TNO innovation for life

VOC emissions from substances used as solvents until 2024

ESIG VOC Inventory 2025

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Summary

Since 2008, ESIG has regularly compiled and published inventories that quantify emissions of substances defined as VOC arising from substances acting as solvents in industrial, professional and consumer applications, produced by its member companies. These inventories represent a substantial share of VOC emissions linked to solvent use within the European Union and the United Kingdom. Since 2019, ESIG has worked closely with TNO on the development these VOC emission inventories for substances used as solvents. This report presents the ESIG 2024 VOC inventory, which provides detailed emissions data for the years 2013 and 2015 through to 2024.

In 2024, overall VOC emissions fell by 7% compared with 2023. Ethanol emissions decreased by 6%, and VOC emissions originating from substances produced by ESIG members and used in solvent applications declined by 7%, reflecting the drop in solvent-related sales reported by ESIG members in 2024. This marks the third consecutive year in which the inventory records the lowest absolute VOC emissions, both with and without ethanol, since the inventory began. Although the precise cause of this decline is still uncertain, the influence of sales data for substances used as solvents adds to the uncertainty in the results. Despite improvements in the methodology over time, uncertainties remain in estimating import and export figures and ethanol use.

The recommendations focus on further improving the accuracy, transparency, and scope of the VOC inventory in order to strengthen its reliability and usefulness. Priority actions include standardising timeseries data and ensuring transparency through clear documentation of assumptions and data sources and reviewing the emission factors applied to substances used in a solvent function. Enhancing estimates of intra- and extra-EU trade using more detailed economic data and improving the methodology for ethanol emissions in collaboration with stakeholders, are also important. Expanding the inventory to include other substances used as solvents, such as methanol, would help capture a wider range of VOC emissions. These updates would further increase the inventory's robustness and make it an even more valuable resource for national inventory compilation across EU Member States.

1 Introduction

Volatile organic compounds (VOCs) contribute, in varying degrees, to the formation of tropospheric ozone and secondary organic aerosols, both of which present risks to human health and the environment (Atkinson and Arey, 2003). They do not refer to a distinct substance group but to a physical property – volatility – of organic substances. This property is defined by vapour pressure or boiling point and describes the tendency of a substance to evaporate. In the remainder of the report, we will refer to substances that fall under the definition of VOCs simply as VOCs for ease of reporting.

In recent decades, emissions of VOCs from road transport have fallen substantially as a result of stricter vehicle emission standards (CEC, 1991). As these reductions have taken effect, the relative importance of other sources of VOC emissions, including substances used as solvents, has increased, drawing greater attention to the need for more accurate estimates of solvent-related emissions (Monks et al., 2015). Solvents form a cornerstone of the modern chemical industry, yet they are not defined as a fixed family of substances. Instead, the term 'solvent' describes a functional role that a chemical compound can assume depending on its application. This functional perspective is essential for understanding their role in processes and emissions reporting.

To support EU air quality objectives, Member States are required to report annual emissions under the National Emission Reduction Commitments Directive (NECD), set out in Directive 2016/2284/EU. These inventories provide a consistent account of anthropogenic emissions. In general, emissions are estimated by combining an activity measure, such as fuel use or distance travelled, with an emission factor. While the EMEP/EEA Guidebook supplies default emission factors, many countries adapt or refine these methods to reflect national conditions more accurately.

Emissions of VOCs arising from substances used in a solvent function represent a significant component of the EU's non-methane VOC (NMVOC) totals. Since substances used as solvents do not emit methane, VOC and NMVOC emissions are equivalent in this context. However, estimating these emissions remains difficult. The use of substances in a solvent function is distributed across many industrial, professional, and household applications, and national statistics often provide limited detail on product availability or consumption as solvent. The free movement of goods within the EU makes it even more difficult to determine national consumption of substances as solvents, since trade statistics record only total quantities and do not distinguish between different uses – such as use as a solvent of for other purposes. As a result, simplified approaches such as per capita emission factors are often applied, although these methods do not capture national variation and can limit the ability to assess the effects of specific reduction measures.

To improve data quality, the European Solvents Industry Group (ESIG), operating within the European Chemical Industry Council (CEFIC), has compiled information on the quantities of substances used as solvents placed on the EU market. These data have become increasingly valuable for estimating solvent-related VOC emissions, and several national inventory teams have shown interest in ESIG's approach. However, VOC is a broader category: some VOC-emitting products are not used as solvents, and imports/exports may not be fully reflected.

This report outlines the methodology applied by TNO to estimate emissions for the 2025 ESIG VOC inventory. The timeseries has been updated to include data for 2024 and now covers the period from 2013 to 2024, excluding 2014 for which no data is available.

2 Methodology

This section describes the method applied for the 2025 ESIG inventory. The general approach follows the procedures used in earlier editions of the inventory, as documented in previous TNO reports (R12311, 2020; R12580, 2021; R12732, 2022; R10260, 2023, R12659, 2024).

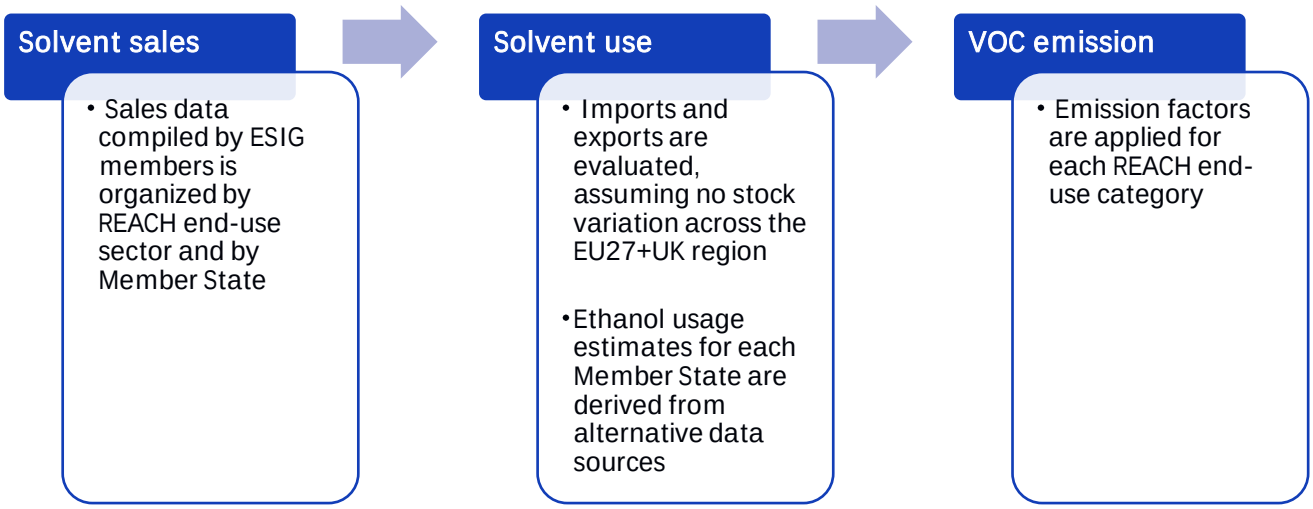

Figure 2.1: ESIG VOC inventory methodology overview

2.1 General methodology

The methodology begins with an assessment of the volumes of substances used as solvents placed on the market in each EU Member State, with the United Kingdom included throughout the full period analysed. These substances are allocated to end-use categories according to the REACH classification system. A conversion matrix linking REACH categories to NFR reporting sectors, taken from the EMEP/EEA Guidebook, is shown in **Table 2.1**. It should be noted that the method considers the total quantity of substances used as solvent and does not include information on the specific chemical composition of individual products.

The main steps are as follows:

1. **Collection and allocation of sales data:** Sales information for substances used as solvents is obtained from ESIG members, which together account for most solvent-related production in Europe. There were no changes to the list of reporting companies in 2024. Reported sales are assigned to individual countries and to REACH end-use categories (see **Table 2.1**). Products sold to intermediaries such as distributors, the eventual end-use is unknown, and these volumes are therefore allocated across REACH categories proportionally, including an additional category for unspecified uses.

2. **Assumption regarding sales and use, and treatment of trade flows:** The inventory assumes that annual sales of substances used as solvents represent annual solvent use, with no change in stock levels and no net import or export for EU27 plus the UK when considered as a whole. Because goods move freely within the European market, substances purchased in one Member State may be used elsewhere and potentially for purposes other than solvent use. Estimating these cross-border flows is necessary, yet detailed tracking data are not available. Previous attempts to refine these estimates were inconclusive, so the proportions of intra-EU imports and exports derived for 2013 and 2015 are carried forward to later years. Further explanation is provided in Section 2.2.

3. **Include of ethanol:** Ethanol is not included in the ESIG sales dataset because ethanol producers are not ESIG members. However, given its increasing importance used as a solvent, ethanol has been included in the inventory since 2016, with estimates extended back to 2013 to ensure consistency across the full timeseries. Estimated ethanol use is based on data from the European Renewable Ethanol (ePure). Details are provided in Section 2.3.

4. **Application of emission factors:** A consistent set of emission factors is applied, as described in Section 2.4.

Although sales by Member State are available, confidentiality requirements and competition rules mean that some countries must be grouped. Since 2020, the following groupings have been used:

- Belgium and Luxembourg
- Bulgaria and Romania
- Cyprus, Greece, and Malta
- Estonia, Latvia, and Lithuania

The overall methodology remains closely aligned with that used in earlier ESIG inventories, and the dataset has now been updated to include the year 2024 within the timeseries.

2.2 Import and export within the EU

As previously mentioned, inventory assumes no trade into or out of the EU27 including the United Kingdom and considers only movements within the internal market. For the period 2013 to 2017, intra-EU trade was assessed using import and export shares derived from the 2013 and 2015 inventories, as described in the ESIG position paper (ESIG, 2018) and in Pearson (2019). The same approach was applied when processing data for 2016 and 2017. In some cases, confidentiality requirements meant that data had to be aggregated into country groups. This occasionally produced imbalances for smaller countries within a cluster, whose values were influenced by the solvent use of a larger Member State. To address this, consumption of substances used as solvents per country was compared with the EU average per capita solvent use, and adjustments were introduced to ensure that each country remained within twice the EU average, while maintaining balanced import and export shares within the group.

From 2018 onwards, import and export estimates were based on an extrapolation of the 2013 to 2017 data. Sales were collected at the level of individual countries, and the proportions derived from earlier years were used as a first estimate of solvent usage for

each reporting year. These estimates were then adjusted so that national solvent use corresponded with that year's sales totals. Where a country showed a marked year-on-year change in sales, its import and export values were reviewed. To manage such variations, a limit was placed on the maximum annual percentage change for each country, and any surplus above this limit was redistributed among countries with lower changes, proportional to their estimated usage. The caps were aligned with trends in overall solvent use across the EU27 and the UK with 15 % for 2018, 2020, 2022 and 2023 and 10% for 2019 and 2021.

2.3 Emissions from ethanol use

Ethanol consumption, which is not covered by ESIG member reporting, represents an increasingly important component as a solvent. Estimates of ethanol use within the EU27 plus the United Kingdom were based on production and import data provided by the European association for renewable ethanol production (ePure, 2024). Export data were not included due to limited availability. Expert judgement from ESIG indicates that around 75 % of industrial ethanol consumption, excluding uses in fuel, food and beverages, can be attributed to solvent applications. These volumes were converted to mass using a density of 789 kg per cubic metre.

$$E = \rho_{Ethanol} \times Share_{solv\_ind} \times (Production + Import) \times Share_{ind\_prod}$$

where:

E	Total ethanol use in EU27+UK (ton)
$\rho_{Ethanol}$	Density of ethanol (kg/m^3)
$Share_{solv\_ind}$	Share of use for solvents in industrial applications (estimated at 75%)
$Production$	Total ethanol production in EU27+UK (m^3)
$Import$	Total ethanol import into EU27+UK (m^3)
$Share_{ind\_prod}$	Share of ethanol production for industrial applications

Ethanol consumption was then allocated to individual countries using national population as a proxy, assuming a uniform per capita solvent-related ethanol use across the EU27 plus the United Kingdom. The methodology was modified for 2020 and 2021 to account for the exceptional increase in demand for ethanol-based hand sanitiser during the COVID-19 pandemic. The substantial rise in ethanol imports observed in 2020 was attributed entirely to solvent use, while the reduction in imports in 2021 was taken to reflect a corresponding decrease in consumption. From 2022 onwards, the standard approach was reinstated, indicating that ethanol use had returned to typical levels with no remaining pandemic-related effect.

2.4 Emission factors

VOC emissions from substances used as solvent use were estimated using established emission factors assigned to each REACH end-use category. These emission factors, expressed as kilograms of VOC emitted per kilogram of product, are unchanged from those applied in earlier ESIG inventories. They are presented in Table 2.1 together with the corresponding NFR categories, as outlined in Chapter 2D3a of the 2019 EMEP/EEA Guidebook (EEA, 2023). For consistency within the ESIG inventory, ethanol is allocated entirely to category 2D3a, reflecting the fact that it is predominantly used in consumer applications, particularly during the pandemic period.

Table 2.1: Emission Factors per REACH end-use sector

REACH end-use sector	*EF (kg/kg solvent)*	*Link to NFR category*
Agrochemical uses	1	2D3a
Binder and Release Agents	1	2D3i
Blowing Agents	1	2D3i
Cleaning Industrial + Leather treatment, electronics, semiconductor	0.7	2D3e
Cleaning-Professional Consumer	0.5	2D3a
Coatings-Industrial + adhesives, resins, inks, refining and blending + reprographics	0.75	2D3d (80%), 2D3h (15%), 2D3i (5%)
Coatings-Professional/Consumer + Thinners, paint industry + emulsions + automotive	0.75	2D3a (30%), 2D3d (70%)
De-Icing	1	2D3a (50%), 2D3i (50%)
Functional Solvents (incl. solvents used in chemical processes, e.g. process aids, intermediates, extraction, dewaxing agents)	0.1	2D3g
Metal working/rolling oils/Lubricant uses	0	2D3i
Oil field chemicals-drilling-mining-extraction	0	2D3i
Other consumer uses (household, aerosols, cosmetics)	0.9	2D3a
Pharmaceuticals manufacturing	0.3	2D3g
Polymers Processing (incl. rubber-tyre production) + Industrial resins, synthetic rubber, process	0.1	2D3g
Road and construction	0.95	2D3b
Use as Fuel/Combustion + Fuel additives	0.0025	2D3i
Water Treatment	0.05	2D3i
Ethanol (in hand sanitizers but also in other applications)	0.9	2D3a

3 Results

3.1 Import and export

Table 3.1 presents the patterns of t imports and exports of substances used as solvents, reporting net flows for each country, or for grouped countries where confidentiality requirements apply. A positive value indicates that a country is a net importer, while a negative value reflects a net export surplus. These data provide important insight into how solvents circulate within the EU27 plus the United Kingdom, which is a key consideration when estimating VOC emissions at the national level.

Table 3.1: Net imports per country (or countries group) in kton VOC emissions for 2013 and 2015-2024

Country	2013	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Austria	9.6	32	34	33	41	19	11	14	10	7	7
Slovenia						-0.2	-1.7	-1.1	-0.2	-1	-1
Croatia*	**n/a**					20	17	18	16	17	19
Belgium	-60	-99	-94	-95	-156	-128	-73	-86	-93	-72	-62
Luxembourg											
Bulgaria	46	40	37	37	41	43	38	36	38	35	36
Romania											
Cyprus	-8.1	-3.2	16	15	15	1.5	17	16	16	15	14
Greece						14					
Malta	0.9	0.5		0.9		0.9					
Czech Republic	49	48	49	53	55	31	27	20	26	28	30
Slovakia						21	21	22	22	25	22
Denmark	2.6	6.8	7.1	7.1	8	-1	-3.2	-2.7	-0.8	-2	-3
Finland	19	29	7.8	7.8	10	9.4	6	-2.5	10	9	8
Estonia			23	22	26	12	23	22	22	20	20
Latvia											
Lithuania						11					
France	5.6	0.8	4.4	4.2	1.4	-7.4	24	6.6	-1.1	2	16
Germany	-291	-243	-246	-246	-288	-302	-302	-306	-281	-232	-240
Hungary	15	16	17	17	19	20	16	17	17	16	14
Ireland	0.5	0.1	0.3	0.3	1.4	0.6	-0.7	-0.4	-0.9	-1	-1
Italy	133	128	116	114	129	112	70	85	62	43	39
Netherlands	-89	-113	-119	-119	-108	-87	-104	-101	-92	-97	-91
Poland	69	64	51	53	62	61	57	59	56	49	46
Portugal	78	78	76	35	39	35	31	33	38	33	29
Spain				39	64	81	73	86	76	64	56
Sweden	18	15	15	15	16	15	9.8	12	11	7	8
United Kingdom	3.7	0.7	4.4	4.3	22	16	43	54	50	37	37

** Croatia was not included in the 2013 inventory as it only joined the EU on July 1st, 2013.*

3.2 Ethanol

Table 3.2 summarises the VOC emissions associated with ethanol use as a solvent across the full timeseries. As noted in previous editions of the inventory, emissions in 2013 and 2015 are noticeably higher than in the subsequent period from 2016 to 2019. This pattern remains difficult to interpret and may suggest issues related to data quality or completeness in those earlier years. In 2020, VOC emissions rise sharply, with a smaller but still elevated value in 2021, reflecting the extensive use of ethanol-based hand sanitiser during the COVID-19 pandemic. By 2022, as demand returned to typical levels, ethanol-related emissions aligned once again with pre-pandemic values. In 2024, emissions decreased by 6%, driven primarily by a 13% decrease in the industrial share of imports, followed by a 4% decrease in industrial ethanol production within the EU, based on the ePure (2024) data on ethanol production by end-use.

Table 3.2: Estimated VOC emissions from ethanol per country in kton VOC emissions for 2013 and 2015-2024

Country	2013	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Austria	9.2	8.8	6.4	6.3	5.7	6.1	12.5	9.4	6.0	6.9	6.5
Belgium	12.1	11.6	8.3	8.1	7.4	7.9	16.2	12.2	7.8	8.9	8.4
Bulgaria	7.9	7.4	5.2	5.1	4.6	4.8	9.8	7.3	4.6	4.9	4.6
Croatia	4.6	4.4	3.1	3.0	2.7	2.8	5.7	4.3	2.6	2.9	2.7
Cyprus	0.9	0.9	0.6	0.6	0.6	0.6	1.3	0.9	0.6	0.7	0.7
Czech Republic	11.4	10.9	7.7	7.6	6.9	7.4	15.1	11.1	7.1	8.2	7.7
Denmark	6.1	5.8	4.2	4.1	3.8	4.0	8.2	6.2	3.9	4.5	4.2
Estonia	1.4	1.4	1.0	0.9	0.9	0.9	1.9	1.4	0.9	1.0	1.0
Finland	5.9	5.6	4.0	3.9	3.6	3.8	7.8	5.9	3.7	4.2	34.5
France	71.1	68.5	48.9	47.9	43.5	46.6	95.1	71.6	45.6	51.5	4.0
Germany	87.3	83.7	60.3	59.2	53.7	57.5	117.2	88.0	56.0	63.8	48.6
Greece	11.9	11.2	7.9	7.7	7.0	7.4	15.1	11.3	7.1	7.9	7.4
Hungary	10.7	10.2	7.2	7.0	6.3	6.8	13.8	10.3	6.5	7.3	6.8
Ireland	5.0	4.8	3.5	3.4	3.1	3.4	7.0	5.3	3.4	4.0	3.8
Italy	64.7	62.6	44.5	43.4	39.2	41.4	84.1	62.7	39.7	44.6	41.9
Latvia	2.2	2.0	1.4	1.4	1.3	1.3	2.7	2.0	1.3	1.4	1.3
Lithuania	3.2	3.0	2.1	2.0	1.8	1.9	3.9	3.0	1.9	2.2	2.0
Luxembourg	0.6	0.6	0.4	0.4	0.4	0.4	0.9	0.7	0.4	0.5	0.5
Malta	0.5	0.5	0.3	0.3	0.3	0.3	0.7	0.5	0.4	0.4	0.4
Netherlands	18.2	17.4	12.5	12.2	11.1	12.0	24.5	18.5	11.8	13.5	12.7
Poland	41.2	39.2	27.9	27.2	24.6	26.3	53.5	40.0	25.3	27.8	26.0
Portugal	11.4	10.7	7.6	7.4	6.7	7.1	14.5	10.9	7.0	8.0	7.6
Romania	21.7	20.5	14.5	14.1	12.7	13.4	27.2	20.3	12.8	14.4	13.5
Slovakia	5.9	5.6	4.0	3.9	3.5	3.8	7.7	5.8	3.7	4.1	3.9

Slovenia	2.2	2.1	1.5	1.5	1.3	1.4	3.0	2.2	1.4	1.6	1.5
Spain	50.6	47.9	34.1	33.4	30.3	32.5	66.7	50.1	31.9	36.4	34.5
Sweden	10.4	10.0	7.2	7.2	6.6	7.1	14.6	11.0	7.0	8.0	7.5
United Kingdom	69.2	66.8	48.0	47.2	43.0	46.2	94.5	71.4	46.1	52.2	49.3
EU27+UK	**547**	**524**	**374**	**367**	**333**	**355**	**725**	**544**	**347**	**391**	**368**

3.3 Overall VOC emissions

Table 3.3 provides a detailed overview of total volatile organic compound (VOC) emissions for the years 2013 and 2015–2023. As in **Table 3.1**, data for certain countries are aggregated to maintain confidentiality when individual country-level information cannot be disclosed due to competition rules.

As highlighted in previous reports, the results reveal significant trends: emissions in 2016 and 2017 were markedly lower than those reported in 2013 and 2015. However, a notable uptick in emissions occurred in 2018, raising questions about possible underreporting of production activities by companies during earlier periods. Also, as previously mentioned, the sharp increase in emissions during 2020, and to a lesser degree in 2021, can be attributed to the surge in ethanol usage for hand sanitizers amid the global COVID-19 pandemic. Notably, in 2020, ESIG reported reduced quantities of non-ethanol substances in solvent application, likely reflecting the impact of pandemic-related disruptions, including reduced production or temporary industry closures during initial lockdowns.

In 2022, VOC emissions saw a sharp decrease compared to 2021 (18%), followed by a more modest 4% decline from 2022 to 2023. The downward trend in overall VOC emissions continues in 2024, with a further 7% reduction compared to last year's 4% decline, making 2024 once again the lowest emissions year on record. This decrease is driven by a 6% reduction in ethanol-related emissions, as described in Section 2.2, and a 7% decrease in VOC emissions reported by ESIG members, compared to 2023.

For ESIG-reported VOC emissions, this decline occurs despite a marginal 1% increase in total sales in solvent applications. This is primarily due to the growth occurring in sectors with relatively low emission factors. For example, sectors showing the largest increase in sales, such as Functional Solvents, have relatively low emission factors of around 0.1 ton NMVOC per ton. In contrast, the sectors experiencing the most significant decreases in sales, including Coatings-Professional/Consumer and Agrochemical uses, have relatively high emission factors of approximately 0.75 ton NMVOC per ton and 1 ton NMVOC per ton, respectively (cf. Table 2.1). As a result, even modest reductions in these high-emission-factor sectors contribute disproportionately to the overall reduction in VOC emissions.

Table 3.3: VOC emissions per country (or countries group) in kton for 2013 and 2015-2023 (including ethanol use)

Country	2013	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Austria	63	88	84	84	91	58	54	55	44	39	38
Slovenia						13	15	15	12	11	10
Croatia*	n/a					24	24	24	19	22	24
Belgium	59	63	33	37	41	38	43	41	37	34	30
Luxembourg											
Bulgaria	81	72	63	63	64	68	82	68	61	58	59
Romania											
Cyprus	38	36	36	32	36	2	45	38	37	34	30
Greece						30					
Malta	1	1		1		1					
Czech Republic	83	82	74	81	83	51	55	55	45	51	54
Slovakia						28	32	33	27	31	27
Denmark	25	24	20	19	19	21	25	25	20	21	22
Finland	56	62	28	27	29	29	28	29	23	21	23
Estonia			32	29	33	16	35	35	31	30	30
Latvia											
Lithuania						16					
France	295	270	219	216	237	256	273	267	226	205	179
Germany	326	409	259	236	257	256	277	262	205	190	189
Hungary	33	32	29	29	32	35	38	35	32	32	28
Ireland	23	21	14	14	14	15	20	17	17	15	15
Italy	386	381	347	334	373	352	343	342	268	260	242
Netherlands	78	74	94	95	101	93	102	100	80	75	70
Poland	160	141	125	133	137	128	157	154	123	120	112
Portugal	323	332	289	52	58	54	54	54	57	51	44
Spain				233	270	249	250	255	206	205	186
Sweden	68	49	40	43	48	49	51	50	48	43	44
United Kingdom	220	228	216	220	224	239	258	253	201	191	168
EU27+UK	**2318**	**2366**	**2002**	**1979**	**2145**	**2120**	**2263**	**2207**	**1816**	**1741**	**1624**

** Croatia was not included in the 2013 inventory as it only joined the EU on July 1st, 2013.*

Table 3.4 and /
Figure 3.1 provide a comparative analysis of total VOC emissions from solvent applications in the EU27+UK as estimated in this study versus the figures reported by individual countries in their official inventories. However, a comparison for 2024 is not currently possible since official country-reported emission data will only become available in the first half of 2026. From 2013 onward, the differences generally range between 17% and 22%, with exceptions in 2016 and 2017, where the discrepancies are notably larger. These larger differences may indicate that the ESIG inventory underestimated emissions during those years due to relatively low reported figures. In 2023, the difference is also significant, with EMEP-reported emissions being 39% higher than those in the ESIG inventory, the highest in the time series.

This disparity is driven by substantial reductions in both ESIG-reported emissions and ethanol levels.

Overall, the trend indicates that country-reported emissions often exceed those recorded in the ESIG inventory. A number of underlying reasons contribute to this pattern, as outlined below:

1. **Differences in scope:** EMEP data encompasses VOC emissions from all products uses, not just used as solvents. While "solvents" account for most of the emissions in the EMEP data, this broader scope means a direct comparison is not entirely fair, and lower emissions based on ESIG data are expected. For instance, emissions from liquefied gases used as propellants in aerosol dispensers (as noted in the UK inventory by Pearson, 2019) or methanol used in de-icing applications are not included in the ESIG inventory. Depending on the methodologies applied by individual countries, such emissions may be partially or fully included in their official national inventories. Despite these scope differences, the comparison remains valuable for identifying gaps and fostering discussions to improve the accuracy and consistency of national inventories.
2. **Methodological variations:** National inventories (compiled for EMEP) often rely on simplified approaches due to data limitations, introducing additional uncertainty in the reported figures. This methodological approach may result in smoother trends in the data, such as the 4% decrease in EMEP emissions observed between 2020 and 2021 and again between 2021 and 2022.
3. **Incomplete coverage of the ESIG sales data:** While the ESIG inventory accounts for a significant share of production for solvent applications, it may not capture all solvent production within Europe or account for imports from outside the EU, both of which could influence emissions.
4. **Uncertainties related to intra-EU trade:** Estimating intra-EU imports and exports, along with assessing emissions from ethanol, adds considerable uncertainty to the ESIG inventory, particularly regarding the allocation of emissions across different countries.
5. **Macroeconomic shifts:** As mentioned earlier, the discrepancies may also reflect a reduction in European production, driven by the decline of industry in Europe, which would imply that the assumption that there is no net import into Europe no longer holds. Increasing competition with foreign industries may limit local production. However, this hypothesis is difficult to confirm without incorporating (macro-) economic data into the analysis.

Table 3.4: Comparison between the ESIG VOC inventory (including and excluding ethanol use) and officially reported emissions of VOC (EMEP) for the EU27+UK across all years (2013 and 2015-2024)

Year	ESIG excl.	Ethanol	ESIG incl.	EMEP	Difference	Difference (%)
2013*	1775	547	2323	2754	431	19%
2015	1842	524	2366	2689	323	14%
2016	1628	374	2002	2593	591	30%
2017	1613	367	1980	2635	656	33%
2018	1813	333	2145	2614	469	22%
2019	1765	355	2120	2584	463	22%
2020	1538	725	2263	2747	484	21%
2021	1663	544	2207	2616	410	19%
2022	1470	346	1816	2499	683	38%
2023	1350	391	1741	2421	679	39%
2024	1256	368	1624	-	-	-

** Croatia was not included in the 2013 ESIG inventory as it only joined the EU on July 1st, 2013.*

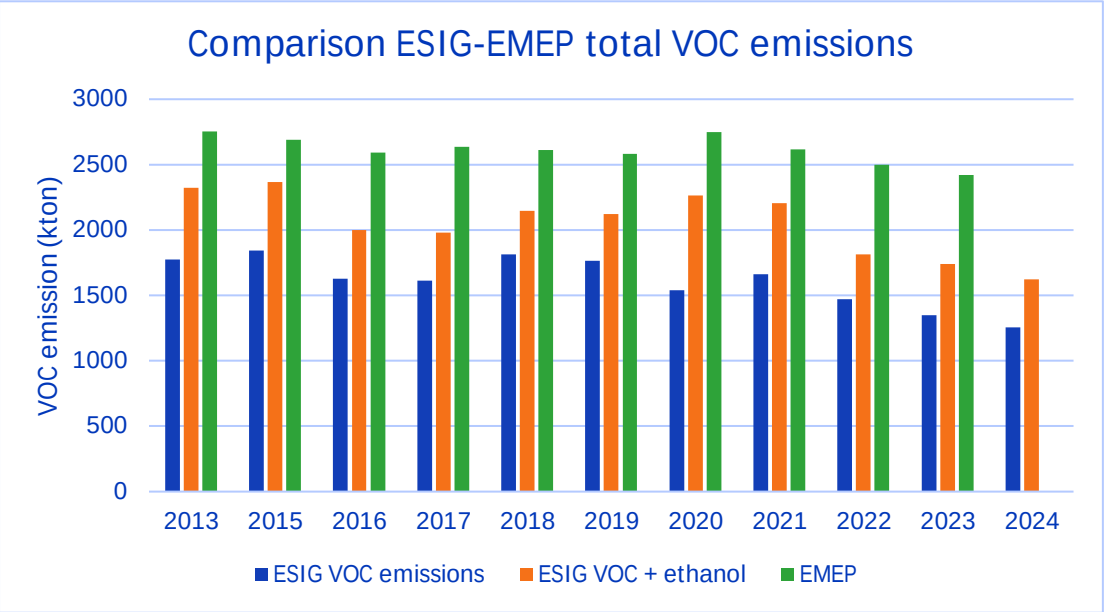

Figure 3.1: Comparison between total VOC emissions in kton from the ESIG VOC inventory (including and excluding ethanol use) and officially reported emissions of VOC (EMEP) for the EU27+UK for 2013 and 2015-2024

While the overall comparison provides a broad perspective on total VOC emissions, a closer look at the country level (Figure 3.2) reveals significant variations. This figure compares ESIG and officially reported EMEP emissions for the year 2023. While some countries demonstrate a strong alignment between the two datasets, others, such as Germany, France, and Italy, continue to show marked discrepancies. These disparities likely arise from methodological differences in how individual countries calculate their emission inventories, with most national inventories relying on simple methods, as mentioned earlier. Some countries, in Scandinavia for example, have adopted more advanced methodologies for calculating VOC emissions from solvents (Fauser, 2010; Skårman et al., 2016), which may include substances not covered in the ESIG inventory. When comparing VOC emissions from the ESIG inventory with those reported to EMEP for Denmark and Sweden, the differences are 27% for both (as seen in **Figure 3.2**). While these discrepancies are lower than the overall totals, they remain significant.

The disparities between ESIG and EMEP VOC emissions may also point to limitations in the ESIG inventory, particularly in accurately accounting for the import and export of solvents. Additionally, the years 2020 and 2021 introduce another layer of complexity, related to VOC emissions from ethanol, which has not been consistently addressed across the different versions of the inventory, due to the pandemic and its significant impact on ethanol consumption.

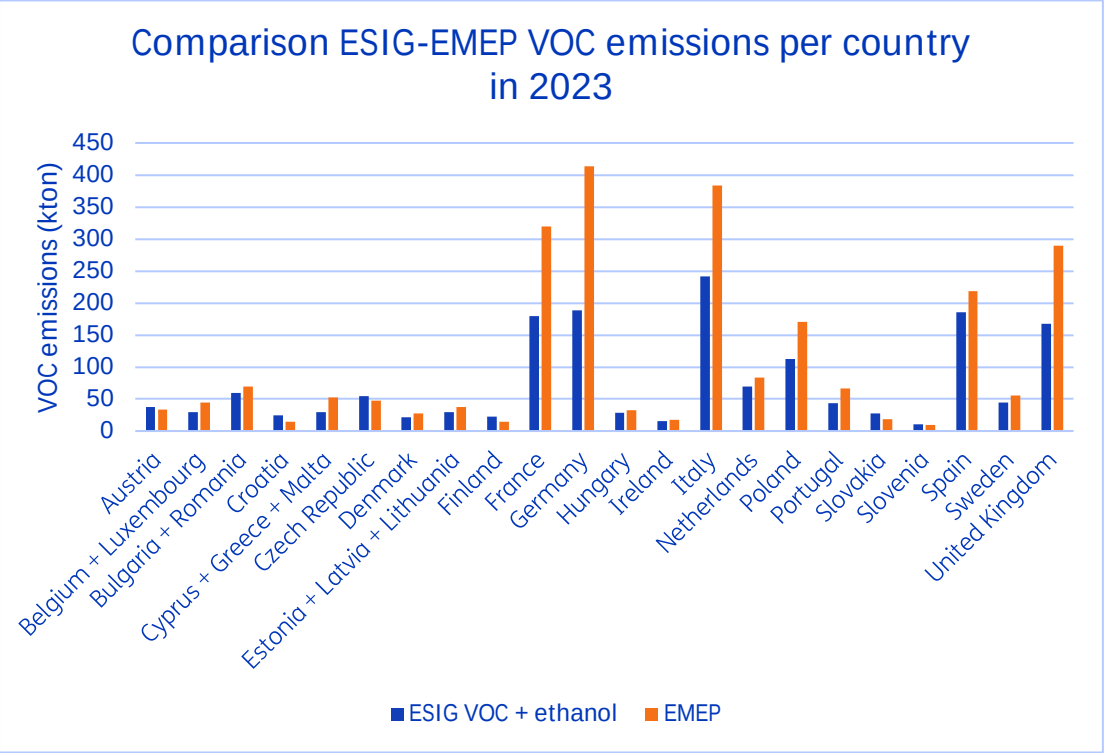

Figure 3.2: Comparison between total VOC emissions in kton from the ESIG VOC inventory (including ethanol use) and officially reported emissions of VOC (EMEP) per country (or countries group) for 2023

4 Conclusions and recommendations

This report presents an updated inventory of VOC emissions from substances used in a solvent application, based on sales information supplied by the European Solvents Industry Group (ESIG). The inventory covers the period from 2013 to 2024, with the exception of 2014 for which data are unavailable, and includes all 27 EU Member States as well as the United Kingdom. The dataset provides information on solvent distribution by country and across REACH end-use sectors. Although the inventory does not account for imports or exports outside the EU, it incorporates estimates of intra-EU trade developed from earlier ESIG inventories and expert judgement. Ethanol, which is not provided through ESIG member reporting since ethanol producers are not part of ESIG, is nevertheless included due to its relevance. Usage estimates are derived from data supplied by the European Renewable Ethanol Association (ePure). Emissions are calculated using sector-specific factors linked to REACH end-use classifications.

Overall, the inventory offers a consistent framework for estimating solvent-related VOC emissions across the EU27 plus the UK, based on data for substances produced and marketed for use as solvents within these regions. Nevertheless, the voluntary nature of the data submission process and the structure of reporting under the REACH Directive create the possibility of gaps or inconsistencies. In addition, the free movement of goods within the European market means that VOC emissions may occur in countries other than where the solvents were originally sold. While intra-EU trade estimates rely on proxy information and expert assessment, this remains a key source of uncertainty, particularly at the level of individual countries. Uncertainty was likely greater in 2020 and 2021 due to the sharp increase in ethanol use in disinfectants during the COVID-19 pandemic, which was difficult to quantify precisely. These factors should be considered when interpreting country-level results.

Key recommendations

1. **Consistency and transparency in data collection and methodology:** Strengthening consistency across the timeseries is essential. This includes harmonising data sources, defining solvent uses clearly, and applying a uniform methodology. Equally important is improving transparency through comprehensive documentation of data sources, assumptions, and methodological choices. Clearer record-keeping will enhance data quality, support verification, and increase confidence in the inventory, while also facilitating engagement with stakeholders.

2. **Methodological improvements:** Although the inventory has undergone several refinements in recent years, further enhancements would improve its robustness and usefulness, particularly in the following areas:

    2.1. **Emission factors:** The emission factors used for each end-use sector are based on earlier work (Pearson, 2019). Technological developments, changes in product

formulations and shifts in industrial practices may have altered the characteristics of solvent emissions since these factors were originally established. A review of the emission factors, supported by updated research and stakeholder input, would help ensure that they continue to reflect current conditions.

2.2. **Intra-EU trade estimates:** Current estimates rely heavily on expert judgement. Future improvements could draw on more detailed macroeconomic or sector-level data to develop more reliable proxies. However, access to such data is limited and may be costly, presenting a practical challenge.

2.3. **Ethanol production and imports:** Ethanol-related emission estimates depend on proxy information and assumptions regarding the proportion of industrial imports used as solvents. Collaboration with industry organisations such as ePure may enable more refined methodologies. Alternative datasets, such as Eurostat information on ethanol-based fuels, could support improved separation of industrial ethanol use from other applications, allowing for more precise emission estimates.

2.4. **Extra-EU trade estimates:** The ESIG VOC inventory currently assumes minor imports or exports of solvents into or out of the EU, reflecting the lack of comprehensive solvent trade statistics. Given changing market conditions, revisiting this assumption is recommended. A structured method for estimating extra-EU trade could be developed using economic proxies similar to those proposed for intra-EU trade, helping to capture relevant market shifts and improve accuracy.

3. **Expansion of the scope of the inventory:** Future updates should consider extending coverage to additional solvents beyond ethanol, particularly methanol, which is an important VOC-emitting substance. This could involve obtaining methanol sales data directly from ESIG members where possible or creating a dedicated methodology to integrate methanol emissions in a manner consistent with the approach used for ethanol. Any extension of scope would require careful evaluation of implications for end-use sector definitions and potential adjustments to the emission factor framework to preserve accuracy and relevance.

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