

ESIG has finalised its 2021 solvent volatile organic compounds (VOC) emission inventories and results are in line with previous numbers: Solvent VOC emissions have stabilized in the EU28 (EU27+UK) since 2008 in the range of 2000-2300 ktonnes, including ethanol. Whereas in 2016-2019 the numbers were on the lower side of this range, the figures for 2020 and 2021 are higher due to increased use of ethanol for hand sanitizers as part of the Covid-19 pandemic.

General trend and comparison (amounts in ktonnes)

| year | ESIG VOC emissions | ESIG VOC emissions with ethanol | EEA inventories* | EEA vs ESIG difference |
|------|--------------------|---------------------------------|------------------|------------------------|
| 2008 | 2159 | na | 3311 | 35% |
| 2009 | 1917 | na | 2950 | 35% |
| 2013 | 1775 | 2323 | 2593 | 12% |
| 2015 | 1842 | 2366 | 2525 | 7% |
| 2016 | 1628 | 2002 | 2528 | 26% |
| 2017 | 1613 | 1980 | 2569 | 30% |
| 2018 | 1813 | 2145 | 2539 | 18% |
| 2019 | 1765 | 2120 | 2503 | 18% |
| 2020 | 1538 | 2265 | 2559 | 13% |
| 2021 | 1663 | 2209 | | |

* based on reporting in 2022

Both ESIG and EEA data show relatively stabilized emission level in the later 2010s, the difference between the two datasets being around 25% from 2016 onwards. In reporting of solvents in 2018 however, the difference decreased to 18% and in 2019 the difference was similar. In 2020, the ESIG VOC emissions decreased, which may be attributed to lower production/sales given the Covid-19 crisis. On the other hand, ethanol consumption increased given the use in hand sanitizer, which all in all led to an increase in VOC emissions overall. In 2021 this increased use of ethanol was still found, albeit lower than in 2020. In 2021, calculated VOC emissions decreased compared to 2020 by 3%. This paper presents the final numbers. The ESIG solvents emission inventories have been conducted with the support of TNO.

ESIG (European Solvents Industry Group)
Rue Belliard 40 b.15 B-1040 Brussels Belgium

esig@cefic.be www.esig.org

A sector group of Cefic 
European Chemical Industry Council - Cefic aisbl

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ESIG Solvent VOC Emissions Numbers 2021 per country

Summary of results for aggregated country groups applied by ESIG 2021

| Countries | TOTAL EMISSIONS BY COUNTRY OF PRODUCTION Hydrocarbon+Oxygenated solvents (ktonne/country) | IMPORT/EXPORT Corrections | Ethanol emissions | Emissions NMVOC in ktonne/country |
|------------------------------|----------------------------------------------------------------------------------------------|---------------------------|-------------------|-----------------------------------|
| Austria | 31.95 | 13.77 | 9.48 | 45.72 |
| Belgium + Luxembourg | 114.26 | -86.10 | 12.94 | 28.16 |
| Bulgaria + Romania | 4.66 | 35.60 | 27.72 | 40.26 |
| Croatia | 1.20 | 18.38 | 4.28 | 19.58 |
| Cyprus + Greece + Malta | 9.67 | 15.71 | 12.83 | 25.38 |
| Czech Republic | 23.78 | 20.25 | 11.14 | 44.04 |
| Denmark | 21.18 | -2.71 | 6.20 | 18.47 |
| Estonia + Latvia + Lithuania | 6.32 | 22.27 | 6.39 | 28.59 |
| Finland | 25.25 | -2.49 | 5.87 | 22.76 |
| France | 189.23 | 6.55 | 71.81 | 195.78 |
| Germany | 479.74 | -305.84 | 88.26 | 173.90 |
| Hungary | 7.70 | 16.55 | 10.33 | 24.25 |
| Ireland | 12.34 | -0.38 | 5.31 | 11.96 |
| Italy | 194.39 | 84.71 | 62.87 | 279.10 |
| Netherlands | 182.41 | -101.19 | 18.55 | 81.22 |
| Poland | 55.26 | 59.09 | 40.16 | 114.34 |
| Portugal | 10.40 | 33.07 | 10.93 | 43.48 |
| Slovakia | 5.07 | 22.06 | 5.79 | 27.13 |
| Slovenia | 13.44 | -1.12 | 2.24 | 12.32 |
| Spain | 118.84 | 86.18 | 50.31 | 205.02 |
| Sweden | 27.33 | 11.93 | 11.02 | 39.26 |
| United Kingdom | 128.16 | 53.70 | 71.64 | 181.87 |
| Total EU-27+UK | 1662.58 | 0.00 | 546.07 | 2208.65 |

Data on import/export are taken from J. Pearson for 2016 & 2017, based on adjusted 2015 import/export. From 2018 onwards, import/export estimates are based on the import and export estimates from the year before which are adjusted for the increase/decrease in VOC emissions.

For 2021, import and export estimates have been estimated for this year as well as revised for the years before. This does not affect EU28 totals but at country level adjustments have been made. The main goal of this update was to improve consistency in the methodologies for all years to the extent possible. Once the EEA data is available, we will add the comparison table.

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ESIG Solvent VOC Inventories for the EU – a top down approach¹

In summary, ESIG's top-down approach consists of three operations:

1. Collecting the solvent sales volumes in each EU country according to REACH end use sector.
2. Applying the air emission factor for each use sector & calculating VOC emissions.
3. Applying import/export corrections.

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1. All companies which are part of ESIG are invited to submit their solvent sales volumes by end-use sector for each European country (EU-27+ UK).

Notes:

- The sales numbers are about 90% of all oxygenated and hydrocarbon VOC solvents² manufactured and then sold in the European Union hence highly confidential. There are collated by Cefic, and carefully and confidentially analyzed.
 - No data from chlorinated/halogenated solvents are included anymore as all uses are in closed system, meaning no emission to air.
 - Excluded from ESIG's portfolio is also any substance which main use is not as solvent such as Toluene, Benzene and Xylene - DMF, NMP, THF - Propylene Glycols - Methanol.
 - The end-use sector are the same market sectors as defined for the Generic Exposure Scenario (GES) of the Registration, Evaluation and Authorisation of Chemicals Regulation (REACH). For the estimation of environmental exposure, ESIG has developed **Specific Environmental Release Categories (SpERCs)**, which provide sector-specific release fractions, associated operational conditions and risk management measures.
2. The emissions factors (see table below) have been assessed by using the GES approach, and estimate the percentage of VOCs emitted into the air. The solvent VOC emissions per sector are then calculated by multiplying the solvent volumes by the emission factor for that sector. These emissions factors depend on two parameters: the final end-use of the solvent and the type of solvent. As each of these end-uses is associated with one or more generic exposure scenarios (GES)

¹ For more information on the method used, former technical papers can be consulted: https://www.esig.org/wp-content/uploads/2018/03/201802_ESVOC_techncial-paper-solvent-VOC-emissions-2015_final-1.pdf
<https://www.esig.org/wp-content/uploads/2019/03/Atmospheric-Environment-John-VOC-article-201903.pdf>

² Members are asked to report only solvent sales for VOC solvents according to the definition given in the Industrial Emissions Directive: 'volatile organic compound' means any organic compound (...), having at 293,15 K a vapour pressure of 0,01 kPa or more, or having a corresponding volatility under the particular conditions of use"

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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).

Not all solvents are VOC and not all VOCs 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.

3. 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 member states and so an estimate has to be made. Cefic (with as source Eurostat) has data for overall chemicals 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 for 2015, which has been extrapolated to the later years. These calculations assume that there is no net import or export to or from the EU. These data show that Belgium, Germany and Netherlands are substantial exporters of solvents and downstream products (as such “exporting” VOC emissions) within the EU. 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. An apportion is made based on population data. For the 2021 ESIG emissions, the import and export assumptions have been reassessed, where especially for smaller countries adjustments were made.

Changes in 2013-2021 time series compared to 2016-2020 time series

By the end of 2022, the time series 2013 and 2015-2021 have been completed for the ESIG inventory. The results have been communicated to the inventory teams late 2022, early 2023.

The changes are the following:

- Extension of the time series, adding one year at the end (2021) and two years at the beginning (2013 and 2015).
- With the addition of the new years, import and export have been reassessed for the time series, which results in relatively small changes overall, however for some specific countries the differences can be larger.
- The calculation of ethanol use for hand sanitizers has been revised with new data available from the industrial branch organization (E-PURE) for the EU27+UK as a whole.
- The distribution of ethanol use over individual Member States has been revised. The old distribution was based on a Eurostat indicator for the use of personal care products, where some



countries were missing and therefore received no emissions related to ethanol. Given the Covid-19 pandemic, ethanol has become a significantly more important source of emissions and the products were used by the general population. Therefore, a distribution to countries proportional to the total population in each year has been assumed in the new inventory. This causes quite some changes in each country, especially for 2020 where the impact of Covid-19 on ethanol-related VOC emissions is significant.

- Since ethanol emissions have been included in NFR category 2D3a, also the per capita emission factors for this specific source category have been revised in the new inventory, and in some cases these are significantly different.

Comparison of the results

Because of the changes outlined above, the emission estimates for historical years (2016-2020) in the latest version may be different from the previous ESIG inventory. The changes are relatively larger for smaller countries as are the uncertainties, which relates to the difficulties in assessing the transport of solvents or solvent containing products between EU Member States prior to the use of them. At the overall EU27+UK level the total VOC emissions are 1-2% smaller in each of the years 2016-2020. At Member State level however, the differences may be significant, ranging from -68% (Latvia) to +31% (France) compared to the previous inventory. It should be stressed however that the new estimates are thought to represent better reality.

When looking at category 2D3a (domestic solvent use) only, similar observations can be made. Compared to the previous version of the ESIG inventory, the EU27+UK total difference for each of years 2016-2020 is maximum 2%. At the level of individual countries however, the differences are significantly larger, for 2020 ranging from -83% (Malta) to +75% (France). The main factor in this difference, for both 2D3a and the total VOC emissions, is the change made in the distribution of ethanol-related VOC emissions over individual countries as described above (emissions from ethanol are 100% allocated to category 2D3a).

The table below provides per capita emission factors for all sectors and for category 2D3a only derived from the ESIG VOC inventory results, for the current latest version (2013-2021) compared to the previous version (2016-2020). All numbers refer to the year 2020 and represent the ESIG VOC inventory including ethanol.



Per capita emissions (kg/person) derived for the year 2020 for all sectors and for NFR category 2D3a only

| Country | All sectors | | 2D3a only | |
|----------------|-------------|-------------|-------------|-------------|
| | 2016-2020 | 2013-2021 | 2016-2020 | 2013-2021 |
| AT | 6.17 | 6.06 | 1.55 | 2.31 |
| BE | 2.35 | 3.51 | 0.69 | 1.69 |
| BG | 2.05 | 2.89 | 1.38 | 1.78 |
| HR | 5.04 | 5.80 | 2.78 | 1.91 |
| CY | 1.49 | 2.97 | 1.19 | 1.71 |
| CZ | 5.50 | 5.16 | 1.10 | 2.16 |
| DK | 3.58 | 4.23 | 1.83 | 2.73 |
| EE | 2.72 | 5.28 | 0.94 | 2.65 |
| FI | 6.51 | 5.16 | 1.89 | 2.43 |
| FR | 5.32 | 4.05 | 3.66 | 2.09 |
| DE | 2.77 | 3.34 | 0.94 | 1.76 |
| GR | 3.13 | 3.82 | 1.58 | 1.82 |
| HU | 3.08 | 3.90 | 0.80 | 1.85 |
| IE | 3.97 | 4.09 | 0.47 | 1.73 |
| IT | 7.32 | 5.76 | 2.96 | 1.94 |
| LV | 2.05 | 6.31 | 1.04 | 2.38 |
| LT | 1.99 | 5.78 | 0.47 | 2.22 |
| LU | 2.22 | 4.25 | 1.09 | 1.80 |
| MT | 1.64 | 3.47 | 0.31 | 1.81 |
| NL | 4.54 | 5.84 | 0.80 | 2.19 |
| PL | 3.88 | 4.15 | 2.09 | 1.84 |
| PT | 1.80 | 5.25 | 0.60 | 2.32 |
| RO | 2.41 | 3.20 | 0.61 | 1.58 |
| SK | 2.19 | 5.93 | 1.32 | 4.14 |
| SI | 5.11 | 7.02 | 1.33 | 1.87 |
| ES | 5.75 | 5.29 | 3.09 | 2.46 |
| SE | 4.69 | 4.89 | 1.44 | 2.02 |
| UK | 3.34 | 3.86 | 2.00 | 2.00 |
| Average | 4.31 | 4.40 | 2.00 | 2.02 |



How to access and use ESIG data?

The ESIG inventories are an accepted Tier 2a method according to the EMPE/EEA air pollutant emission inventory guidebook, however, the top down approach using REACH end uses and confidentiality considerations make it difficult to use the data when establishing the country inventories.

Due to the high confidentiality of sales data Cefic statistics impose certain rules. When there are fewer than 3 original entries there is no show of data for a category. In few cases countries are grouped together to allow to display at least some numbers. Here again population numbers could serve to split between countries to get some results.

Thanks to efforts done by the UK, a table is added as an annex to the EMEP/EEA air pollutant emission inventory guidebook 2019, chapter 2.D.3.a.Domestic solvent use mapping the NFR categories against Reach end use sectors showing where and when ESIG data can be used (see table below). For instance for INDUSTRIAL CLEANING: 100% is attributed to 2D3e, so in case of no own activity data the ESIG number can be used instead.

Since ESIG data are based on real data from EU solvents manufacturers, the ESIG emission inventories remain a valuable source of information and can also be used for comparisons.

Member States can obtain more information upon request for full details per REACH category provided data is not confidential. Additionally, based on the mapping, ESIG can per member state, and provided no confidentiality claims apply, provide a reattribution to the NFR categories.

REACH end use categories & Emission Factors

| | End-use | Release to air | Remarks |
|---|----------------------------------|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | Agrochemical uses | 100% | assumed to be completely released to the atmosphere and utilize solvents that are VOC. |
| 2 | Blowing Agents | 100% | |
| 3 | De-Icing | 100% | |
| 4 | Binder and Release Agents | 100% | |
| 5 | Industrial Cleaning | 70% | Cleaning agents used industrially are mostly handled in a closed system and are partially released to atmosphere. |
| 6 | Professional & Consumer Cleaning | 50% | 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 |

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| | | | consumers that are completely released to atmosphere. Therefore, an average 50% emission factor is applied. |
| 7 | Industrial, Professional and Consumer Coatings | 75% | The emission factor of the entire coatings industry is 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%. Therefore, a conservative emissions factor of 75% is applied. |
| 8 | Functional Solvents | 10% | include solvents used in chemical processes including intermediates, polymerization and extraction resulting in a low emission factor of 10%. |
| 9 | Metal working/Rolling Oils/ Lubricant uses | 0% | taken over from ATIEL, the technical Association of the European Lubricants Industry. |
| 10 | Oil field chemicals-Drilling- Mining-Extraction | 0% | Solvents used are mostly heavy and non-VOC. |
| 11 | Polymers Processing (inc. rubber-tyre production) | 10% | Value from ESIG GES/SpERCS. |
| 12 | Road and Construction | 95% | Value from ESIG GES/SpERCS. |
| 13 | Use as Fuel/Combustion | 0.25% | 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. |
| 14 | Water Treatment | 5% | Value from ESIG GES/SpERCS |
| 15 | Other Consumer uses (household, aerosols, cosmetics) | 90% | Solvents used by consumers in household and aerosol applications are completely released to the atmosphere. Solvents used in cosmetic applications. are heavy and non-VOC products. Therefore, an estimated 90% emission factor has been applied. |
| 16 | Pharmaceuticals Manufacturing | 30% | Value from ESIG GES/SpERCS. |

Table annexed to the EMEP/EEA air pollutant emission inventory guidebook 2019, chapter 2.D.3.a.Domestic solvent use

| REACH end-use sector | 2D3a | 2D3b | 2D3c | 2D3d | 2D3e | 2D3f | 2D3g | 2D3h | 2D3i |
|------------------------------------------------------------------------------------------------------------------------------------|-------|-------|------|------|-------|------|-------|------|-------|
| Agrochemical uses | 100 % | | | | | | | | |
| Blowing agents | | | | | | | | | 100 % |
| De-icing | 50 % | | | | | | | | 50 % |
| Binder and release agents | | | | | | | | | 100 % |
| Cleaning industrial and leather treatment | | | | | 100 % | | | | |
| Cleaning — professional consumer | 100 % | | | | | | | | |
| Coatings — industrial and adhesives, inks | | | | 80 % | | | | 15 % | 5 % |
| Coatings — professional/consumer and thinners, paint industry | 30 % | | | 70 % | | | | | |
| Functional solvents (including solvents used in chemical processes, e.g. process aids, intermediates, extraction, dewaxing agents) | | | | | | | 100 % | | |
| Metal working/rolling oils/lubricant uses | | | | | | | | | 100 % |
| Oil field chemicals, drilling, mining, extraction | | | | | | | | | 100 % |
| Polymers processing (including rubber-tyre production) and industrial resins, synthetic rubber, process | | | | | | | 100 % | | |
| Road and construction | | 100 % | | | | | | | |
| Use as fuel/combustion and fuel additives | | | | | | | | | 100 % |
| Water treatment | | | | | | | | | 100 % |
| Other consumer uses (household, aerosols, cosmetics) | 100 % | | | | | | | | |
| Pharmaceuticals manufacturing | | | | | | | 100 % | | |
| Others — please specify below | | | | | | | | | 100 % |

2.D Solvent and product use

- 2.D.3.a Domestic solvent use including fungicides
- 2.D.3.b Road paving with asphalt
- 2.D.3.c Asphalt roofing
- 2.D.3.d Coating applications
- 2.D.3.e Degreasing
- 2.D.3.f Dry cleaning
- 2.D.3.g Chemical products
- 2.D.3.h Printing
- 2.D.3.i, 2G Other solvent and product use

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