12) kg $O_2$ = (44/12) kg $CO_2$*

Such that:

*1 kg C + 2.667 kg $O_2$ à 3.667 kg $CO_2$*

And similarly for $H_2$ and S:

*1 kg $H_2$ + 8 kg $O_2$ à 9 kg $H_2O$*

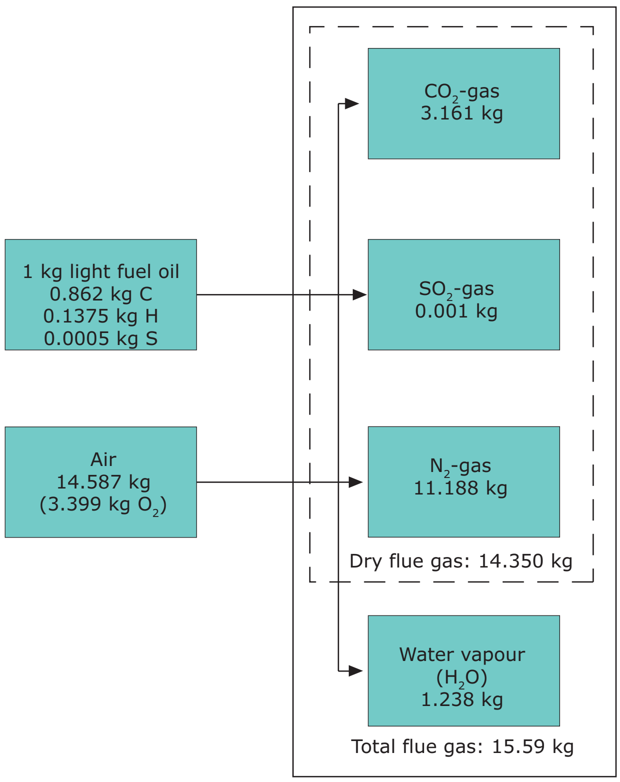
*1 kg S + 1 kg $O_2$ à 2 kg $SO_2$*

- Solid fuels (coal, brown coal, wood, etc.): 6 %
- Liquid fuels: 3 % or 15 % for gas turbines
- Gaseous fuels: 3 % or 15 % for gas turbines

All calculations in this report are based on the calculated dry flue gas volumes and on the net calorific values of the different fuels (IPCC 2006, and for lignite Member State averaged values from Euracoal 2013).

It is difficult to estimate accurately the flue gas volumes for biomass and lignite because it itself contains oxygen and this oxygen takes part in the combustion process. Furthermore, the chemical composition of biomass can vary significantly. Since the LCP dataset does not contains details on biomass type (i.e. solid, liquid or gaseous), the Platts dataset was used to obtain further detail on the type of combusted biomass in order to differentiate between wood, peat, biogas (landfill gas, sewage digester gas), wastewater sludge and bio-derived liquid fuel. The Platts dataset shows that 68 % of the units that have biomass as a main fuel use wood, and in most cases wood is an alternative fuel in co-combustion units. In Finland, Ireland and Sweden, peat is also used as a main fuel (11 % of the units). In some cases, there is no extra information available on the type of biomass.

**Figure 2.1 Calculation of stoichiometric flue gas volume from atomic composition of light fuel oil**




**Source:** Modified from DEB, 1982; and Babcock & Wilcox Co., 2007.

As wood is the main biomass fuel type, the chemical composition of wood pellets was used to calculate the calorific value and flue gas volumes for all biomass. Wood pellets are often the main biomass source burned in electrical power plants because of their high combustion efficiency. The pellets themselves are densely compacted sawdust or other wastes from sawmilling, with low moisture content (below 10 %). Furthermore, the ELVs for 'wood' and 'peat' are the same, so there is no refinement necessary for further analysis.

The Platts dataset was also used to differentiate between the different types of 'other solid fuels' from the LCP dataset because of the variability in flue gas volumes in the combustion of anthracite, (sub) bituminous coal and lignite ([6]). Using the coal details from Platts at a Member State level, the following grouping of coal types was used for the analysis:

- hard coal consisting of Platts coal types: anthracite, bituminous coal;
- lignite consisting of Platts coal types: lignite and (sub)bituminous coal;
  mixed coal consisting of Platts coal mix: bituminous/lignite, bituminous/(sub) bituminous.

For each Member State, a weighted average was calculated across the distribution of different coal groups using the electrical capacity ($MW_e$) of the units from the Platts dataset. Annex II provides a detailed summary.

### *Step 3: Estimation of $NO_x$, $SO_2$, dust, $PM_{10}$ and $PM_{2.5}$ emissions corresponding to the IED and LCPD ELVs and the lower BAT AELs*

**Case 1: All plants have emissions not exceeding the lower BAT AELs**

Plant-level emissions were estimated using

([6]) The value of the flue gas volume corresponding to each fuel type is a sensitive parameter in the assessment. Use of a higher flue gas volume value implies lower emission concentrations will subsequently be estimated. Annex II provides further examples of the flue gas volume calculations by fuel type.

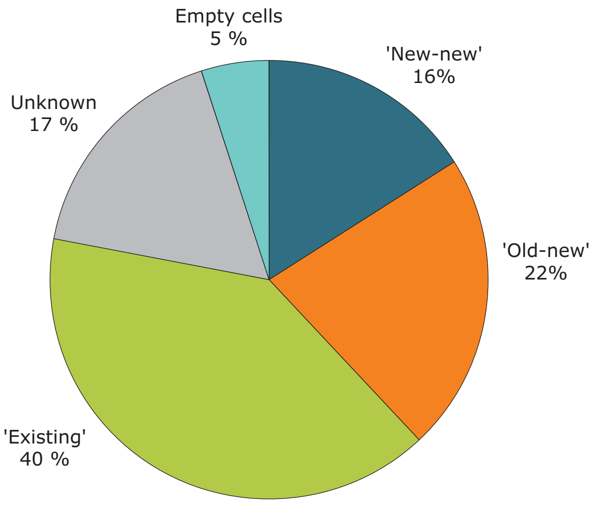
emission factors corresponding to the BAT lower AELs that are provided based on the age of the plant. The LCP dataset contains plant ages and their distribution is presented in Figure 2.2.

For the 'new-new' and 'old-new' plants (terminology of the LCPD), the BAT AELs of new plants were applied, while for the 'existing' plants, unknown and empty cells, the AELs for existing plants were applied. If the estimated value was higher than the 2009 emission, then the 2009 emission was retained since this means the reported emission is already lower than the AEL. The difference in such cases is termed the 'surplus reduction' throughout this report — that is, the difference between the estimated emission corresponding to the lower BAT AELs (or LCPD ELVs) and the reported emission, where the latter is lower. As information on the emission abatement beyond the AEL is lost by simply retaining the 2009 emissions, an estimation of this 'surplus reduction' or excess was made in such situations.

**Case 2: All units have emissions not exceeding the LCPD ELVs**
Emissions at plant level were estimated using emission factors corresponding to the regular-case LCPD ELVs and using the same plant age assumptions as was done for the BAT AELs. If the estimated value was higher than the 2009 emission at plant level, the latter was retained since this means that the reported emission is already lower than the LCPD ELVs. The 'surplus reductions' were also calculated.

**Case 3: All plants have emissions not exceeding the IED ELVs**
Emissions at plant level were estimated using emission factors corresponding to the IED ELVs. The same plant age assumptions were applied as for the calculation of the BAT AELs and the LCPD ELVs. If the estimated value was higher than the 2009 unit emission, the latter was retained since this means that the current emission is already lower than the IED ELVs. The 'surplus reductions' were also calculated.

**Figure 2.2 Age distribution of the 1 595 LCPs considered in this report**




Actual emissions for $NO_X$, $SO_2$ and dust were obtained from the 2009 LCP dataset as previously described. While the LCP dataset contains data on dust emissions, no information is provided concerning the $PM_{2.5}$ or $PM_{10}$ fractionation. These fractions were therefore estimated using default average emission factors for averaged abatement technologies from the *EMEP/EEA air pollutant emission inventory guidebook* (EEA, 2009). The fuel type used strongly influences the PM emission factors. Dust emissions from gaseous fuels consist of 100 % $PM_{10}$ and $PM_{2.5}$ emissions, while the fractions from the combustion of different coal types are 66 % $PM_{10}$ and 30 % $PM_{2.5}$. The combustion of liquid fuels entails a distribution of 75 % $PM_{10}$ and 50 % $PM_{2.5}$.

***Step 4: Comparison of the pollutant emissions calculated for each of the three cases with the reported emissions for the year 2009***

The calculated emissions in the three cases described above were aggregated at Member State level. The theoretical emission reduction potential of $NO_X$, $SO_2$ and dust was then estimated by comparing with the reported LCP emissions for 2009.

# 3 Results and discussion

This chapter presents and describes the assessment performed for each of the three pollutants $NO_X$, $SO_2$ and dust, and the estimated theoretical emission reduction potential of emissions at plant level.

## 3.1 Analysis of fuel type and use

Fuel type plays a key role in the interpretation and comparison between Member States of the 2009 emissions and in the calculation of the theoretical emission reduction potential. The ELVs are specified for different fuel types. Figure 3.1 shows that in 2009, 56 % 'other solid fuels' (in terms of thermal input (TJ)) and 35 % natural gas of the total fuel use were used by the selected 1 595 plants. The use of biomass, liquid fuels and other gases is much smaller, between 2 and 4 %. Using data from the EEPP dataset to determine the average distribution within the 'other solid fuels' group (hard coal, lignite, mixed coal) revealed that 63 % used hard coal, 34 % lignite and 3 % mixed coal. The use of biomass, liquid fuels and other gases is much smaller, between 2 and 4 %. The biggest impact in reduction can therefore be expected for coal/lignite and natural gas.

Where a plant uses only one fuel type, a direct link to the emissions and the fuel type used is possible. However, where plants use a multi-fuel mixture, it is not possible to simply link emissions to just one fuel type since only total emissions per pollutant are available and fuels may be used either consecutively or simultaneously. If no fuel type makes up more than 95 % of the total fuel usage, the combustion plant is considered 'multi-fuel'. Figure 3.2 shows that coal and biomass represent the highest share in emissions as illustrated in the distribution of plants using different single fuel types.

Comparison of Figure 3.1 and Figure 3.2 shows that 35 % of the total fuel is natural gas, which is used by 47 % of the 1 595 plants. 'Other solid fuels' comprises 56 % of the total fuel, which is used by less than 37 % (i.e. 14 % plus the largest share (23 %) of the multi-fuel plants') of the total number of plants.

**Figure 3.1 Shares of fuel used (TJ) by the 1 595 plants**

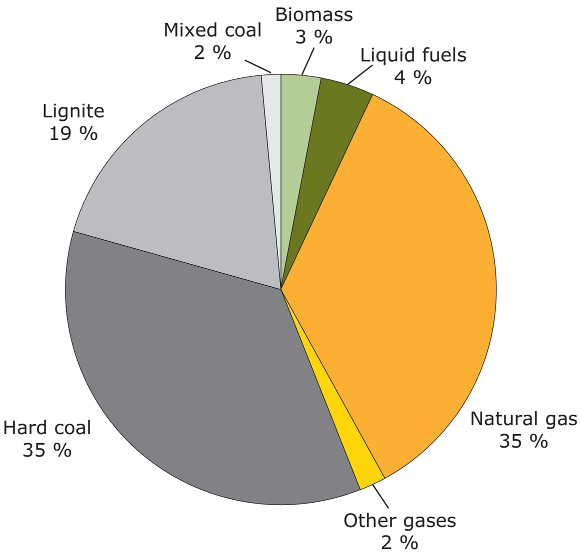
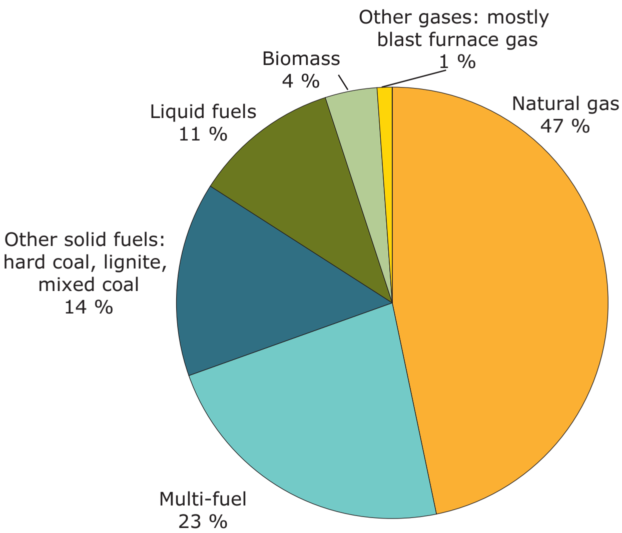



**Figure 3.2 Distribution of the 'single fuel type' classification in the LCP dataset**



This implies that gas plants normally have smaller thermal and electrical capacities than coal plants.

## 3.2 Comparison of 2009 $NO_x$ emissions with LCPD and IED ELVs and lower BAT AELs

The effect on $NO_x$ emissions corresponding to a hypothetical full implementation of the lower BAT AELs and the LCPD and IED ELVs has been estimated (Table 3.1). If the estimated emission limit (BAT, LCPD or IED) is higher than the 2009 plants emission, then the latter will be retained since this means that the current reported emissions are already lower than the respective limit values. The largest reduction (69 %) would be achieved if all plants reached the most stringent limit values from the lower BAT AELs. The least reduction (5 %) is related to the LCPD ELV.

The $NO_x$ emissions in 2004 analysed in the previous EEA report (EEA, 2008) for the EU-25 were 20 % higher than the LCPD ELVs whereas, in 2009, a similar comparison (again based on EU-25) shows emissions are only 6 % higher. It should be noted however that the two studies employ different methodologies, so any comparison of values should be undertaken carefully. This confirms that good progress has been made by Member States in reducing their emissions since the previous report.

Germany, Poland and the United Kingdom have the highest reported 2009 $NO_x$ emissions from the selected LCPs (Figure 3.3). However, emissions reported by Germany are already consistent with all but the most stringent lower BAT AELs. Figure 3.3 also shows that for a number of Member States (Belgium, Germany, Hungary, Luxembourg, the Netherlands, Slovenia and Sweden), the potential emission reductions are almost the same when comparing the theoretical IED and LCPD ELVs. This suggests the 2009 emissions are close to or already below the limit values.

For the plants where the 2009 emission was already lower than the ELVs, the 'surplus reductions' (i.e. the emission reduction already achieved below the limit values) was calculated. These amounted to 1 155 kt for the LCPD, 190 kt for IED and 8 kt for lower BAT emission levels. The surplus reductions are negligible compared with the lower BAT AEL, implying that only a very limited number of plants already reach the lower BAT AEL. The surplus reduction already achieved compared with the LCPD ELVs is high for a number of Member States, especially for Czech Republic, Germany and Poland, which suggests that these Member States have more stringent ELVs than required or plants in any case operate below the level of the LCPD ELVs.

It is noted that a small number of very large plants account for a substantial share of the total emissions (Figure 3.4) with only 50 (or 3 %) of the 1 595 plants accounting for 50 % of emissions, and 454 (or 28 %) accounting for 90 % of emissions. Germany, Poland and the UK account for 27 of the largest emitting plants, together representing more than 30 % of the total EU-27 emissions. It is important to note, however, that a small number of large plants may actually be more efficient than smaller plants; the absolute magnitude of emissions from a plant does not necessarily inform on relative operating efficiencies.

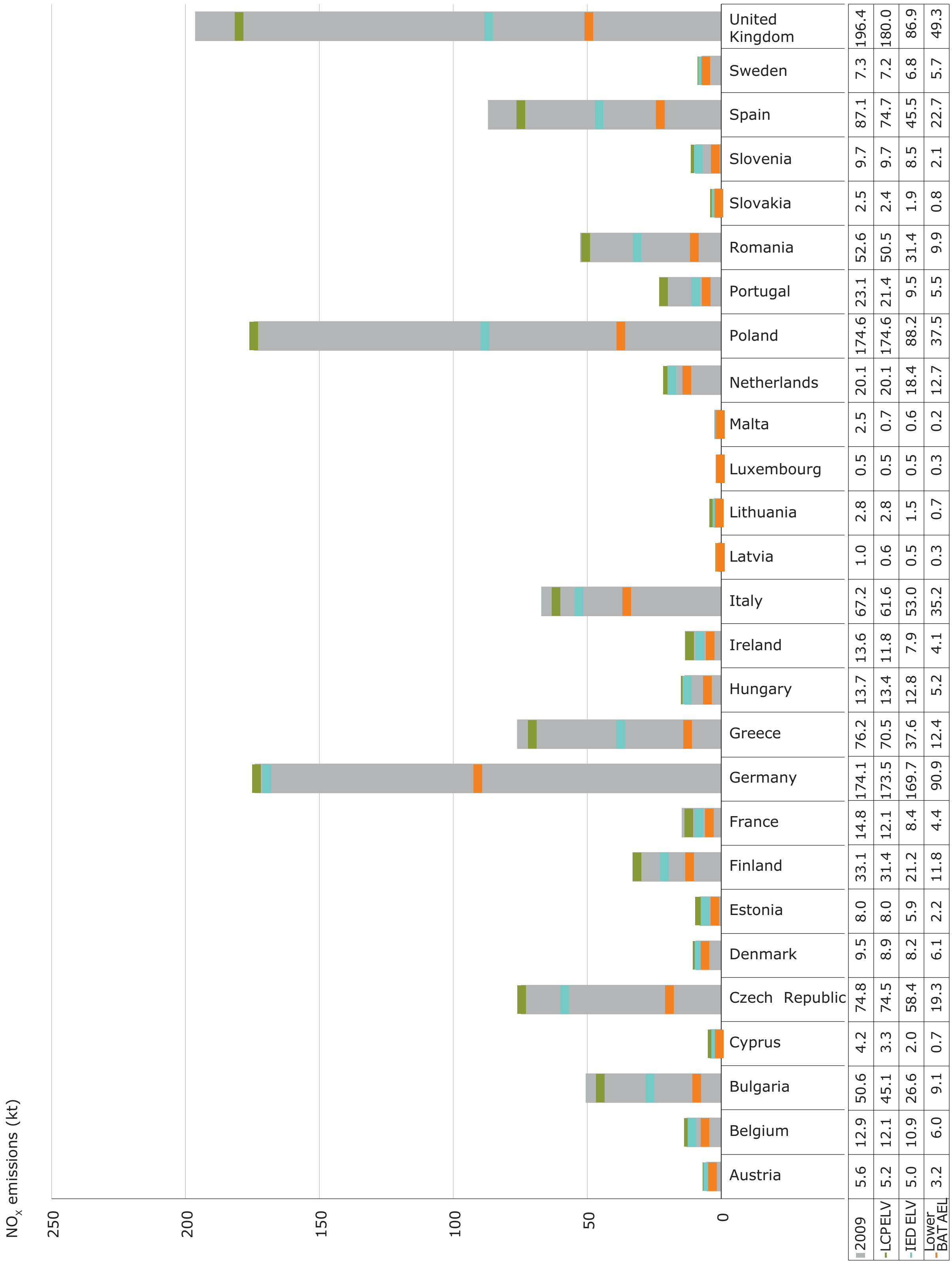
In terms of the cross-checking performed of reported emissions, only 40 of the 50 plants representing 50 % of the $NO_x$ emissions could be linked to E-PRTR facilities. For 28 of these plants, there is little difference (+/– 5 %) between the two datasets; however, two plants (one each in Bulgaria and Greece) have reported emissions that are significantly greater than the E-PRTR facility at 32 % and 155 %, respectively (Table 3.2). The reasons for such significant differences are not clear.

Overall, the $NO_x$ emissions from the selected LCPs account for 85 % of the total E-PRTR 'Thermal power stations and other combustion installations' sector

**Table 3.1 Gap between 2009 $NO_x$ emissions and emissions based on the LCP emission limits, the IED emission limits, and the lower BAT AELs**

| | Reported emissions 2009 | Potential emissions based on LCPD ELVs | | Potential emissions based on IED ELVs | | Potential emissions based on lower BAT AELs | |
|---|---|---|---|---|---|---|---|
| | Emissions (kt) | Emissions (kt) | % reduction compared to 2009 emissions | Emissions (kt) | % reduction compared to 2009 emissions | Emissions (kt) | % reduction compared to 2009 emissions |
| $NO_x$ | 1 138 | 1 077 | – 5 % | 728 | – 36 % | 358 | – 69 % |

**Figure 3.3 2009 $NO_x$ emissions (kt) compared with LCPD and IED emission limits, and the lower BAT AELs (1 595 plants)**




| | 2009 | LCPELV | IED ELV | Lower BAT AEL |
|---|---|---|---|---|
| Austria | 5.6 | 5.2 | 5.0 | 3.2 |
| Belgium | 12.9 | 12.1 | 10.9 | 6.0 |
| Bulgaria | 50.6 | 45.1 | 26.6 | 9.1 |
| Cyprus | 4.2 | 3.3 | 2.0 | 0.7 |
| Czech Republic | 74.8 | 74.5 | 58.4 | 19.3 |
| Denmark | 9.5 | 8.9 | 8.2 | 6.1 |
| Estonia | 8.0 | 8.0 | 5.9 | 2.2 |
| Finland | 33.1 | 31.4 | 21.2 | 11.8 |
| France | 14.8 | 12.1 | 8.4 | 4.4 |
| Germany | 174.1 | 173.5 | 169.7 | 90.9 |
| Greece | 76.2 | 70.5 | 37.6 | 12.4 |
| Hungary | 13.7 | 13.4 | 12.8 | 5.2 |
| Ireland | 13.6 | 11.8 | 7.9 | 4.1 |
| Italy | 67.2 | 61.6 | 53.0 | 35.2 |
| Latvia | 1.0 | 0.6 | 0.5 | 0.3 |
| Lithuania | 2.8 | 2.8 | 1.5 | 0.7 |
| Luxembourg | 0.5 | 0.5 | 0.5 | 0.3 |
| Malta | 2.5 | 0.7 | 0.6 | 0.2 |
| Netherlands | 20.1 | 20.1 | 18.4 | 12.7 |
| Poland | 174.6 | 174.6 | 88.2 | 37.5 |
| Portugal | 23.1 | 21.4 | 9.5 | 5.5 |
| Romania | 52.6 | 50.5 | 31.4 | 9.9 |
| Slovakia | 2.5 | 2.4 | 1.9 | 0.8 |
| Slovenia | 9.7 | 9.7 | 8.5 | 2.1 |
| Spain | 87.1 | 74.7 | 45.5 | 22.7 |
| Sweden | 7.3 | 7.2 | 6.8 | 5.7 |
| United Kingdom | 196.4 | 180.0 | 86.9 | 49.3 |

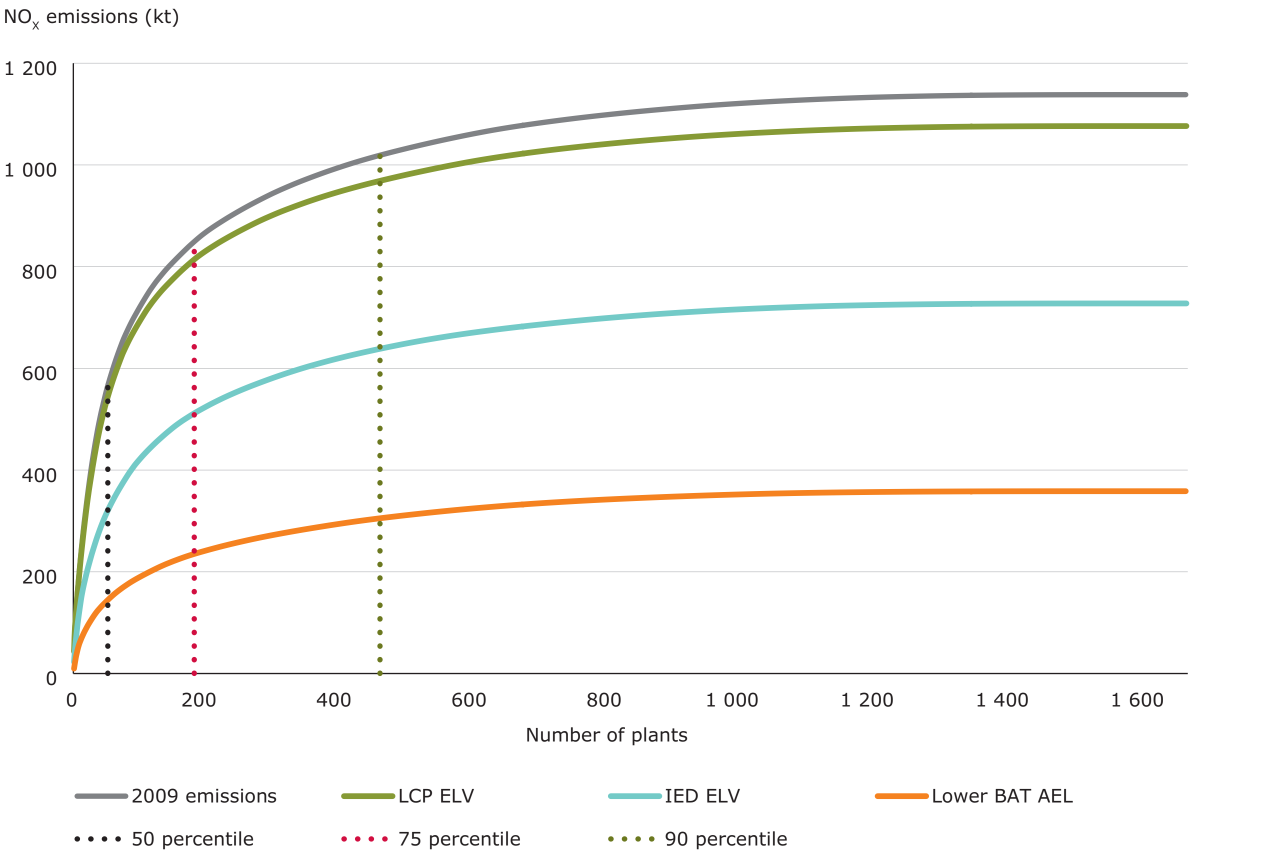
**Table 3.2 Plants with emissions significantly greater than the relevant E-PRTR facility**

| Country | Plant name | Plant location | E-PRTR company name | E-PRTR facility name | LCP $NO_x$ (t) | E-PRTR $NO_x$ (t) | Difference (E-PRTR/ LCP) |
|---|---|---|---|---|---|---|---|
| Greece | PPC S.A. — Amyntaio ST I-II | Amyntaio, Florina | PPC S.A. | PPC S.A. SES AMYNTAIOY | 10 909 | 4 270 | – 155.5 % |
| Bulgaria | TPP 'Bobov dol' | Golemo selo, municipality Bobov Dol, region Kyoustendil | TETS — BOBOV DOL | TETs 'Bobov dol' | 6 378 | 4 840 | – 31.8 % |

emissions. A plant-by-plant comparison at Member State level was not possible because there is no official link between plants in the LCP dataset with E-PRTR facilities. This situation could be improved if Member States were to make an explicit link between the two datasets in order to enable a proper and accurate comparison of the reported emissions to be made. It is recommended that a link be created between these two datasets by encouraging the reporting of the E-PRTR National Identification Code when reporting to the LCP inventory under the IED.

In line with the amount of the different fuels used, coal-fired power plants ('other solid fuels') have the highest proportion of 2009 $NO_x$ emissions (63 %), and coal co-combustion plants ('multi-fuel' plants) account for 21 % of emissions.

**Figure 3.4 Cumulative distribution of the $NO_x$ emissions under different scenarios (1 595 plants)**



## 3.3 Comparison of 2009 $SO_2$ emissions with LCPD and IED ELVs and lower BAT AELs

The potential estimated effect of meeting the emission limits for $SO_2$ is shown in Table 3.3. As described previously, if the estimated emission value (LCPD, IED and BAT) was higher than the 2009 emission then the latter was retained since this means that the current emission was already lower than the emission limits. The largest reduction (94 %) would be achieved if all plants reached the most stringent limit values of the lower BAT AEL and the least reduction (47 %) to the LCPD ELV.

The previous report (EEA, 2008), which was based on 450 facilities from the 2004 EPER dataset, indicated that reported emissions of $SO_2$ were 61 % above the estimated emission corresponding to the LCPD ELVs. Figure 3.5 shows the 2009 (EU-25) $SO_2$ emissions were 39 % higher than the LCPD ELVs, a positive evolution compared to the earlier study based on 2004 data. The 2009 EU-27 emissions are 90 % higher than the LCPD ELVs largely due to the reported emissions from the two most recent EU Member States, Bulgaria and Romania, both of which report emissions significantly above the $SO_2$ LCPD ELV (Figure 3.6). It is important to note that both these Member States had derogations in place in 2009.

**Table 3.3 Gap between 2009 $SO_2$ emissions and emissions based on the LCP emission limits, the IED emission limits, and the lower BAT AELs**

| | Reported emissions 2009 | Potential emissions based on LCPD ELVs | | Potential emissions based on IED ELVs | | Potential emissions based on lower BAT AELs | |
|---|---|---|---|---|---|---|---|
| | Emissions (kt) | Emissions (kt) | % reduction compared to 2009 emissions | Emissions (kt) | % reduction compared to 2009 emissions | Emissions (kt) | % reduction compared to 2009 emissions |
| $SO_2$ | 1 662 | 876 | – 47 % | 572 | – 66 % | 98 | – 94 % |

**Figure 3.5 Total 2009 $SO_2$ emissions in the EU-25 and the EU-27 compared with LCPD and IED emission limits, and the lower BAT AELs**

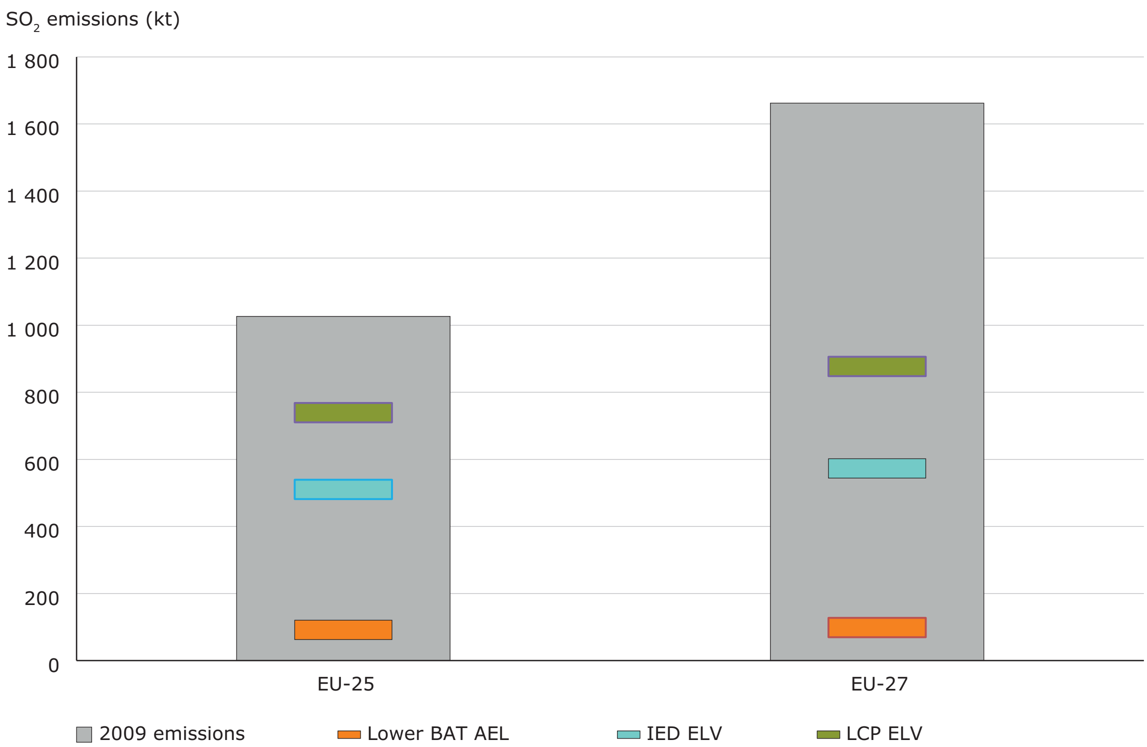


Figure 3.6 presents the $SO_2$ emissions for 2009 compared with lower BAT AELs, LCPD ELVs and IED ELVs for each Member State. The highest $SO_2$ emissions were reported by Bulgaria, Poland and Romania. Compared to the reported 2009 emissions, Bulgaria, Estonia ([7]), Greece and Romania would achieve the largest reduction percentage (98–99 %) if the selected plants in these countries reached the lower BAT AELs. The largest reduction effort in absolute tonnes $SO_2$ would have to be realised by Bulgaria, Greece, Poland and Romania.

For a number of Member States (Austria, Belgium, Germany, Hungary, the Netherlands, Portugal, Slovenia and Sweden), the reduction needed to reach the LCPD and IED ELVs is small. This means that the 2009 emissions are close to or already below the limit values for these Member States, which means that the 2009 emissions are retained and no further reduction can be realised. It is likely these Member States have ELVs that are more stringent than the LCPD and IED ELVs.

For the plants where the 2009 emission was already lower than the ELVs, the 'surplus' reduction was calculated. This amounted to 1 044 kt for LCPD, 236 kt for IED and 15 kt for lower BAT. For many Member States, especially Czech Republic, Germany and the United Kingdom, the surplus reduction compared with the LCPD ELVs is high.

In the case of Germany, the large difference between the LCPD and IED ELVs, and the lower BAT AEL is two-fold. On the one hand, the lower BAT AEL with a $SO_2$ concentration of 20 mg/Nm$^3$ is extremely low. On the other, the lower BAT AEL does not reflect the special situation of combustion plants fuelled with high-sulphur containing lignite (Umweltbundesamt, personal communication). The next revision of the LCP BREF will consider such issues.

Even much more than for $NO_X$, a limited number of very large plants account for a large share of the total $SO_2$ emissions. Only 20 (1 %) of the 1 595 plants represent 50 % of the total emissions, while 165 (10 %) represent 90 % of the emissions. Bulgaria, Greece and Romania account for 14 of the 20 largest emitting plants, together representing 76 % of the total emissions. All 20 plants could be linked to E-PRTR facilities and, for most, the reported emissions compared reasonably well. The exception was for four plants in Bulgaria, where for three plants the reported LCP emissions were only 63–80 % of those reported to E-PRTR and one, 'Toplofikatsia Sliven', where the emissions were 73 % higher than E-PRTR. This most likely represents an error in either the E-PRTR or the LCPD reporting.

The 2009 $SO_2$ emissions from the 'other solid fuels' plants are the highest (73 %) of total emissions followed by the 'multi-fuel' plants (24 %), which are dominated by the coal co-combustion plants. Therefore, the largest reduction potential can be found in the 'other solid fuels' and 'multi-fuel' plants. $SO_2$ emissions from natural gas, other gases and biomass are negligible. Liquid fuel emissions are low and decreasing not just because of the lower S-content of the fuel, but also because of the limited utilisation of liquid fuels in power plants (Figure 3.1 and Figure 3.2).

([7]) In Estonia, oil shale is the main fuel type used by power plants. There is no emission limit value for oil shale so the 'mixed coal' factor was used for the comparisons against the three emission limits.

**Figure 3.6 2009 $SO_2$ emissions (kt) compared with the LCPD and IED emission limits, and the lower BAT AELs (1 595 plants)**


| Country | 2009 | LCP ELV | IED ELV | Lower BAT AEL |
|---|---|---|---|---|
| Austria | 1.4 | 1.3 | 1.4 | 0.7 |
| Belgium | 2.5 | 2.3 | 1.9 | 0.6 |
| Bulgaria | 308.5 | 68.9 | 30.1 | 3.7 |
| Cyprus | 13.3 | 7.5 | 2.4 | 1.0 |
| Czech Republic | 93.8 | 81.2 | 56.6 | 9.9 |
| Denmark | 2.7 | 2.7 | 2.4 | 1.5 |
| Estonia | 40.7 | 15.2 | 7.4 | 0.9 |
| Finland | 20.1 | 19.1 | 14.1 | 5.7 |
| France | 16.9 | 11.3 | 7.6 | 2.3 |
| Germany | 121.5 | 121.1 | 119.4 | 25.6 |
| Greece | 188.1 | 65.7 | 37.6 | 4.5 |
| Hungary | 9.8 | 9.8 | 9.0 | 2.1 |
| Ireland | 15.7 | 7.4 | 3.7 | 0.5 |
| Italy | 51.5 | 47.7 | 27.8 | 5.5 |
| Latvia | 0.0 | 0.0 | 0.0 | 0.0 |
| Lithuania | 4.2 | 1.1 | 0.6 | 0.3 |
| Luxembourg | 0.0 | 0.0 | 0.0 | 0.0 |
| Malta | 3.5 | 0.6 | 0.6 | 0.2 |
| Netherlands | 5.9 | 5.9 | 5.9 | 2.1 |
| Poland | 237.0 | 185.2 | 98.7 | 11.1 |
| Portugal | 7.1 | 7.1 | 7.1 | 0.9 |
| Romania | 327.0 | 68.7 | 32.6 | 3.7 |
| Slovakia | 3.2 | 3.0 | 1.7 | 0.3 |
| Slovenia | 6.0 | 6.0 | 5.6 | 0.9 |
| Spain | 66.8 | 44.1 | 32.4 | 5.1 |
| Sweden | 2.6 | 2.6 | 2.0 | 1.4 |
| United Kingdom | 111.8 | 90.5 | 63.8 | 7.5 |

## 3.4 Comparison of 2009 dust emissions with LCPD and IED ELVs and lower BAT AELs

The effect on dust emissions of a hypothetical full implementation of the LCPD and IED ELVs and the BAT AELs has been estimated and is presented in Table 3.4. As for the other pollutants, if the estimated value (LCPD, IED or BAT) was higher than the 2009 emission at plant level, the latter was retained since this means that the current emission was already lower than the LCPD, IED or BAT emission limits. Dust emissions were not analysed in the previous report so no comparisons with the earlier study are made.

A 79 % reduction would potentially be realised if all plants achieve emissions consistent with the lower BAT AELs, and a smaller reduction (29 %) by achieving the LCPD ELV (Figure 3.7).

Bulgaria, Greece, Poland and Romania have the highest 2009 dust emissions (Figure 3.7), which were still above the LCPD ELVs for dust by 2009. In moving toward emissions at the level of the IED ELVs, the largest reduction effort in tonnes of dust will have to be realised by Bulgaria, Estonia, Greece, Poland and Romania.

Since the health impact of dust and dust fractions ($PM_{10}$ and $PM_{2.5}$) differs largely, it was decided to estimate the dust fractions even though they are not directly available from the LCP dataset used in this study (Figure 3.8). Details of the simple approach used to estimate the $PM_{2.5}$ and $PM_{10}$ fractions is provided in the methodology section of this report.

The results show that $PM_{10}$ emissions account for 82 % (range 75–88 %) of total dust emissions on average, and $PM_{2.5}$ account for 54 % (range 40–67 %) on average. For the plants where the 2009 emission was already lower than the emission limits, the 'surplus reduction' was calculated to be 170 kt for LCPD, 21 kt for IED and 4 kt for lower BAT AELs. The surplus reductions are small compared with the lower BAT AEL values and high compared with the IED ELVs.

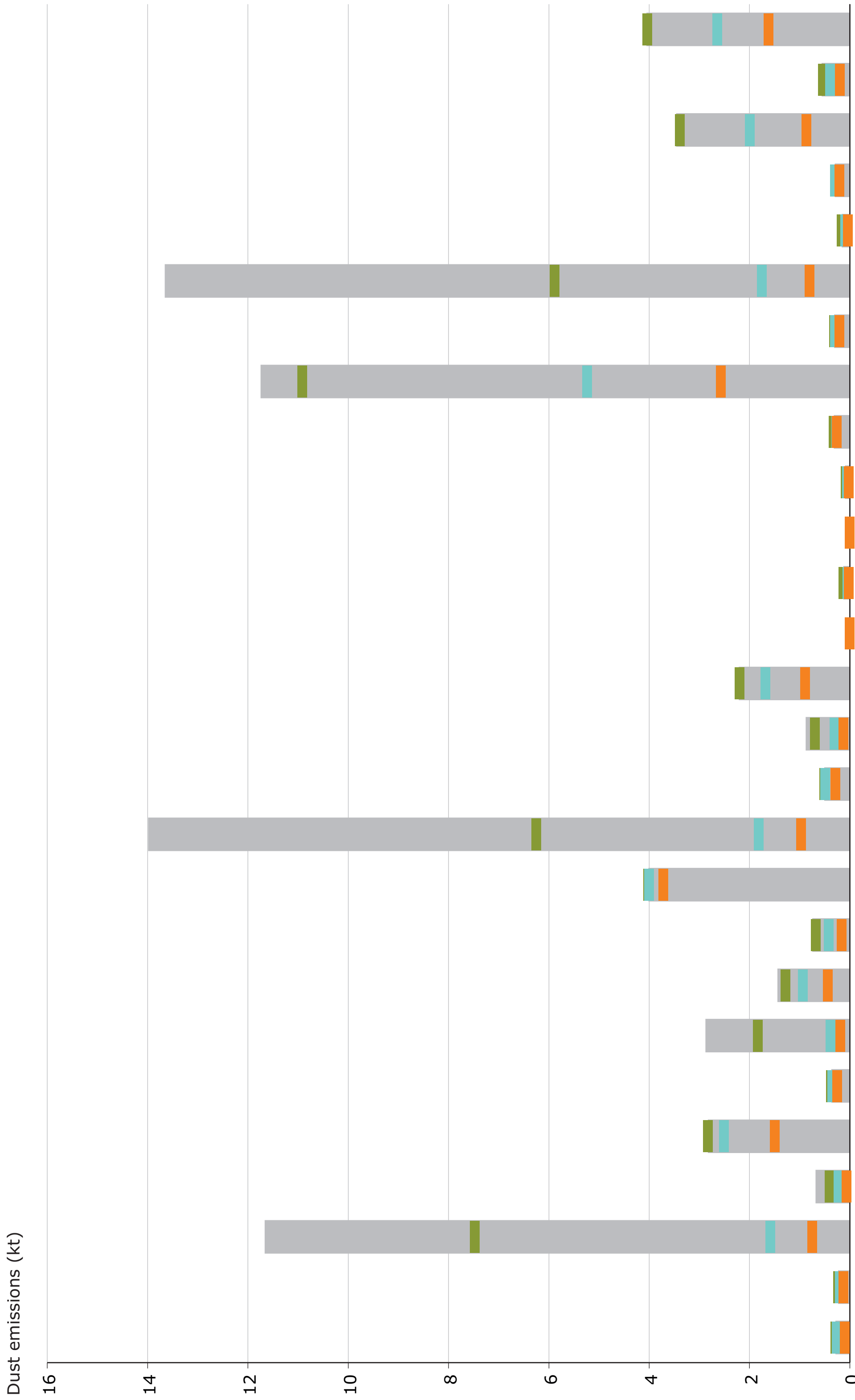
As with $NO_X$ and $SO_2$, a very limited number of very large plants account for a very large share of the total emissions. Only 21 (1 %) of the 1 595 plants represent 50 % of the total 2009 dust emissions, while 175 (11 %) plants represent 90 % of the emissions. Bulgaria, Greece and Romania account for 17 of the top 21 emitting plants and these 17 together represent 82 % of emissions from the top 21 pants, or 40% of total emissions.

The disaggregation of the emissions per fuel type was calculated by linking the emissions to the 'single fuel type' reported in the LCP dataset. The results show that very large coal ('other solid fuels') plants and coal co-combustion ('multi-fuel') plants account for most of the dust emissions with 69 % and 26 %, respectively. Dust emissions are negligible from natural gas and other gases fuel types, and those from liquid fuels are also low, because of the limited utilisation of liquid fuels in power plants (Figure 3.1 and Figure 3.2). The largest reduction potential can therefore be found in the 'other solid fuels' and 'multi-fuel' plants. The lower BAT AELs are strict for existing and new coal-using plants, and so the theoretical achievement of levels of emissions consistent with the AELs would yield high emission reductions.

**Table 3.4 Gap between 2009 dust emissions and emissions based on the LCP emission limits, the IED emission limits, and the lower BAT AELs**

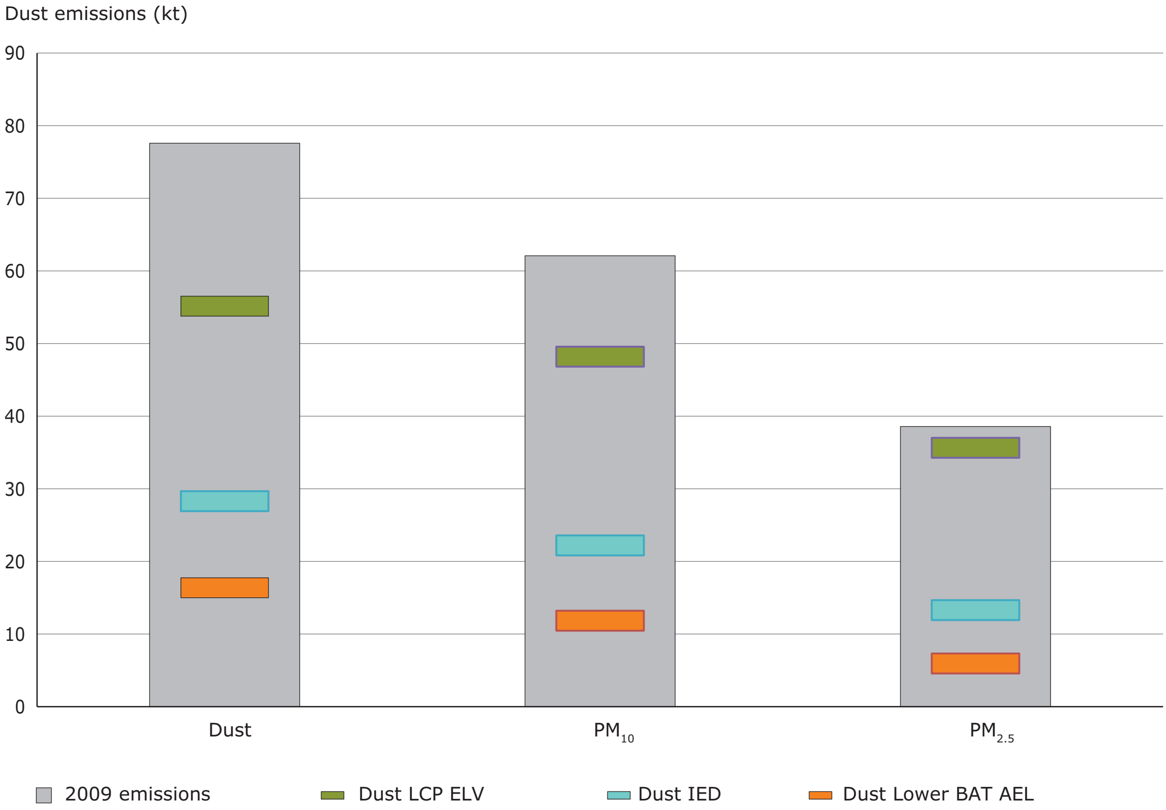
| | Reported emissions 2009 | Potential emissions based on LCPD ELVs | | Potential emissions based on IED ELVs | | Potential emissions based on lower BAT AELs | |
|---|---|---|---|---|---|---|---|
| | Emissions (kt) | Emissions (kt) | % reduction compared to 2009 emissions | Emissions (kt) | % reduction compared to 2009 emissions | Emissions (kt) | % reduction compared to 2009 emissions |
| Dust | 77.6 | 55.1 | – 29 % | 28.2 | – 64 % | 16.4 | – 79 % |

**Figure 3.7 2009 dust emissions compared with the LCPD and IED emission limits, and the lower BAT AELs (1 595 plants)**




| | 2009 | LCP ELV | IED ELV | Lower BAT AEL |
|---|---|---|---|---|
| United Kingdom | 4.1 | 4.0 | 2.6 | 1.6 |
| Sweden | 0.6 | 0.5 | 0.4 | 0.2 |
| Spain | 3.5 | 3.4 | 2.0 | 0.9 |
| Slovenia | 0.3 | 0.3 | 0.3 | 0.2 |
| Slovakia | 0.2 | 0.2 | 0.1 | 0.0 |
| Romania | 13.7 | 5.9 | 1.8 | 0.8 |
| Portugal | 0.3 | 0.3 | 0.3 | 0.2 |
| Poland | 11.7 | 10.9 | 5.2 | 2.6 |
| Netherlands | 0.3 | 0.3 | 0.3 | 0.3 |
| Malta | 0.1 | 0.1 | 0.1 | 0.0 |
| Luxembourg | 0.0 | 0.0 | 0.0 | 0.0 |
| Lithuania | 0.1 | 0.1 | 0.1 | 0.0 |
| Latvia | 0.0 | 0.0 | 0.0 | 0.0 |
| Italy | 2.2 | 2.2 | 1.7 | 0.9 |
| Ireland | 0.9 | 0.7 | 0.3 | 0.1 |
| Hungary | 0.5 | 0.5 | 0.5 | 0.3 |
| Greece | 14.0 | 6.2 | 1.8 | 1.0 |
| Germany | 4.0 | 4.0 | 4.0 | 3.7 |
| France | 0.7 | 0.7 | 0.4 | 0.2 |
| Finland | 1.4 | 1.3 | 0.9 | 0.4 |
| Estonia | 2.9 | 1.8 | 0.4 | 0.2 |
| Denmark | 0.4 | 0.4 | 0.3 | 0.3 |
| Czech Republic | 2.8 | 2.8 | 2.5 | 1.5 |
| Cyprus | 0.7 | 0.4 | 0.2 | 0.1 |
| Bulgaria | 11.7 | 7.5 | 1.6 | 0.7 |
| Belgium | 0.2 | 0.2 | 0.2 | 0.1 |
| Austria | 0.3 | 0.3 | 0.3 | 0.1 |

**Figure 3.8 2009 dust emissions and estimation of $PM_{10}$ and $PM_{2.5}$ fractions and the LCPD and IED emission limits, and the lower BAT AEL (1 595 plants)**



# 4 Uncertainty analysis

## 4.1 Introduction

The calculations used to estimate the theoretical emissions of 1 595 LCPs corresponding to LCPD and IED ELVs and the lower BAT AELs in this report are inevitably based on certain assumptions and parameters involving some uncertainty. Two important sources of possible uncertainty were quantified using a sensitivity analysis on:

1. the impact of parameters used to estimate the flue gas volume;
2. the effect of different flue gas volumes on Member State level emissions.

As previously described, the 2009 emissions data officially reported to the European Commission under the LCPD is used in this report. This report does not evaluate uncertainty due to the quality and completeness of the LCP dataset. Gaps in the reporting of emissions by Member States were filled in the context of a study done for the European Commission (AMEC, 2012) and gaps in the type and nature of some plants were filled where necessary using the Platts EEPP and publicly available information sources. Quantitative information on potential errors and uncertainties in the datasets and approach used is not available and therefore it is not possible to provide a full uncertainty analysis with information on confidence intervals of the calculated emissions.

## 4.2 Scope of the sensitivity analysis

The calculations used to estimate the emissions are based mainly on information in the LCP dataset. However, in order to relate this information to AELs and ELVs, which are given in concentration units (mg/Nm³), additional information is needed to convert them. Most important is the fuel composition and the calorific values taken from the literature i.e. from IPCC, 2006 and for lignite from Euracoal, 2013. This data is specific for the atomic composition for each of the fuel types but the calorific value is given as a range. For the calculation of flue gas volumes within this study, the average calorific value was used for each fuel type. In order to assess the impact of the range of the calorific values within the calculation and for the overall study results, a sensitivity analysis was performed and is presented in Section 4.3. Since the calorific value is the most uncertain parameter for the study results, this was addressed in the sensitivity analysis to explore the uncertainty and its impacts on the calculated emissions.

## 4.3 Sensitivity analysis on the impact of parameters used to estimate the flue gas volume

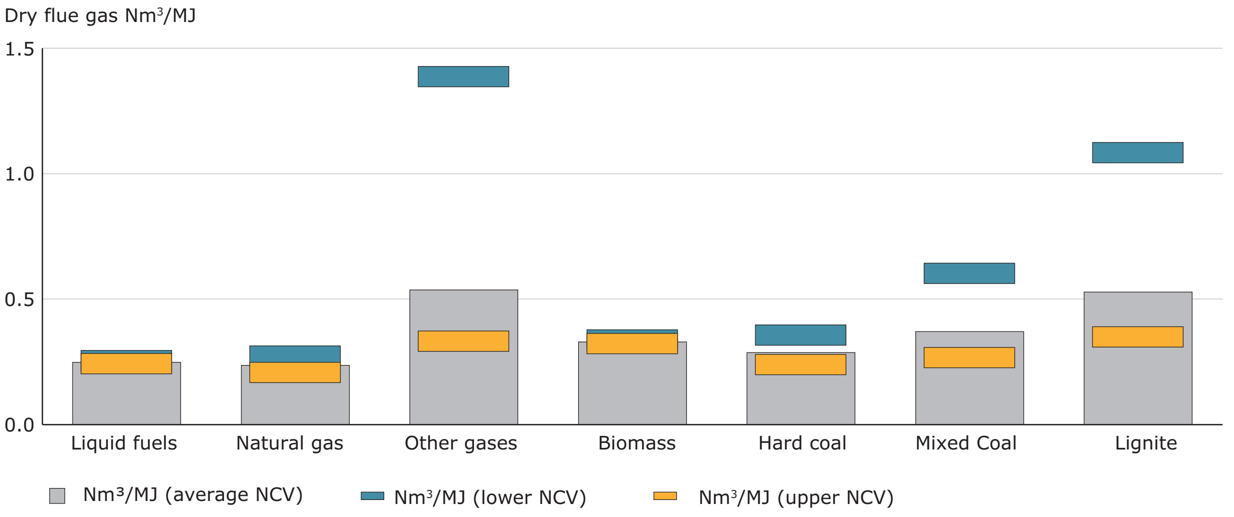
The estimated flue gas volume per fuel is an important parameter because the emissions for $NO_X$, $SO_2$ and dust (mg/Nm³) are calculated based on the flue gas volume, which in turn is dependent on the calorific value assumed for each fuel. The range of flue gas volumes for each of the seven fuel types corresponding to the lower, upper and average calorific values are presented in Figure 4.1, illustrating the effect of this uncertainty.

Table 4.1 shows that for liquid fuels and biomass the differences in the flue gas are small and remain within 5 % of the average. The fuels with the highest uncertainty are lignite and 'other gases'. The given uncertainties for each of the fuel types are in line with the ranges of the calorific values. The high uncertainty of 'Other gases' has a lesser impact on

**Table 4.1 Overview of deviations from the average calorific value for each fuel**

| Fuel type | Deviation from average (%) |
|---|---|
| Liquid fuels (TJ) | 2.3 |
| Natural gas (TJ) | 12.1 |
| Other gases (TJ) | 38 |
| Biomass (TJ) | 2.1 |
| Hard coal | 16.5 |
| Mixed coal | 27.9 |
| Lignite | 33.9 |

**Figure 4.1 The range of flue gas volumes corresponding to the lower, upper range and average net calorific values for each of the seven fuel types addressed in this study**



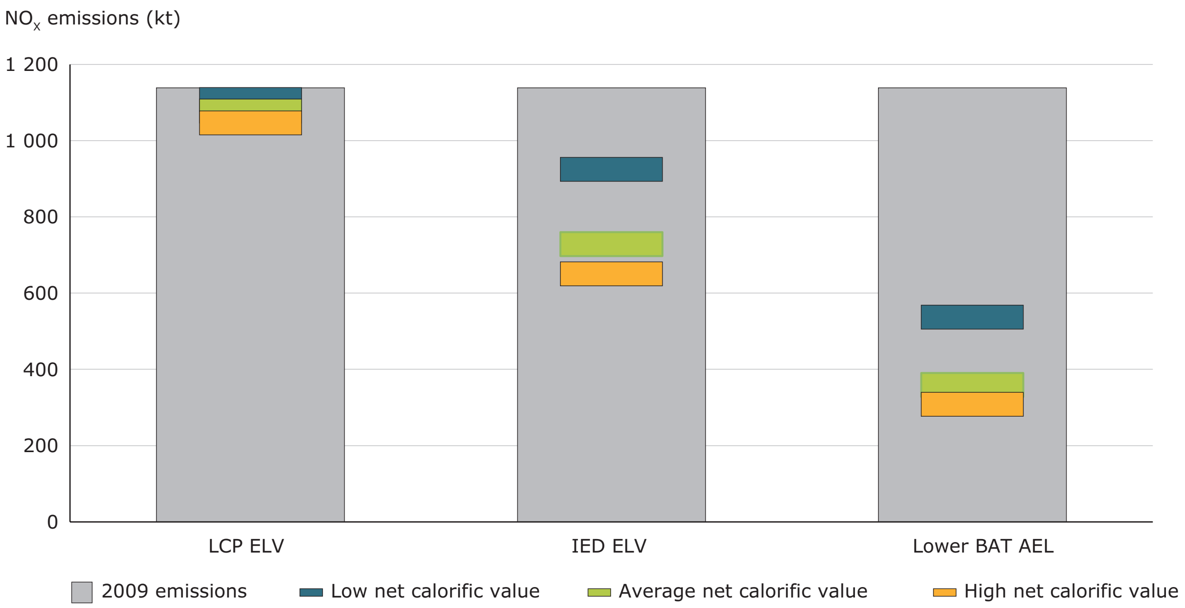

the overall certainty because it is not often used in plants compared to lignite (Figure 3.1).

## 4.4 Sensitivity analysis on the impact of the calorific value for $NO_x$ emissions

In order to estimate the impact of the fuel calorific value on the estimated $NO_x$ emissions, a sensitivity analysis was performed showing the emissions in an aggregated form for all EU Member States.

Figure 4.2 shows the effects on the results due to different calorific values of the fuels. There is a clear difference for each AEL and ELV. The reported $NO_x$ emissions in 2009 are the baseline to show the effect that is represented in Figure 4.2 by the columns. For the three emission limits, the average calorific value for each fuel is the same. These values show the level of emissions that would have been realised if the respective AEL or ELVs would have been fulfilled. Note that this figure is an aggregation of all plants under the scope of this study.

**Figure 4.2 Sensitivity of 2009 $NO_x$ emissions from LCP for lower BAT AEL, LCPD ELV and IED ELV by variation of fuel net calorific values compared to the reported emissions**



Taking into account the upper and lower calorific values, the analysis shows that the effect of the fuel calorific value becomes marginal for the relatively high LCPD ELV and progressively more important (higher uncertainty) towards lower ELV and AEL. This is the case as many plants already have lower emissions compared to the LCPD ELV and some have lower compared to the IED ELV. In the analysis, these lower emissions (for 2009) were used to calculate the emissions instead of the respective AEL or ELVs. Using the reported emission data for this report significantly reduces the uncertainty and is therefore very low especially for the LCPD ELVs.

Table 4.2 provides an overview of the deviation between the emissions related to the average fuel net calorific value and the lower and upper ranges of the net calorific values.

## 4.5 Sensitivity analysis on the impact of the net calorific value for $SO_2$ emissions

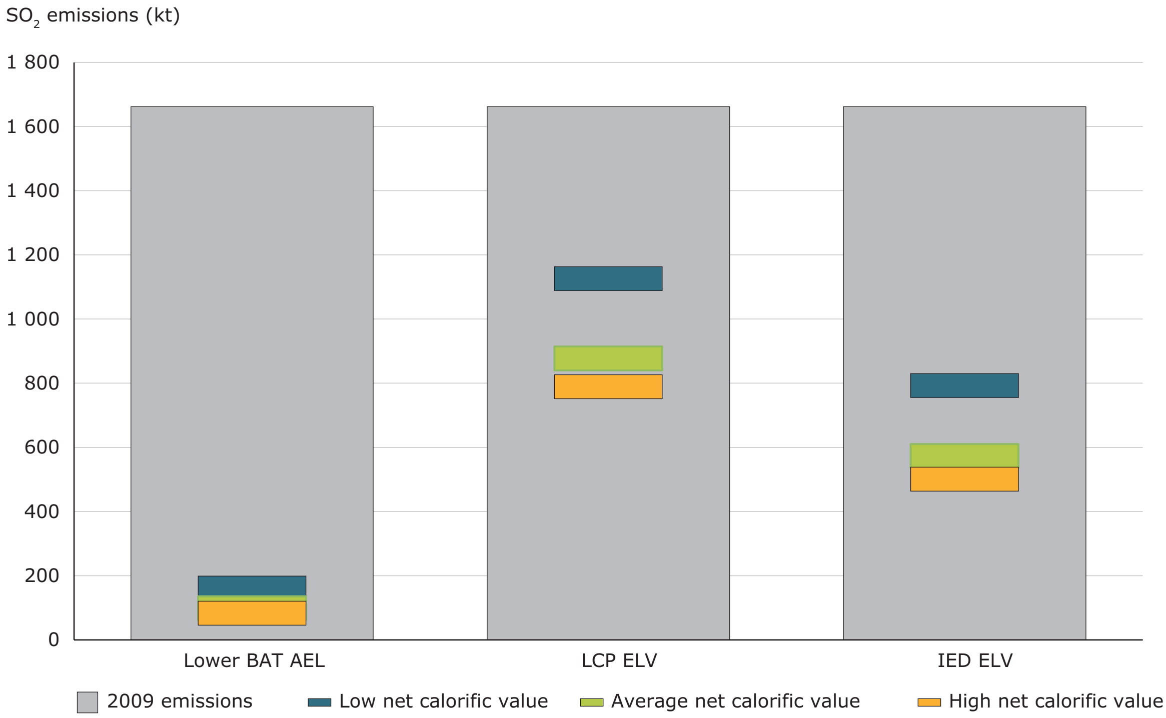
In order to estimate the impact of the range in fuel net calorific values on the estimated $SO_2$ emissions, a similar sensitivity analysis was performed showing the emissions in an aggregated form for all Member States. Figure 4.3 illustrates the effects on the results due to different net calorific values of the fuels.

The 2009 $SO_2$ emissions are used as the baseline to show the effect that is represented in Figure 4.3 by the columns. The indicated emissions would have been realised if the respective AEL or ELVs had been fulfilled. By taking the upper and lower net calorific values into account, the analysis shows that the effect of the fuel net calorific value is marginal for

**Table 4.2 Overview of the emission deviation from the net average calorific value**

| | $NO_x$ | | $SO_2$ | | Dust | |
|---|---|---|---|---|---|---|
| | Lower range of NCV (%) | Upper range of NCV (%) | Lower range of NCV (%) | Upper range of NCV (%) | Lower range of NCV (%) | Upper range of NCV (%) |
| LCPD ELV | 2.1 | − 3.5 | 19.6 | − 12.9 | 14.7 | − 10.5 |
| IED | 18.3 | − 13.9 | 24.1 | − 16.8 | 21.3 | − 14.3 |
| Lower BAT AEL | 29 | − 19.2 | 35 | − 21.4 | 26.6 | − 18 |

**Figure 4.3 Sensitivity of $SO_2$ emissions from LCP for the emissions limits by variation of fuel net calorific values**



the relatively strict lower BAT AEL. The $SO_2$ result for the LCPD ELV is quite different compared to that for the $NO_X$ fuel net calorific value deviation, and is almost the same as deviation for the IED ELV. This is the case since only a few plants already have 2009 emissions that are lower than the LCPD and IED ELVs. Thus, the effect of the fuel net calorific value is more important for $SO_2$ than for $NO_X$ emissions.

## 4.6 Sensitivity analysis on the impact of the net calorific value for dust emissions

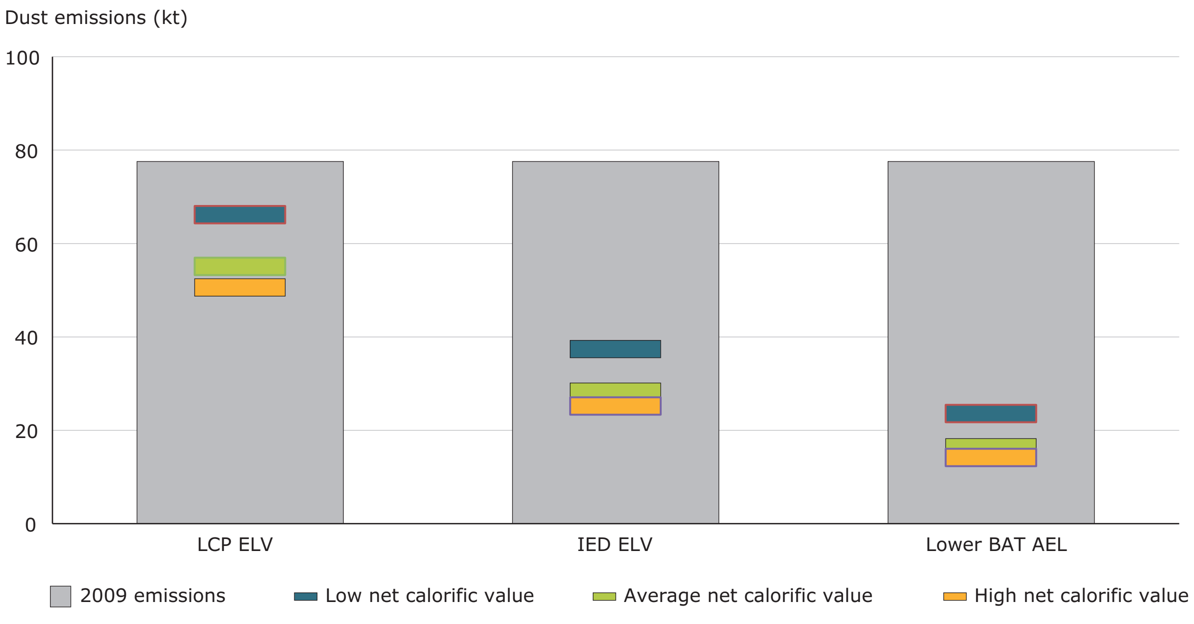
In order to estimate the impact of the range in fuel net calorific values on the estimated dust emissions, a sensitivity analysis was performed showing the aggregated emissions for Member States. Figure 4.4 illustrates the effects on the results due to different net calorific values of the fuels and once again the reported 2009 dust emissions are represented by the columns.

For each AEL and ELV, a slightly different picture appears. For the lower BAT AELs as well as for the LCPD and IED ELVs, the average net calorific value for each fuel is the same. The analysis shows that the effect of the fuel calorific value is almost the same for the AEL and ELVs taking into account the upper and lower net calorific values. Similar to $SO_2$ results, the LCPD ELV for the fuel net calorific value variation show almost the same deviation from the average as is the case for the IED ELV. Additionally, the LCPD ELV fuel net calorific value has less effect because the reported emissions are used and the better performing plants meet the LCPD ELV.

## 4.7 Conclusions of the sensitivity analysis on the impact of the net calorific values for emissions

In general, the effect of uncertainty across the range of fuel net calorific values on the calculated emissions is between 2.5 % (LCPD ELV for $NO_X$) and 35 % (lower BAT AEL for $SO_2$). However, the upper end of the uncertainty range is high because the sensitivity analysis is analysing the effect on emissions of the calorific value at the lower or upper end. In reality, the calorific value will only differ slightly within a Member State and is highly dependent on the origin of the fuels. In order to improve the level of certainty of the results presented in this study, it is recommended that future data reporting should include the calorific value of each fuel in use in a plant or even Member State. This is most important for the fuel category 'other solid fuels' as it is used in the LCP dataset and herein for lignite. Especially if 'other solid fuels' would be subdivided in three groups regarding the calorific values as made in this study, the methodology would be strengthened because the assumption used to distinguish 'other solid fuels' into 'hard coal', 'mixed coal' and 'lignite' would become obsolete.

**Figure 4.4 Sensitivity of 2009 dust emissions compared to LCPD and IED ELVs and BAT AEL by variation of fuel net calorific value**



# 5 Conclusions

Since 2004, there has been good progress across the EU-27 in reducing emissions of the three pollutants addressed in the LCPD (i.e. $NO_X$, $SO_2$ and dust). Emissions of $NO_X$ from all LCPs declined by 30 % during the period to 2009, and $SO_2$ and dust by more than 50 %.

The main purpose of this study was to assess the theoretical emission reduction potential of selected electricity-generating plants by comparing the reported 2009 emissions of $NO_X$, $SO_2$ and dust with:

i. the IED ELVs;
ii. the current ELVs of the LCPD; and
iii. the lower AELs contained in the LCP BREF.

The conclusions were based upon the official 2009 emissions reported by 1 595 LCPs under the LCPD (EEA, 2012b).

## 5.1 Emission reduction potential of $NO_X$, $SO_2$ and dust

The key findings of this study are that $NO_X$ emissions could be 5–69 % lower, $SO_2$ 47–94 % lower and dust 29–79 % lower if all selected plants achieved the LCPD ELVs or the 'lower end of BAT' AELs (Table 5.1). The future implementation of the IED and its mandatory ELVs is expected to deliver emission reductions between these various ranges for the respective pollutants.

While the potential scope to further reduce emissions may appear high given the reduction already reported in emissions between 2004 and 2009, these results are broadly consistent with an independent analysis performed in the context of the recent revision of the United Nations Economic Commission for Europe (UNECE) Convention on Long-range Transboundary Air Pollution (CLRTAP) Gothenburg Protocol, in which EU-27 emissions of $NO_X$, $SO_2$ and $PM_{10}$ from the electricity and heat production sector were forecast to fall by 22 %, 58 % and 39 %, respectively, by 2020 (IIASA, 2012). Indeed, based on the results of this report, it appears several Member States are close to meeting or have already achieved the IED emission limits (Figure ES.2 for $NO_X$, Figure ES.3 for $SO_2$ and Figure ES.4 for dust), although importantly there may be individual plants that have further reductions to make.

**Table 5.1 Summary of 2009 $NO_X$, $SO_2$ and dust emissions and the potential emissions estimated based on (i) the LCP emission limits, (ii) the IED emission limits and (iii) the lower BAT AELs**

| | Reported emissions 2009 | Potential emissions based on LCPD ELVs | Potential emissions based on IED ELVs | Potential emissions based on lower BAT AELs |
|---|---|---|---|---|
| $NO_X$ emission (kt) | 1 138 | 1 077 | 728 | 358 |
| $NO_X$ reduction compared to 2009 | | – 5 %<br>– 62 kt | – 36 %<br>– 411 kt | – 69 %<br>– 780 kt |
| $SO_2$ emission (kt) | 1 662 | 876 | 572 | 98 |
| $SO_2$ reduction compared to 2009 | | – 47 %<br>– 786 kt | – 66 %<br>– 1 089 kt | – 94 %<br>– 1 564 kt |
| Dust emission (kt) | 77.6 | 55.1 | 28.2 | 16.4 |
| Dust reduction compared to 2009 | | – 29 %<br>– 22 kt | – 64 %<br>– 49 kt | – 79 %<br>– 61 kt |

Germany, Poland and the United Kingdom report the highest 2009 $NO_X$ emissions in absolute terms from LCPs. As progress towards the implementation of the IED ELVs takes place, the largest reduction efforts will have to be made by Greece, Spain, Poland and the United Kingdom.

For a relatively large number of Member States (including Belgium, Germany, Hungary, Luxembourg, the Netherlands, Slovenia and Sweden), the theoretical reduction that would be realised by reaching the NOx LCPD and IED ELVs is almost the same. For the purposes of this study, where the reported 2009 emissions were already below the limit values these emission values were retained for the assessment and no further reduction was assumed.

It is also clear that just a limited number of very large plants account for a substantial share of the total $NO_X$ emissions. Only 50 (3 %) of the examined 1 595 plants were responsible for 50 % of the total emissions, while 454 (28 %) accounted for 90 % of the emissions. Germany, Poland and the United Kingdom account for 27 of the largest emitting plants, together representing more than 30 % of the total EU-27 emissions. It is important to note, however, that a small number of large plants may actually be more efficient than smaller plants; the absolute magnitude of emissions from a plant does not necessarily inform on relative operating efficiencies.

The highest 2009 $SO_2$ emissions for LCPs are reported by Bulgaria, Poland and Romania. The largest future reductions will have to be realised by these three Member States, as well as by Greece. For a number of Member States (Austria, Belgium, Germany, Hungary, the Netherlands, Portugal, Slovenia and Sweden), the reduction that should be realised by reaching the LCPD ELV and IED ELV is almost the same. For $SO_2$, just 20 (1 %) of the examined 1 595 plants account for 50 % of the total emissions, while 165 (10 %) contributed 90 % of the total emissions. Bulgaria, Greece and Romania account for 14 of the largest emitting plants and together for almost 40 % of the total EU-27 LCP emissions.

Bulgaria, Greece, Poland and Romania have the highest 2009 dust emissions. If emissions are to reach levels consistent with the IED ELVs, the largest reduction effort in tonnes dust will have to be realised by these Member States, as well as by Estonia. For a number of Member States (Austria, Belgium, Czech Republic, Denmark, Germany, Hungary, the Netherlands, Portugal, Slovenia and Sweden), the reduction that should be realised by achieving the LCPD and IED ELVs is almost the same. Only 21 (1 %) of the examined 1 595 plants represent 50 % of the total reported 2009 dust emissions, while 175 (11 %) of the 1 595 plants represent 90 % of the emissions. Bulgaria, Greece and Romania account for 17 of the largest emitting plants and together account for just over 40 % of the total EU-27 dust emissions.

## 5.2 Applicability of the approach

In the earlier EEA report assessing the theoretical scope to reduce emissions from electricity-generating LCPs (EEA, 2008), the fuel type use at EPER facilities was estimated using reported $CO_2$ emissions. As a result, the level of uncertainty was relatively high as the fuel type distribution could only be roughly estimated given the lack of detailed fuel information available from the pollutant register. In this report, the level of certainty is greatly enhanced since the assessment is based upon the officially reported LCP dataset, which contains detailed information on the thermal capacity, fuel type, fuel usage and emissions for each plant. Of the 3 310 plants in the LCPD dataset, 1 595 plants were identified as being in the ESI and CHP sectors and were selected for use within this report. The plants used in this study are deemed to adequately represent the proportion of electricity producers at the Member State and EU-27 levels and, along with supplementary information obtained from the Platts dataset (Platts, 2011), allows for a meaningful indication of the difference between 2009 emissions and the future potential emission reductions that would occur with a theoretical full implementation of the IED ELVs.

Flue gas volumes were estimated using the composition of the fuel and average net calorific values based on the officially reported 2009 LCP fuel type and fuel usage. Where applicable, data from the Platts dataset was used to further improve the level of quality and reduce the uncertainty in this report compared to the previous study.

- The Platts dataset was used to differentiate between ESI and CHP plants for three Member States (Italy, the Netherlands and Sweden) where only a generic sector code had been reported under the LCPD.
- The dataset was also used to determine the average distribution on coal types (hard coal, lignite, mixed coal) and biomass (wood was retained as main biomass fuel type) for the plants using 'other solid fuels' and 'biomass' on a Member State basis. These refinements were needed because flue gas calculation is highly dependent on the type of coal and biomass.

For the assessment of the theoretical emission reductions of $NO_X$, $SO_2$ and dust through implementation of the LCPD and IED ELVs and the lower BAT AELs, the respective emissions limit and AEL values could be applied directly on the calculated flue gas volumes per fuel type. The results of these calculations are the theoretical emissions per fuel type and per plant. The emissions per fuel type were then aggregated to obtain emissions per plant and then totalled to obtain emissions per Member State. For multi-fuel plants, it was not possible to relate the emissions to the different fuel types used. Consequently, the calculation of the estimated emissions under the ELVs was performed on a plant-by-fuel–type basis, while the comparison with the 2009 emissions was done on a plant basis.

## 5.3 Uncertainty

The emission calculations in this report were determined using an average fuel calorific value. A sensitivity analysis was performed in order to assess the sensitivity of this parameter. Due to different ranges of the calorific values that can be assumed for each fuel, the choice of value can have an impact on the overall results in the study. The effect was quantified on an aggregated EU level and is between 2.5 and 35 % depending on the pollutant type and the respective AEL or ELVs to which the effect is being compared to. The analysis showed that the highest impact on the certainty of the study results is related to lignite and its wide range of possible calorific values. In order to raise the overall certainty for future studies using this methodology, it is recommended that Member States (or plants) using 'other solid fuels', a category in the LCP dataset, should report the calorific value of their fuels.

# Glossary

| | |
|---|---|
| AEL | associated emission level |
| BAT | best available techniques |
| BREF | Reference document on best available techniques for large combustion plants, as adopted in 2006 under the IPPC Directive |
| $CO_2$ | carbon dioxide |
| EEA | European Environment Agency; http://www.eea.europa.eu |
| Eionet | European Environmental Information and Observation Network |
| ELV | emission limit value |
| EPER | European Pollutant Emission Register |
| E-PRTR | European Pollutant Release and Transfer Register; http://prtr.ec.europa.eu |
| ETC/ACM | European Topic Centre on Air pollution and Climate change Mitigation |
| EU | European Union |
| EU-25 | the 25 Member States following the enlargement of the EU in 2004 |
| EU-27 | the 27 Member States following the enlargement of the EU in 2007 |
| GJ | gigajoule = $10^9$ joules |
| IED | Industrial Emissions Directive (2010/75/EU) |
| IPPC | Integrated Pollution Prevention and Control |
| kt | kilotonne = 1 000 tonnes (metric) = 1 000 000 kg = 1 gigagram (Gg) |
| LCP | large combustion plant |
| LCPD | Large Combustion Plant Directive (2001/80/EC) |
| LRTAP | UNECE Convention on Long-range Transboundary Air Pollution |
| MW | megawatt = $10^6$ watt |
| $MW_e$ | megawatt electrical (capacity) |
| $MW_{th}$ | megawatt thermal (capacity) |
| NMVOC | non-methane volatile organic compound |
| $NO_X$ | nitrogen oxides |
| PM | particulate matter |
| $PM_{10}$ | particulate matter that passes through a size-selective inlet with a 50 % efficiency cut-off at 10 µm aerodynamic diameter |
| $PM_{2,5}$ | particulate matter that passes through a size-selective inlet with a 50 % efficiency cut-off at 2.5 µm aerodynamic diameter |
| $SO_2$ | sulphur dioxide |
| VOC | volatile organic compound |

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# Annex I Example calculations of flue gas volumes for selected fuels

Theoretical combustion:

- 1 kg C + 2.667 kg $O_2 \rightarrow$ 3.667 kg $CO_2$
- 1 kg H2 + 8 kg $O_2 \rightarrow$ 9 kg $H_2O$
- 1 kg S + 1 kg $O_2 \rightarrow$ 2 kg $SO_2$

The following calculations are based upon Babcock and Wilcox Co. (2007).

### Heavy fuel oil

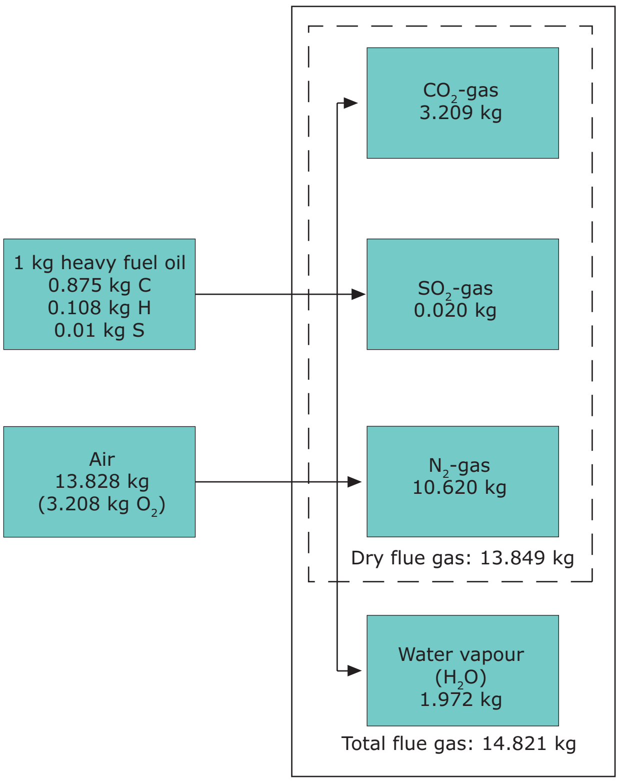
An example calculation of the flue gas weight due to the combustion of 1 kg of heavy fuel oil is provided below, assuming a S-content of 1 % and 0.7 % non-combustible compounds and impurities.

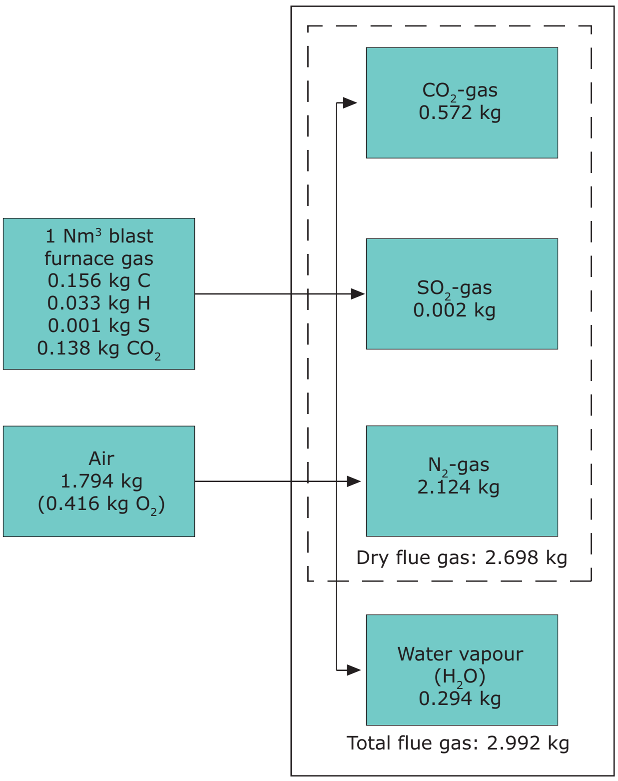
The combustion of 1 kg of heavy fuel oil therefore leads to a total dry flue gas volume of 10.14 $Nm^3$.

The net calorific value of 1 kg of heavy fuel oil amounts to 39.8–41.7 MJ/kg (lower–upper net calorific values). The dry flue gas volume in a stoichiometric combustion process of heavy fuel oil amounts to 0.249 $Nm^3$/MJ when calculated with the average net calorific value.

### Blast furnace gas

Fuel type 'other gases' in the LCP dataset is mainly 'blast furnace gas' from the steel industry that is used for electricity generation. Blast furnace gas contains large amounts of carbon monoxide (CO) and $CO_2$ gas, of which the latter will not take part in the combustion process. The composition of the gas is highly variable, the values from http://www.gutenberg.org/files/22657/22657-h/chapters/gases.html were used.



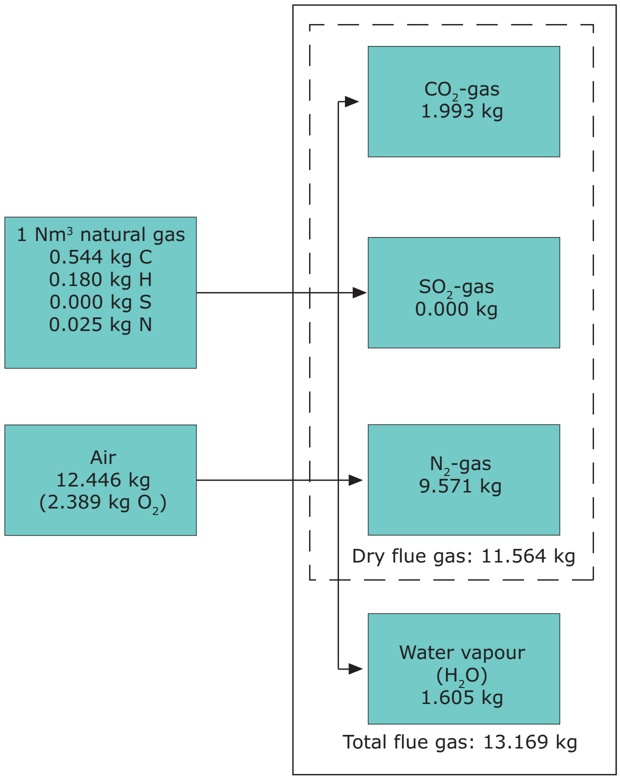
The combustion of 1 Nm³ of blast furnace gas therefore leads to a total flue gas volume of 2.494 Nm³.

The net calorific value of 1 Nm³ of blast furnace gas amounts to 1.535–6.4 MJ/kg (lower–upper net calorific values). The dry flue gas volume in a stoichiometric combustion process of blast furnace gas amounts to 537 Nm³/MJ when calculated with the average net calorific value.

## Natural gas

The combustion of 1 Nm³ of natural gas leads to a total flue gas volume of 10.669 Nm³.

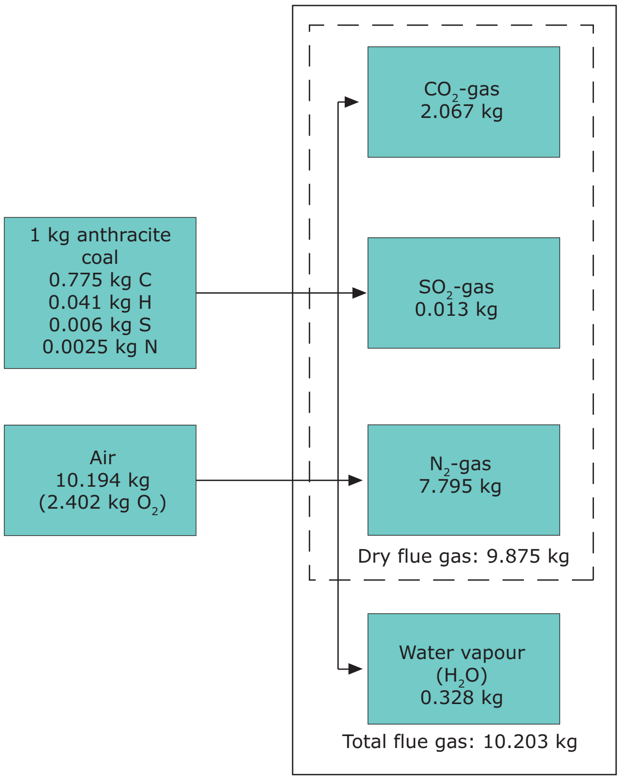
The net calorific value of 1 Nm³ of natural gas amounts to 31.7–41.9 MJ/kg (lower–upper net calorific values). The dry flue gas volume in a stoichiometric combustion process of natural gas amounts to 0.236 Nm³/MJ when calculated with the average net calorific value.




## Coal (anthracite, hard coal)

The combustion of 1 kg of hard coal leads to a total dry flue gas volume of 7.293 Nm³.

The net calorific value of 1 kg of hard coal amounts to 21.6–32.2 MJ/kg (lower–upper net calorific values). The dry flue gas volume in a stoichiometric combustion process of hard coal amounts to 0.271 Nm³/MJ when calculated with the average net calorific value.



# Annex II Detail from Platts EEPP on coal plants

Extract from the Platts EEPP dataset for all units reported to use coal/oil shale as the main fuel at a Member State level. For a number of coal units more details are given on the specific coal type that is used and for others no detail is reported (Coal). The distribution of different coal types was calculated as the weighted average, using the sum of the electrical capacity ($MW_e$). The calculated weighted average is distributed per Member State and then applied to every plant using 'other solid fuels'.

- Anth: Anthracite or semi-anthracite coal
- Anth/Bit: Anthracite and bituminous coal
- Bit: Bituminous coal
- Bit/Anth: Bituminous and anthracite coal
- Bit/Lig: Bituminous coal and lignite (brown coal)
- Bit/Sub: Bituminous and (sub)bituminous coal
- Gob: Gob (bituminous mining waste)
- Lig: Lignite (brown coal)
- Lig/Bit: Lignite and bituminous coal
- Lig/Sub: Lignite and (sub)bituminous coal
- Wstbit: Waste bituminous coal (coal fines and refuse, also gangue).

Estonia reports the use of 'other solid fuels' in the LCP dataset. The Platts EEPP dataset shows that 'oil shales' are used in 37 units with an electrical capacity of 4 272 $MW_e$.

**Table AII.1 Number of coal plants from the EEPP dataset by Member State**

| Member State | Fuel | Number of coal-using units | Sum of $MW_e$ |
|---|---|---|---|
| AT | Coal | 13 | 1 118.1 |
| AT | Anth | 1 | 137 |
| AT | Bit | 6 | 1 284 |
| AT | Bit/Sub | 1 | 124 |
| AT | Lig | 3 | 455 |
| BE | Coal | 9 | 1 174.7 |
| BE | Anth | 2 | 202 |
| BE | Bit | 37 | 3 768.7 |
| BG | Anth | 2 | 120 |
| BG | Bit | 24 | 1 914.4 |
| BG | Lig | 34 | 6 496 |
| CZ | Coal | 24 | 509.45 |
| CZ | Bit | 19 | 1 629.8 |
| CZ | Bit/Lig | 5 | 435.6 |
| CZ | Lig | 106 | 11 673.76 |
| CZ | Lig/Bit | 4 | 134 |
| DE | Coal | 74 | 9 982.235 |
| DE | Anth | 9 | 623.26 |
| DE | Bit | 294 | 60 358.06 |
| DE | Bit/Anth | 1 | 808 |
| DE | Bit/Lig | 20 | 975.93 |

**Table AII.1 Number of coal plants from the EEPP dataset by Member State (cont.)**

| Member State | Fuel | Number of coal-using units | Sum of $MW_e$ |
|---|---|---|---|
| DE | Bit/Sub | 5 | 870 |
| DE | Lig | 280 | 41 607.43 |
| DE | Lig/Bit | 3 | 461 |
| DE | Sub | 8 | 228.292 |
| DK | Coal | 6 | 87.5 |
| DK | Bit | 57 | 7 944 |
| EE | Shale | 37 | 4 272 |
| EL | Coal | 7 | 975 |
| EL | Bit | 2 | 1 600 |
| EL | Lig | 13 | 4 129.5 |
| EL | Lig/Bit | 12 | 2 680 |
| ES | Coal | 11 | 1 058.5 |
| ES | Anth | 1 | 148 |
| ES | Anth/Bit | 17 | 4 566 |
| ES | Bit | 14 | 3 733.2 |
| ES | Bit/Anth | 1 | 365 |
| ES | Bit/Lig | 1 | 553 |
| ES | Gob/Bit | 1 | 50 |
| ES | Lig | 11 | 850 |
| ES | Lig/Bit | 4 | 510 |
| ES | Lig/Sub | 3 | 1 050 |
| ES | Sub | 6 | 1 245.58 |
| FI | Coal | 7 | 454 |
| FI | Bit | 23 | 4 183.2 |
| FI | Lig | 1 | 60 |
| FI | Sub | 1 | 36 |
| FR | Coal | 79 | 4 254.31 |
| FR | Anth | 2 | 110 |
| FR | Bit | 54 | 9 169.4 |
| FR | Bit/Lig | 3 | 1 231 |
| FR | Bit/Wstbit | 1 | 253 |
| FR | Lig | 3 | 227 |
| FR | Sub | 7 | 1 317 |
| FR | Wstbit | 1 | 125 |
| HU | Coal | 4 | 236 |
| HU | Bit | 6 | 510 |
| HU | Lig | 39 | 3 332.5 |
| HU | Sub | 5 | 92 |
| IE | Coal | 7 | 285 |
| IE | Bit | 3 | 915 |
| IT | Coal | 33 | 11 495.05 |
| IT | Bit | 37 | 11 429 |
| IT | Bit/Lig | 2 | 250 |
| IT | Lig | 2 | 68 |
| LV | Coal | 3 | 423 |

**Table AII.1 Number of coal plants from the EEPP dataset by Member State (cont.)**

| Member State | Fuel | Number of coal-using units | Sum of $MW_e$ |
|---|---|---|---|
| NL | Coal | 7 | 1 543 |
| NL | Bit | 20 | 9 109 |
| PL | Coal | 303 | 9 205 |
| PL | Bit | 289 | 33 193.28 |
| PL | Lig | 51 | 13 869.3 |
| PT | Coal | 6 | 854.75 |
| PT | Anth | 2 | 100 |
| PT | Bit | 6 | 1 878 |
| RO | Coal | 14 | 2 274 |
| RO | Bit | 10 | 1 460 |
| RO | Lig | 65 | 8 587 |
| SE | Coal | 9 | 333 |
| SE | Bit | 8 | 473.3 |
| SI | Coal | 8 | 185.3 |
| SI | Lig | 9 | 1 499.6 |
| SK | Coal | 17 | 1 370.2 |
| SK | Bit | 10 | 866 |
| SK | Lig | 18 | 987.55 |
| UK | Coal | 40 | 8 226.74 |
| UK | Bit | 269 | 46 892 |
| UK | Bit/Anth | 7 | 1 900 |
| UK | Anth | 2 | 520 |
| UK | Lig | 1 | 600 |
| UK | Wstbit | 4 | 120 |

**Table AII.2 The weighted average distribution of the 'Other solid fuels' LCP fuel type by Member State**

| Member State | Fuel | Coal type | Distribution coal type |
|---|---|---|---|
| AT | Coal | Hard coal | 71.1 % |
| AT | Coal | Lignite | 22.8 % |
| AT | Coal | Mixed coal | 6.2 % |
| BE | Coal | Hard coal | 100.0 % |
| BG | Coal | Hard coal | 23.8 % |
| BG | Coal | Lignite | 76.2 % |
| CZ | Coal | Hard coal | 11.7 % |
| CZ | Coal | Lignite | 84.1 % |
| CZ | Coal | Mixed coal | 4.1 % |
| DE | Coal | Hard coal | 58.3 % |
| DE | Coal | Lignite | 39.5 % |
| DE | Coal | Mixed coal | 2.2 % |
| DK | Coal | Hard coal | 100.0 % |
| EE | Shale | Mixed coal | 100.0 % |
| EL | Coal | Hard coal | 19.0 % |
| EL | Coal | Lignite | 49.1 % |
| EL | Coal | Mixed coal | 31.9 % |
| ES | Coal | Hard coal | 67.4 % |
| ES | Coal | Lignite | 24.1 % |
| ES | Coal | Mixed coal | 8.5 % |
| FI | Coal | Hard coal | 97.8 % |
| FI | Coal | Lignite | 2.2 % |
| FR | Coal | Hard coal | 74.6 % |
| FR | Coal | Lignite | 12.4 % |
| FR | Coal | Mixed coal | 12.9 % |
| HU | Coal | Hard coal | 13.0 % |
| HU | Coal | Lignite | 87.0 % |
| IE | Coal | Hard coal | 100.0 % |
| IT | Coal | Hard coal | 97.3 % |
| IT | Coal | Lignite | 0.6 % |
| IT | Coal | Mixed coal | 2.1 % |
| NL | Coal | Hard coal | 100.0 % |
| PL | Coal | Hard coal | 70.5 % |
| PL | Coal | Lignite | 29.5 % |
| PT | Coal | Hard coal | 100.0 % |
| RO | Coal | Hard coal | 14.5 % |
| RO | Coal | Lignite | 85.5 % |
| SE | Coal | Hard coal | 100.0 % |
| SI | Coal | Lignite | 100.0 % |
| SK | Coal | Hard coal | 46.7 % |
| SK | Coal | Lignite | 53.3 % |
| UK | Coal | Hard coal | 98.6 % |
| UK | Coal | Lignite | 1.2 % |
| UK | Coal | Mixed coal | 0.2 % |

## Platts EEPP biomass plants

Extract from Platts EEPP for all units reported to use biomass as the main or alternative fuel at a Member State level. For a number of units with biomass as the main fuel more details are given on the specific biomass type that is used and for others no detail is reported. Table AII.3 shows that the largest use of biomass takes place as co-combustion in coal plants (Main fuel: coal / Alternative fuel: biomass, wood, etc.). Only selected units with an electrical capacity higher than 15 $MW_e$ (50 $MW_{th}$ input times 30 % efficiency = 15 $MW_e$) were used.

**Table AII.3 EEPP details for plants reported as using biomass**

| Country | Main fuel | Units | Detail main fuel | Alternative fuel ([a]) | Sum of $MW_e$ |
|---|---|---|---|---|---|
| AT | Coal | 3 | | Wood/gas/ref | 70.2 |
| AT | Coal | 1 | Anth | Bgas | 137 |
| AT | Coal | 1 | Bit/Sub | Biomass | 124 |
| BE | Wood | 8 | | | 236.95 |
| BE | Wood | 3 | | Liq/oil | 47.2 |
| BE | Wood | 1 | | None | 26 |
| BE | Wood | 1 | | Rdf | 40 |
| CZ | Coal | 2 | Bit/Lig | Wood | 110 |
| CZ | Coal | 2 | Lig | Biomass | 235 |
| CZ | Coal | 14 | Lig | Wood | 1 452 |
| CZ | Coal | 1 | Lig/Bit | Wood | 35 |
| DK | Biomass | 1 | Straw | Coal | 19.6 |
| DK | Biomass | 1 | Straw | Coal/oil | 80 |
| DK | Biomass | 1 | Straw | Gas/ref/wood | 28 |
| DK | Biomass | 3 | Straw | None | 102 |
| DK | Biomass | 1 | Straw | Oil | 32 |
| DK | Coal | 4 | Bit | Biomass | 1 240 |
| DK | Wood | 1 | | Coal | 52 |
| DK | Wood | 1 | | Gas | 95 |
| EE | Wood | 2 | | Peat | 31.4 |
| EE | Wood | 1 | | Peat/gas | 23.5 |
| FI | Biomass | 1 | | Peat | 25 |
| FI | Coal | 1 | | Gas/wood | 50.5 |
| FI | Coal | 1 | | Wood | 25 |
| FI | Coal | 1 | Bit | Oil/wood | 238 |
| FI | Coal | 1 | Sub | Wood | 36 |
| FI | Peat | 1 | | Biomass | 46 |
| FI | Peat | 2 | | Coal | 87 |
| FI | Peat | 1 | | Coal/oil/wood | 88 |
| FI | Peat | 1 | | Coal/pwst | 25 |
| FI | Peat | 2 | | Coal/wood | 124 |
| FI | Peat | 2 | | Gas/oil | 124 |
| FI | Peat | 3 | | None | 279 |
| FI | Peat | 4 | | Oil | 210 |
| FI | Peat | 8 | | Wood | 428.13 |
| FI | Wood | 24 | | | 464.585 |
| FI | Wood | 1 | | Coal | 94.9 |
| FI | Wood | 2 | | Coal/peat | 320 |
| FI | Wood | 1 | | Coal/ref | 19 |
| FI | Wood | 3 | | Gas | 100 |
| FI | Wood | 2 | | Gas/oil/peat | 45 |

**Table AII.3 EEPP details for plants reported as using biomass (cont.)**

| Country | Main fuel | Units | Detail main fuel | Alternative fuel ([a]) | Sum of $MW_e$ |
|---|---|---|---|---|---|
| FI | Wood | 2 | | Gas/peat | 33 |
| FI | Wood | 1 | | Liq | 105 |
| FI | Wood | 1 | | Oil/peat | 68 |
| FI | Wood | 18 | | Peat | 539.68 |
| FI | Wood | 1 | | Peat/pwst | 26.1 |
| FI | Wood | 2 | | Peat/ref | 34.2 |
| FI | Wood | 1 | | Ref | 19 |
| FR | Wood | 35 | | | 737.69 |
| DE | Coal | 1 | | Wood | 31 |
| DE | Coal | 1 | Bit | Oil/Wstwsl | 310 |
| DE | Coal | 1 | Bit | Wstwsl | 474 |
| DE | Coal | 5 | Sub | Ref/wood | 176.292 |
| DE | Pwst | 1 | | Coal/oil | 23 |
| DE | Pwst | 1 | | Wsth | 17.2 |
| DE | Wood | 1 | | Coal | 41 |
| DE | Wood | 1 | | Ref | 30.975 |
| HU | Biomass | 2 | | | 34.9 |
| HU | Biomass | 2 | Straw | | 74.9 |
| HU | Coal | 1 | Lig | Biomass | 49.9 |
| HU | Wood | 6 | | | 156.5 |
| HU | Wood | 2 | | Coal | 80 |
| IE | Peat | 1 | | None | 128 |
| IE | Peat | 16 | Mill | None | 671 |
| IE | Wood | 1 | | Peat/coal | 100 |
| IT | Biomass | 2 | Litter | Oil/wood | 55 |
| IT | Coal | 2 | | Biomass | 1 320 |
| IT | Coal | 1 | Bit | Biomass | 340 |
| IT | Coal | 2 | Bit | Biomass/oil | 336 |
| IT | Wood | 1 | | Gas | 19.4 |
| LV | Biomass | 1 | | | 23 |
| LV | Coal | 2 | | Biomass | 400 |
| LV | Coal | 1 | | Wood | 23 |
| LT | Biomass | 1 | | Ref | 20 |
| NL | Biomass | 2 | Litter | | 69 |
| NL | Coal | 1 | | Biomass | 1 000 |
| NL | Coal | 1 | Bit | Biomass | 800 |
| NL | Coal | 2 | Bit | Biomass/gas | 1 080 |
| NL | Coal | 2 | Bit | Gas/wood | 1 245 |
| NL | Coal | 2 | Bit | Wood | 1 536 |
| NL | Coal | 1 | Bit | Wood/oil | 635 |
| NL | Wood | 10 | | | 210.4 |
| PL | Biomass | 2 | | | 105 |
| PL | Biomass | 2 | | Coal | 47.1 |
| PL | Biomass | 1 | | Coal/pwst | 37 |
| PL | Coal | 9 | Bit | Biomass | 2 628.8 |
| PL | Coal | 1 | Bit | Wood | 40 |
| PL | Coal | 4 | Lig | Biomass | 905 |
| PL | Coal | 2 | Lig | Peat | 36.3 |
| PL | Wood | 7 | | | 139.5 |

**Table AII.3 EEPP details for plants reported as using biomass (cont.)**

| Country | Main fuel | Units | Detail main fuel | Alternative fuel ([a]) | Sum of $MW_e$ |
|---|---|---|---|---|---|
| PT | Biomass | 3 | | | 63.8 |
| SK | Coal | 1 | Bit | Wood | 110 |
| SK | Coal | 5 | Lig | Biomass | 114.1 |
| ES | Biomass | 1 | | None | 16 |
| ES | Biomass | 1 | | Sun | 22.5 |
| ES | Biomass | 6 | Agwst | None | 91.35 |
| ES | Biomass | 1 | Agwst | Wood | 16 |
| ES | Biomass | 1 | Straw | Agwst | 18 |
| ES | Biomass | 1 | Straw | Wood | 30 |
| ES | Coal | 1 | Gob/Bit | Biomass | 50 |
| ES | Wood | 3 | | Biomass | 50.7 |
| ES | Wood | 1 | | Coke | 36 |
| SE | Biomass | 6 | | | 470.9 |
| SE | Coal | 1 | Bit | Tall/peat | 75 |
| SE | Peat | 1 | | Coal/wood | 130 |
| SE | Wood | 32 | | | 676.48 |
| SE | Wood | 2 | | Coal | 60 |
| SE | Wood | 1 | | Coal/gas/peat | 20 |
| SE | Wood | 1 | | Coal/oil | 35 |
| SE | Wood | 3 | | Coal/oil/peat | 151 |
| SE | Wood | 2 | | Coal/ref | 100 |
| SE | Wood | 1 | | Liq | 28 |
| SE | Wood | 11 | | None | 192.4 |
| SE | Wood | 6 | | Oil | 208.75 |
| SE | Wood | 1 | | Oil/peat | 28 |
| SE | Wood | 7 | | Peat | 163.93 |
| SE | Wood | 4 | | Ref | 137 |
| SE | Wood | 1 | | T/p/o/c | 250 |
| UK | Bgas | 1 | | Biomass | 20 |
| UK | Biomass | 22 | | | 2 718.6 |
| UK | Biomass | 2 | | Wood | 146 |
| UK | Biomass | 3 | Litter | Oil/wood | 81.2 |
| UK | Biomass | 3 | Straw | | 122 |
| UK | Coal | 6 | | Biomass | 2 352 |
| UK | Coal | 45 | Bit | Biomass | 21 594 |
| UK | Coal | 3 | Bit/Anth | Biomass | 1 500 |
| UK | Wood | 31 | | Biomass | 2 137.2 |

**Note:** ([a]) Agwst: Agricultural waste;
Bgas: Biogas from digestion of agricultural waste or food waste or other organic material;
Gob: Gob (bituminous mining waste);
Liq: Pulping liquor (black liquor);
Pwst: Paper mill waste or sludges;
Rdf: Refuse-derived fuel;
Ref: Refuse (unprocessed municipal solid waste);
T/p/o/c: Tall oil or tall oil pitch/peat/oil/coal;
Wstwsl: Wastewater sludge;
Wsth: Waste heat.

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