# Solvent VOC Emissions Inventories 2008-2015

## ESIG has finalised its 2015 solvent VOC emission inventories

**Solvent VOC Emissions have stabilized in the EU28 since 2008** at just under 2000ktonnes, with Member States total estimates at some 30% or more above the ESIG estimates

Emissions factors have been established for each European country or group of countries in 2015, and it is recommended that these factors be used by EEA and Member States to quantify Solvent VOC Emissions

- **Introduction**

Air quality is a principal factor impacting upon the welfare, health and climate on our planet. The subject is complex considering the emissions from many sources (natural and man-made), the atmospheric chemical reactions of these emissions and the trans- boundary air pollution between continents. One main challenge is ozone formed by photochemical reaction between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in sunlight. Whereas NOx emission inventories are well defined, the challenge has been to quantify VOC inventories, particularly those from solvents.

ESIG, the European Solvents Industry Group, has contributed to the reduction of VOC emissions from solvents for many years. As an example, ESIG has helped industry to implement the Solvents Emissions Directive [(1)] whereby European VOC solvent emissions have been reduced substantially. In Europe, two main bodies, the European Commission and the United Nations Economic Community for Europe, are setting targets for emissions, including NOx, NMVOC (Non Methane VOC), $SO_2$, $NH_3$ and PM2.5 (Particulate Matter less than 2.5µm). These take the form of ceilings on each these emissions for all countries in the EU for 2020 and 2030 (the EC National Emissions Ceiling Directive). The UNECE Gothenburg Protocol, which goes beyond the EU, covers emissions ceilings for Norway, Ukraine, Switzerland, Russia, Canada and the US as well.

ESIG Members have submitted their volumes of both hydrocarbon and oxygenated solvents produced, for each of the EU-27 countries for the years 2008, 2009 and 2013. In 2015, these data included Croatia to make the EU-28. Using industry expertise within ESIG, solvent VOC emissions have been calculated for all the EU-27 Member States for 2008, 2009, and 2013, with all 28 Member States included in 2015. The aim of this position paper is to provide a method to establish VOC solvent emissions and assist Member States improve the quality of their reported VOC solvent emissions in the European Union.

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- **ESIG Solvent VOC Inventories for the EU in 2008, 2009, 2013& 2015-The Process**

All companies which are part of ESIG have been invited to submit their solvent volumes by end-use sector for each European country (EU-27) for 2008, 2009 and 2013. This same process was repeated in 2017 to include all solvents for the year 2015 which now included Croatia as part of the EU28. The statistics were reported by end-use sector in the same market sectors as reported in the Generic Exposure Scenario (GES) of the Registration, Evaluation and Authorisation of Chemicals Regulation (REACH)[2] (see Appendix) for both hydrocarbon and oxygenated solvents. Nearly 100% of all solvents manufactured in the European Union were collated by Cefic, and carefully and confidentially analyzed. This position paper details our findings which represents a top-down approach to define solvent VOC emissions for 2008, 2009, 2013 and 2015.

The emissions factors as defined in the Appendix have been assessed by using the GES database[3], which calculates the percentage of VOCs emitted into the air. The process has been fully detailed in Appendix 1. The solvent VOC emissions per sector are then calculated by multiplying the solvent volumes by the emission factor for that sector. A conservative 100% VOC emissions has been selected for 'others' which gives a margin of error tending towards overestimation of solvent emissions for each country.

In summary, this top down approach consists of two operations:-

1. Defining the solvent volumes in each country for each REACH Use Sector and

2. Defining the air emission factor for that Use Sector

The Solvent VOC Emissions for each Use Sector in each country is obtained by multiplying the values in Operation 1 by the emissions factors in Operation 2.

- **Solvent VOC inventories for the EU-28 Member States**

In practice, Member States are obliged to submit their emissions inventories to the EU Institutes which calculate ozone and assess progress towards achieving air quality targets. Most Member States report data on industry activity in each sector and use a factor to generate the reported emissions. Some countries, such as Denmark[4], calculate the solvent VOC emissions in extensive detail, whereas others, for example, The United Kingdom, make estimates using historical data. All Member States use a bottom up approach which can involve four or more processes to calculate the solvent VOC emissions for that country.

The European Environment Agency (EEA) publishes these inventories[5] and the European Emissions Monitoring and Evaluation Programme (EMEP) use their Unified Eulerian model to calculate European ozone distribution. This position paper has identified the solvent VOC emissions for each end-use sector, for each country or group of countries within the EU, and can be compared with the published EEA solvent VOC inventories. These results are shown in Tables 2, 3, 4 and 5 for combined hydrocarbon and oxygenated solvents with a separate estimate for chlorinated solvents in 2008, 2009, 2013 & 2015. The

total volumes for chlorinated solvents in the EU-27 were 154, 144 and 139.2 ktonnes respectively, which are assumed to be totally released into the air as emissions. No chlorinated data was available for 2015 and so was assumed to remain at the 2013 levels. These represent an overestimate of chlorinated VOC emissions because many chlorinated solvents are for industrial use and remain as a closed system and so are not vented to the atmosphere. These chlorinated solvent emissions have been calculated for each country in proportion to the total hydrocarbon and oxygenated emissions for the countries. In 2008, the ESIG VOC emissions for the EU-27 (including chlorinated solvents) were 2159 ktonnes compared with the EEA estimate of 3335 ktonnes . ESIG EU-27 emissions are some 65% of the EEA estimated solvent VOC emissions. For 2009, total ESIG VOC emissions fell to 1917 ktonnes compared with the EEA estimate of 3050 ktonnes. ESIG VOC emissions total 63% of the estimated EEA VOC emissions for solvents in 2009. The fall in emissions from 2008 to 2009 partly reflects the recession period as well as the completion of the Solvents Emissions Directive over the period 1999 to 2009.

For 2013, ESIG EU-27 emissions were 1978 ktonnes, which compare with an EEA estimated 2928 ktonnes. For 2015, ESIG EU-28 emissions were 1981 ktonnes, which compare with an EEA estimate of 2694 ktonnes. These results are summarized in Table 1.

**TABLE 1 COMPARISON OF TOTAL SOLVENT VOC EMISSIONS**

| ktonnes | ESIG VOC emissions | EEA inventories | ESIG/EEA |
|---|---|---|---|
| 2008 | 2159 | 3335 | 65% |
| 2009 | 1917 | 3050 | 63% |
| 2013 | 1978 | 2928 | 68% |
| 2015 | 1981 | 2694 | 74% |

The trend shown in Table 1 is that solvent VOC Emissions have stabilized in the EU28 since 2008 at just under 2000ktonnes, with Member States total estimates at some 30% or more above the ESIG estimates.

- **Import and Export of solvents within the European Union**

Solvent emissions by country are presented in tables 2, 3, 4 and 5 relating to the years 2008, 2009, 2013 and 2015 respectively. For statistical confidentiality reasons, emissions from countries with less than 3 representative solvent companies on the market, (extended to 5 in 2015), were combined. Due to the free flow of goods in the European Union, there are no direct data for import and export of solvents within the EU and so an estimate has to be made. Cefic (source Eurostat[6]) has data for chemical exports

and imports for each country so that the net chemical transfer can be calculated for each Member State. By assuming this percentage of chemical transfer is directly proportional to percentage of solvent movements, an estimate of solvent import/export related to solvent downstream activities has been made for each country, or group of countries, in the EU. These calculations assume that there is no net import or export to or from the European Union. These data confirm that Belgium, Germany and Netherlands are substantial exporters of solvents and downstream products (as such "exporting" VOC emissions) within the European Union, and are included in Tables 2, 3, 4 and 5. The UK and France are effectively in balance as we assume is Ireland, and it is further assumed that there is no net import or export of solvents for these three countries. The remaining EU Member States are net importers of solvents, and although they export and import to one another, their total net imports are assumed to equal the exports from Belgium, Germany and the Netherlands. The final column in Tables 2, 3, 4 and 5 shows the total solvent VOC emissions taking account of the import/export adjustment.

**For most Member States, the EEA inventories show an overestimation.**

**TABLE 2: COMPARISON OF SOLVENT VOC EMISSIONS WITH 2008 EEA ESTIMATES**

| Year 2008 | ESIG | | | | | EEA |
|---|---|---|---|---|---|---|
| NMVOC in ktonne per country | HC+OXY | CHLOR | TOTAL before I/E | Import / (Export) | Grand TOTAL | TOTAL |
| Austria + Slovenia | 37.5 | 2.9 | 40.4 | 45.7 | 86.1 | 101 |
| Belgium + Luxemburg | 143.1 | 11 | 154.1 | (77.5) | 76.6 | 57 |
| Bulgaria + Romania | 4.3 | 0.3 | 4.6 | 28.1 | 32.7 | 80 |
| Cyprus + Greece | 41.8 | 3.2 | 45.0 | 40.7 | 85.7 | 59 |
| Czech Republic + Slovakia | 17.6 | 1.4 | 19.0 | 41.4 | 60.4 | 124 |
| Denmark | 16.6 | 1.3 | 17.9 | 13.5 | 31.4 | 27 |
| Baltic States + Finland | 23.0 | 1.8 | 24.8 | 25.8 | 50.6 | 68 |
| France | 248.5 | 19.1 | 267.6 | 0.0 | 267.6 | 386 |
| Germany | 636.1 | 48.8 | 684.9 | (405.8) | 279.1 | 669 |
| Hungary | 6.2 | 0.5 | 6.7 | 17.1 | 23.8 | 23 |
| Ireland | 17.7 | 1.4 | 19.1 | 0.0 | 19.1 | 24 |
| Italy | 193.4 | 15 | 208.4 | 147.0 | 355.4 | 466 |
| Malta | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 2 |
| Netherlands | 129.9 | 10 | 139.9 | (83.0) | 56.9 | 57 |
| Poland | 39.2 | 3 | 42.2 | 67.8 | 110.0 | 198 |
| Portugal + Spain | 206.5 | 15.9 | 222.4 | 106.0 | 328.4 | 531 |
| Sweden | 35.0 | 2.7 | 37.7 | 33.2 | 70.9 | 84 |
| United Kingdom | 208.3 | 16 | 224.3 | 0.0 | 224.3 | 379 |
| | **2005** | **154** | **2159** | **0** | **2159** | **3335** |

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## TABLE 3: COMPARISON OF SOLVENT VOC EMISSIONS with EEA 2009 ESTIMATES

| Year 2009 | ESIG | | | | | EEA |
|---|---|---|---|---|---|---|
| NMVOC in ktonne per country | HC+OXY | CHLOR | TOTAL before I/E | Import / (Export) | Grand TOTAL | TOTAL |
| Austria + Slovenia | 35.2 | 2.9 | 38.1 | 40.9 | 79.0 | 77 |
| Belgium + Luxemburg | 132.6 | 10.8 | 143.4 | (68.8) | 74.6 | 50 |
| Bulgaria + Romania | 5.8 | 0.5 | 6.3 | 39.8 | 46.1 | 56 |
| Cyprus + Greece | 34.3 | 2.8 | 37.1 | 38.5 | 75.6 | 59 |
| Czech Republic + Slovakia | 14.9 | 1.2 | 16.1 | 35.7 | 51.8 | 120 |
| Denmark | 14.5 | 1.2 | 15.7 | 1.7 | 17.4 | 27 |
| Baltic States + Finland | 19.9 | 1.6 | 21.5 | 17.6 | 39.1 | 59 |
| France | 207.9 | 16.9 | 224.8 | 0.0 | 224.8 | 349 |
| Germany | 541.6 | 44 | 585.6 | (349.9) | 235.7 | 596 |
| Hungary | 6.1 | 0.5 | 6.6 | 9.9 | 16.5 | 17 |
| Ireland | 14.8 | 1.2 | 16.0 | 0.0 | 16.0 | 23 |
| Italy | 181.8 | 14.8 | 196.6 | 137.4 | 334.0 | 436 |
| Malta | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 1 |
| Netherlands | 133.3 | 10.8 | 144.1 | (88.9) | 55.2 | 54 |
| Poland | 42.8 | 3.5 | 46.3 | 64.5 | 110.8 | 201 |
| Portugal + Spain | 171.9 | 14 | 185.9 | 97.0 | 282.9 | 485 |
| Sweden | 27.5 | 2.2 | 29.7 | 24.4 | 54.1 | 87 |
| United Kingdom | 187.9 | 15.2 | 203.1 | 0.0 | 203.1 | 353 |
| | **1772** | **144** | **1916** | **0** | **1917** | **3050** |

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## TABLE 4: COMPARISON OF SOLVENT VOC EMISSIONS with EEA 2013 ESTIMATES

| Year 2013 | ESIG | | | | | EEA |
|---|---|---|---|---|---|---|
| NMVOC in ktonne per country | HC+OXY | CHLOR | TOTAL before I/E | Import / (Export) | Grand TOTAL | TOTAL |
| Austria + Slovenia | 42.5 | 3.2 | 45.7 | 50.6 | 96.3 | 83.0 |
| Belgium + Luxemburg | 113.6 | 8.6 | 122.2 | (71.1) | 51.1 | 41.2 |
| Bulgaria + Romania | 6.1 | 0.5 | 6.6 | 48.8 | 55.4 | 90.8 |
| Cyprus + Greece | 33.4 | 2.5 | 35.9 | 29.3 | 65.2 | 59.0* |
| Czech Republic + Slovakia | 17.6 | 1.3 | 18.9 | 52.5 | 71.4 | 102.8 |
| Denmark | 16.3 | 1.2 | 17.5 | 2.3 | 19.8 | 29 |
| Baltic States + Finland | 24.9 | 1.9 | 26.8 | 19.1 | 45.9 | 98.5 |
| France | 229.3 | 17.4 | 246.7 | 0 | 246.7 | 318 |
| Germany | 535.1 | 40.5 | 575.6 | (342.5) | 233.1 | 637 |
| Hungary | 6.7 | 0.5 | 7.2 | 7.2 | 14.4 | 38 |
| Ireland | 18.0 | 1.4 | 19.4 | 0.0 | 19.4 | 20 |
| Italy | 194.8 | 14.7 | 209.5 | 139.2 | 348.7 | 363.9 |
| Malta | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0 |
| Netherlands | 157.0 | 11.9 | 168.9 | (102.8) | 66.1 | 56.2 |
| Poland | 49.7 | 3.8 | 53.5 | 71.2 | 124.7 | 208.8 |
| Portugal + Spain | 188.3 | 14.3 | 202.6 | 79.2 | 281.8 | 352.7 |
| Sweden | 38.7 | 2.9 | 41.6 | 17.0 | 58.6 | 86.2 |
| United Kingdom | 166.4 | 12.6 | 179.0 | 0.0 | 179.0 | 342.7 |
| | **1838.4** | **139.2** | **1977.6** | **0** | **1977.6** | **2927.7** |

***Estimated EEA emissions based on 2009 data***

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## TABLE 5: COMPARISON OF SOLVENT VOC EMISSIONS with EEA 2015 ESTIMATES

| Year 2015 | ESIG | | | | | EEA |
|---|---|---|---|---|---|---|
| NMVOC in ktonne per country | HC+OXY | CHLOR | TOTAL before I/E | Import / (Export) | Grand TOTAL | TOTAL |
| Austria+Slovenia+Croatia | 40.5 | 3.2 | 43.7 | 34.4 | 78.1 | 90.0 |
| Belgium + Luxemburg | 149.0 | 8.6 | 157.6 | (104.5) | 53.1 | 42.0 |
| Bulgaria + Romania | 4.7 | 0.5 | 5.2 | 43.7 | 48.9 | 88.0 |
| Cyprus + Greece* | 27.5 | 2.5 | 30 | 19.3 | 49.3 | 2 |
| Czech Republic + Slovakia | 17.3 | 1.3 | 18.6 | 51.7 | 70.3 | 113.0 |
| Denmark | 11.3 | 1.2 | 12.5 | 7.5 | 20.0 | 27 |
| Baltic States + Finland | 20.9 | 1.9 | 22.8 | 31.5 | 54.3 | 49.0 |
| France | 200.9 | 17.4 | 218.3 | 0 | 218.3 | 289 |
| Germany | 568.5 | 40.5 | 609 | (284) | 325.0 | 541 |
| Hungary | 6.1 | 0.5 | 6.6 | 17.2 | 23.8 | 41 |
| Ireland | 16.4 | 1.4 | 17.8 | 0.0 | 17.8 | 19 |
| Italy | 190.5 | 14.7 | 205.2 | 136.3 | 341.5 | 353 |
| Malta | 0.0 | 0 | 0.0 | 0.0 | 0.0 | 0 |
| Netherlands | 169.4 | 11.9 | 181.3 | (121) | 60.3 | 56.0 |
| Poland | 38.2 | 3.8 | 42 | 69.5 | 111.5 | 219 |
| Portugal+Spain** | 195.7 | 14.3 | 210 | 82.1 | 292.1 | 360 |
| Sweden | 24.3 | 2.9 | 27.2 | 16.3 | 43.5 | 57 |
| United Kingdom | 160.6 | 12.6 | 173.2 | 0.0 | 173.2 | 350 |
| | **1841.8** | **139.2** | **1981** | **0** | **1981** | **2694** |

***No data available from Greece***

****Spain and Portugal can be separated out to give totals of 272.3 and 19.8ktonnes respectively***

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- **Error Estimation in Emissions Inventories**

The current ESIG (top-down) study based on solvent emissions in the European Union has shown that EEA inventories (bottom-up process) substantially overestimate EU solvent VOC emissions by 35% in 2008, 37% in 2009, 32%% in 2013 and 26% in 2015 . The availability of the emission factors from the REACH exercise in 2010 has helped ESIG improve the solvents industry data.

The ESIG calculations are based on data received from solvent suppliers and represent over 95% of all suppliers in the European Union. The maximum error that could be made is therefore a 5% underestimate in total solvent volumes. A second inaccuracy could be in the emissions factors used. Whilst these have been based on expert judgement, it is possible that an error of +/- 5% could occur. Whilst every effort has been made not to underestimate ESIG solvent VOC emissions (e.g chlorinated solvents are assumed to be released at 100% into the air), it is therefore possible that ESIG calculated emissions could be 10% too low by adding the two possible sources of error outlined above.

Since, 2016, ESIG has been liaising with a number of Member States to check in more detail why our results differ from theirs. They were also invited to provide information on import/export of solvents if available. In these discussions it was clear that the bottom-up approach was more prone to total error than the top-down approach of ESIG because there are more processes in the calculations. Member States take account of activity data, chemical use, percentage of solvents in chemical products and emission factors often from different sources[4]. Furthermore, it was clear that some Member State inventories included chemicals that are not solvents such as propellants which are gases and not solvents. It was clear in some cases that aerosols had been grossly overestimated. Another concern is that C14+ compounds are too heavy to be solvents but were included in some inventories. All these factors could lead to an overestimate of 30% or more in solvent VOC inventories by some Member States.

It is suggested that a difference of 20% or more between an ESIG value and a Member State estimate merits more detailed study and continued liaison with ESIG and selected Member States is encouraged.

- **Future Work**

Future work will be aimed at better defining and understanding the trans-boundary transport of solvents between European Member States. An estimate has been made using the chemicals import/export data available within Cefic for each Member State for each the years 2008, 2009, and 2013, with 2015 import/export calculations improved based on feedback from selected Member States and a modified import/export to 2013. It was clear that export of solvents from Germany had been overestimated in 2013 and those from The Netherlands and Belgium and Luxemburg had been underestimated. The import of solvents into Denmark was also modified based on official data from Denmark. The 2013 export figures for the three countries could be amended to ensure that ESIG estimates did not exceed the official solvent totals for The Netherlands and Belgium and Luxemburg. Taking the 2013 modifications into account, these data for chemical imports and exports for most of the EU-27 countries are assumed to be

proportional to solvent imports and exports, and a final assessment of solvent emissions in each country has been made for 2015.

This study has excluded any import/export beyond the European Union, and, although the effect on the EU total emissions will be small, any external import may be more pronounced in specific Member States.

Accurate import and export data of solvents between Member States remain the key improvement in future calculations by ESIG on solvent VOC emissions in the European Union.

- **Outlook**

It is important to understand why there is an overestimate of solvent VOC emissions in many Member States.

Germany's calculations, for example, would align with the ESIG results if there were no exports of solvents from Germany to other Member States. However, Becker et al [(7)] have shown that solvent VOC emissions are overestimated in German cities by some 60%. This would bring the EEA estimates for Germany more into line with our ESIG calculations. The reported UK Solvent VOC results are too high by comparison with those from ESIG, especially given that the UK is assumed not to export solvents.

It is clear that Member States do not use the same basis for calculating their solvent VOC emissions**. Is the solvents emission factor per capita available for each country or is it an average value used by Member States**?

These matters need to be addressed. ESIG cannot endorse the average factors of kg/capita emissions proposed by EEA for the domestic sector as reflecting reality. Each country has a different GDP and culture. Some countries cannot afford expensive cosmetics or for that matter, extensive dry cleaning, as an example. As a first approximation, ESIG has calculated an emission factor for the countries/group of countries in this study. The calculation uses the 2013 and 2015 Solvents emissions data and an estimate of the population as reported in *The Economist* publication ("The World in 2015") published in December 2014. These results are shown in Table 6 below. It is clear that the factor varies considerably from country to country, yet these factors will vary annually as can be seen when we repeat the exercise for 2015. The concept of solvent emissions/capita cannot be addressed simply as an average figure for the EU and any new EEA Guidebook on Emissions needs to steer Member States towards a more realistic estimate of their solvent VOC emissions**.**

**It is recommended that EEA endorse the emission factors for 2015 in Table 6 as kg/capita of total solvent VOCs for each country or small groups of countries.**

## TABLE 6 EMISSION FACTORS per capita for SOLVENT VOC EMISSIONS in 2013 and 2015

### Years 2013 &2015

| | Population Million | 2013 VOC Emissions | 2013 Emission Factor Kg/capita | 2015 VOC Emissions | 2015 Emission Factor Kg/capita |
|---|---|---|---|---|---|
| Austria + Slovenia + Croatia* | 10.7 (14.9*) | 96.3 | 9.0 | 78.1 | 5.2 |
| Belgium + Luxemburg | 10.7 | 51.1 | 4.8 | 53.1 | 5.0 |
| Bulgaria + Romania | 28.7 | 55.4 | 1.9 | 48.9 | 1.7 |
| Cyprus + Greece | 11.1 | 65.2 | 5.9 | 49.3 | 4.4 |
| Czech Republic + Slovakia | 16.2 | 71.4 | 4.4 | 70.3 | 4.3 |
| Denmark | 5.7 | 19.8 | 3.5 | 20.0 | 3.5 |
| Baltic States + Finland | 11.7 | 45.9 | 3.9 | 54.3 | 4.6 |
| France | 65 | 246.7 | 3.8 | 218.3 | 3.4 |
| Germany | 81.3 | 233.1 | 2.9 | 325.0 | 4.0 |
| Hungary | 9.9 | 14.4 | 1.4 | 23.8 | 2.4 |
| Ireland | 4.7 | 19.4 | 4.1 | 17.8 | 3.8 |
| Italy | 61.1 | 348.7 | 5.7 | 341.5 | 5.6 |
| Malta | - | 0.0 | 0.0 | 0.0 | 0.0 |
| Netherlands | 16.9 | 66.1 | 3.9 | 60.3 | 3.6 |
| Poland | 38.4 | 124.7 | 3.2 | 111.5 | 2.9 |
| Portugal + Spain | 57.7 | 281.8 | 4.9 | 292.1 | 5.1 |
| Sweden | 9.8 | 58.6 | 6.0 | 43.5 | 4.4 |
| United Kingdom | 64.4 | 179.0 | 2.8 | 173.2 | 2.7 |
| **Total EU27** | **504** | **1977.6** | **average 3.9** | **1981** | **average 3.9** |

- ***Croatia included in 2015 data with a population of 4.2Million people***

It is important to have a first estimate of ozone changes resulting from these reductions in solvent VOC emissions. Indeed, if the EEA solvent VOC emission estimates are replaced with our ESIG solvent VOC emissions, there would be a small but significant reduction of 1-2ppb in ozone peaks in the UK alone[8]. Given that the formation of ozone in the UK and nearly all the EU Member States is NOx-limited, i.e. ozone reduction is more sensitive to NOx reduction than VOC reduction, it is likely that similar small ozone reductions would be predicted across the EU, when European solvent VOC emission inventories are corrected.

Ozone Air Quality Models appear to have underestimated the European Ozone **reduction** already made by the European Solvents Industry. It is important that Member States are encouraged to measure both VOC and NOx emissions to improve European emissions inventories in the future.

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ESIG will continue to liaise with the emissions inventory organizations and the modeling teams in the EU with a view to communicating our detailed solvents VOC emissions data. At the same time ESIG will work towards assessing a more accurate estimate of import/export of solvents between Member States. In this way, ESIG will be working together with legislators to improve air quality in the future both inside and outside the European Union.

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## APPENDIX 1- THE ESTIMATION OF EMISSIONS FACTORS FOR SOLVENT SECTORS

This section explains how the emission factors (or release-to-air percentages) for solvent have been determined. These emissions factors depend on two parameters: the final end-use of the solvent and the type of solvent.

In the first place, the solvent end-uses have been listed according to the same definition as the ones described in the REACH solvent dossiers. Each of these end-uses is associated with one or more generic exposure scenarios (GES) where the release-to-air percentages have been determined from the environmental safety assessment based on realistic data and/or assumptions for particular uses (2010). As an example, the solvents used in the de-icing end-use will be completely released to atmosphere resulting in an emission factor of 100%. On the other hand, a solvent used in drilling application will not be released to air.

The second parameter to be considered is the solvent type. Not all solvents are VOC and not all VOC's are solvents. Their respective properties such as boiling point range, molecular weight make them VOC or not. For example, a C6 Hydrocarbon solvent (Hexane) will be a VOC whereas a heavier C14-C19 hydrocarbon solvent is not a VOC. In a consumer end-use such as cosmetic application, the solvent should be completely released to atmosphere. However this end-use does utilize heavy solvents that are intrinsically non VOC. Hence the emission factor will be lower than 100%.

In this evaluation the emissions factors have been evaluated for each end-use using the above parameters. Some of the assumptions that have been made are described in the table below.

| | End-use | Release to air |
|---|---|---|
| 1 | Agrochemical uses | 100% |
| 2 | Blowing Agents | 100% |
| 3 | De-Icing | 100% |
| 4 | Binder and Release Agents | 100% |
| 5 | Industrial Cleaning | 70% |
| 6 | Professional Consumer Cleaning | 50% |
| 7 | Industrial, Professional and Consumer Coatings | 75% |
| 8 | Functional Solvents | 10% |
| 9 | Metal working/Rolling Oils/Lubricant uses | 0% |
| 10 | Oil field chemicals-Drilling-Mining-Extraction | 0% |
| 11 | Polymers Processing (inc.rubber-tyre production) | 10% |
| 12 | Road and Construction | 95% |
| 13 | Use as Fuel/Combustion | 0.25% |
| 14 | Water Treatment | 5% |
| 15 | Other Consumer uses (household,aerosols,cosmetics) | 90% |
| 16 | Pharmaceuticals Manufacturing | 30% |

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End-use #1, #2, #3 and #4:
Agrochemicals products, blowing agents, de-icing products and binder/release agents are assumed to be completely released to the atmosphere and utilize solvents that are VOC, hence having an emission factor of 100%.

End-use #5:
Cleaning agents used industrially are mostly handled in a closed system and are partially released to atmosphere, hence an emission factor of 70% is applied.

End-use #6:
There are two types of products in this category: dry cleaning agents used by professionals that have very low release percentage and the other cleaning agents used by consumers that are completely released to atmosphere. Therefore an average 50% emission factor is applied.

End-use #7:
The coatings industry supplies the consumer market, the industrial market and the market for professionals. The emission factor of the entire coatings industry will be a combination of consumer and professional paint for the decorative market which has an emission factor of 100% and the industrial paints where the solvents are mostly regenerated resulting in an emission factor assumed to be 10%. Combining them in one line gives you "Coatings" with an emission factor of 75%. Therefore a conservative emissions factor of 75% has been assumed for this substantial Industrial, Professional and Consumer Coatings category.
This assumption takes into account CEPE[(a)] data.

End-use #8:
Functional Solvents include solvents used in chemical processes including intermediates, polymerization and extraction resulting in a low emission factor of 10%.

End-use #9:
Metal working use of rolling oils generate release to the atmosphere estimated to 5% in the GES. Based on ATIEL[(b)], an emission factor of 0% has been applied.

End-use #10:
Solvents used in Oil field drilling, mining and production operations have a low release to air percentage. As these solvents are mostly heavy and non-VOC, the emission factor applied is 0%.

End-use #11:
Polymer processing solvents are estimated to be partially released at 10% in the GES. This value has been taken as the emission factor.

End-use #12:
Road construction products include coatings and fluxed bitumen. The GES estimates that 95% of the solvent are being released to air. This value has been taken as the emission factor.

End-use #13:
Combustion solvents are burnt, generating water and carbon dioxide and therefore do not produce any VOC in the atmosphere. A conservative emission factor of 0.25% has been applied to take into account possible leaks.

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End-use #14:
Solvents used in water treatment applications are estimated to be partially released at 5% in the GES. This value has been taken as the emission factor.

End-use #15:
Solvents used by consumer in household and aerosol applications are completely released to the atmosphere. Part of the other consumer uses solvents are the ones used in cosmetic applications. These ones are heavy and non-VOC products. Therefore an estimated 90% emission factor has been applied.

End-use #16:
Pharmaceuticals manufacturing solvents are estimated to be partially released at 30% in the GES. This value has been taken as the emission factor.

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[a] CEPE: European Council of producers and importers of paints, printing inks and artists colours

[b] ATIEL: European oil companies association

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