ES-VOC-CG
EUROPEAN SOLVENTS VOC CO-ORDINATION GROUP
A CROSS-SECTOR INDUSTRY VOICE

THE OZONE CHALLENGE

ESIG - ES-VOC-CG
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SUMMARY

Background:
Tropospheric ozone (ground-level ozone) is a powerful irritant formed by atmospheric photochemical reactions of hydrocarbon volatile organic compounds (VOCs) and nitrogen oxides (NO_x). Ground-level ozone reduction is being addressed by national and European legislations, such as the Ozone Directive and the National Emissions Ceiling Directive. Member states are also active reducing ozone through the Solvent Emissions Directive and the Paint Product Directive.

Industry challenge:
Industry has played a great part in reducing both NO_x and VOCs with the advent of the three-way catalyst system in gasoline engine technology, the reduction of sulphur in fuels and the reduction of VOCs from solvents.
It remains to evaluate the contribution from the solvents business on the ground-level ozone reduction over the past 18 years and the efficiency of a further reduction of VOCs from paints to continue improving ground-level ozone.
The European Solvents Industry Group (ESIG) has initiated technical work under ES-VOC-CG to answer these questions.

Ozone Modelling Study:
The independent Harwell Trajectory Model has been used in collaboration with Professor Richard Derwent to evaluate the ground-level ozone trend over the period 1990 - 2008.

ES-VOC-CG position:
The study has shown that the Solvents Emissions Directive has been successful in reducing the ground-level ozone up to 7.9 ppb. The solvents business has played its full part in reducing emissions in line with the Solvents Emissions Directive.

Over the period 1990-2005, decorative paints have contributed to a 0.9 ppb ground-level ozone reduction. This reduction, which is within ozone measurement precision, includes the early stages of the 2004 Paints & Varnishes Product Directive. A complete elimination of solvents from decorative paints would only result in an extra 0.2 ppb ground-level ozone reduction, which is minimal.

ES-VOC-CG members believe that elimination of *any further* VOC from decorative paints will only lead to extremely small reductions in ground-level ozone which are impossible to measure and impose unnecessary costs on the industry. The onus is now on the EU27 to reduce their NO_x ceilings in line with the 2010 National Emissions Ceiling Directive in order to achieve further reductions in ground-level ozone by 2010.

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REPORT

Introduction

Ground-level ozone is formed by the atmospheric chemical reactions of hydrocarbon volatile organic compounds (VOCs) and nitrogen oxides (NO_x) in the presence of sunlight in spring and summer months. In the summers of 1989 and 1990, Europe experienced very hot long periods and the ozone levels led to concerns to public health, particularly to those suffering from asthma. Ozone is a powerful irritant, which causes inflammation of the lung passages and there is evidence to show that long-term exposure can cause a chronic decline in breathing.

Industry has played a great part in reducing both NO_x and VOCs, with the advent of the three-way catalyst system in gasoline engine technology, the reduction of sulphur in both gasoline and diesel fuels, and the reduction of VOCs from solvents.

The European Union and the United Nations Economic Commission for Europe have both tackled the ozone problem through legislation, the two most important being the Ozone Directive (1) and the National Emissions Ceilings Directive (2). In addition to national legislations, Member States intend to reduce ground-level ozone through two main directives specific to the solvents sector. There are the Solvent Emissions Directive 1999/13/EC (3) and the Paint & Varnishes Directive 2004/42/EC (4).

The European Solvents Industry Group (ESIG) has set up a technical team to examine air quality and global warming issues related to the solvents business. This team works with the European solvents sectors Coordination group (ESVOC-CG) and so communicates the position of the solvents industry on key air quality issues related to VOCs.

This position paper explains the effectiveness of the Solvent Emissions Directive ("SED") and why further restrictions under the 2004/42/EC Directive ("Paints Directive") will not contribute to a significant further ground-level ozone reduction in Europe.

Objectives of this study

The questions the solvents business has addressed in this position paper are:

- What has been achieved in ground-level ozone reduction since 1990 by the solvents business?
- Would a further reduction in VOCs from paints lead to a reduction in ground-level ozone?

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Ozone Measurements in Europe

One way of checking on ground-level ozone levels in Europe over the past 15 years from 1990 would be to examine the measured trends, and recent work by the European Topic Centre on Air Quality (5) has concluded that there is no clear evidence that European ozone is in decline. The main reasons for this conclusion are the variability in the meteorology over the period and the unsuitability of some of the measurement sites. Indeed, of the 2000 sites considered, only 585 were considered to satisfy the criteria as coverage of hourly values, length of time in operation, and quality. The report also added that the regions with highest ozone levels (Southern and Mediterranean Europe) have benefited most from road transport policies which have reduced both VOCs and NO_x, whereas the solvent reduction policy which reduced VOCs has had a benefit over each part of Europe.

Some measured data is reliable over the last two decades. As an example, ozone measurements from two rural sites in the UK, Harwell and Aston Hill, show a significant downward trend from 1990 to 2007. This is despite the exceptional summers of 2003 and 2006 and shows that ground level ozone control is effective.

However, one sure way of assessing trends in ground-level ozone levels is to examine the results of Ozone Modelling, which has the advantage of smoothing out the effects of meteorology and assessing the effects of declining NO_x and VOC emissions over the period considered.

Ozone Modelling using the Harwell Trajectory Model

Previous modelling work commissioned by the European Solvents Industry Group (ESIG) is reported in Annex-1. In any modelling study it is important to note that intercontinental air pollution has a large impact on European air quality as described in Annex-2. The outcome of this work shows that there is no further need to reduce VOCs from European solvents to meet ground-level ozone and carbon dioxide targets in 2020.

The European Solvents Industry Group has been working closely with Professor Richard Derwent in using the Harwell Trajectory Model for ground-level ozone in determining the progress made by the Solvents Industry in reducing ground-level ozone over the past 18 years from 1990 to 2008.

The Model is detailed in Annex-3 and represents European ground-level ozone trends over the period 1990-2008 in line with VOCs and NO_x emissions reductions, and can identify the contribution to ground-level ozone reduction from the solvents business.

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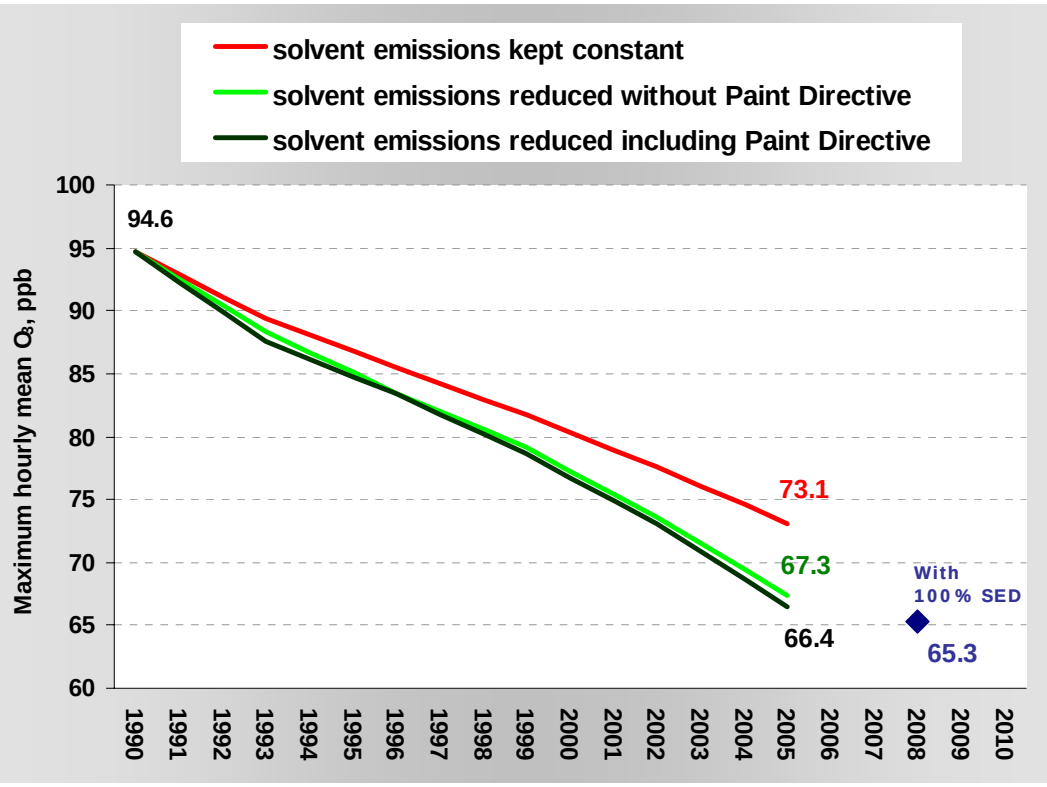
Calculated Ground-level ozone Levels using the Harwell Model

FIGURE-1: Predicted ground-level ozone levels using the Harwell Trajectory Model



The red and black lines in FIGURE-1 show the predicted maximum hourly means for ozone over the period 1990 to 2005, without and with solvent emissions reduction.
Episodic peak ground-level ozone levels estimated using the Harwell Model showed a similar trend over the 1990 - 2005 period compared with the observations from the rural ground-level ozone monitoring sites at Harwell and Aston Hill. This shows that the model and hence the emission inventories reflect well VOC and ground-level ozone trends.

The Effectiveness of the Solvents Emissions Directive

The difference between the model runs with the red and black lines in FIGURE-1 is only the assumptions about VOC emissions from solvents. In the black case, solvent emissions were reduced whereas in the red case, they were held constant at the 1990 levels.

Peak ground-level ozone levels declined from 94.6 ppb to 66.4 ppb between 1990 and 2005 in the Harwell model calculations as seen in the black line. Without any action on solvent emissions, peak ground-level ozone levels would have declined from 94.6 to 73.1 ppb as seen in the red line. The contribution from solvent emission reductions has

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therefore been a substantial 6.7 ppb out of the total decline of about 28.2 ppb, that is to say a substantial contribution of 24%. Not all of this can be attributed to the Solvents Emissions Directive of course because there have been other changes to solvent emissions over that period. Nevertheless, it has been clearly shown that the Solvents Emissions Directive is playing a full part in reducing ground-level ozone.

The solvents industry estimates that some 80 to 90% of solvents reductions as planned in the Solvents Emissions Directive had been applied by 2005 and consequently a further 15% reduction in solvents would be applied by 2008 in order to achieve the full Solvents Emissions Directive. This would lead to a further reduction of ground-level ozone to 65.3 ppb (dark blue diamond in FIGURE-1) meaning that the full effect of reduction in solvent VOCs from 1990 to 2008 has reduced UK ground-level ozone by a total 7.9 ppb.

This result shows that the solvents business has made a substantial contribution to the reduction of ground-level ozone and the Solvents Emissions Directive has had a significant impact on the improvement of ozone air quality. A similar conclusion was made using the independent ozone models by INERIS and TNO in 2006 (Annex-1), which showed the early success of the Solvents Emissions Directive.

Paints Directive

The green line in FIGURE-1 shows the predicted ground-level ozone levels without any changes to decorative paints over the period 1990 to 2005. The difference between the green and the black lines in 2005 of 0.9 ppb represents the changes made in decorative paints over the full period 1990-2005 including the beginning of the product paints directive in 2004 (4).
This predicted contribution to ground-level ozone reduction from paints is very small compared to the predicted total reduction from solvents.
Indeed, 0.9 ppb is within the precision of measured ozone values.

A final sensitivity case was run for 2005 in which there were no emissions at all from decorative paint usage, both trade and retail. This is the "no decorative paint emissions" case. The final predicted ground-level ozone concentration was 65.3 ppb compared with a predicted 66.4 ppb in the base case, so a further reduction of 0.2 ppb bringing the total reduction to 1.1 ppb from 1990.

This illustrates that *any* further reductions in VOCs from paints can only lead to extremely small reductions in ground-level ozone which are impossible to measure – hardly cost effective!

NO_x Reduction

Up to half of the current EU Member States are struggling to meet their NO_x reductions in line with the current NECD and Gothenburg Protocol for 2010. It is critical for future ground-level ozone control that both VOC and NO_x reductions as laid down by the NECD and Gothenburg Protocol are met.

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FIGURE-1 illustrates that ozone targets are being met by member states. This is the result of greater reductions in VOCs essentially due to reduced emissions from road transport and from the Solvents Emissions Directive. Just as the solvents business has worked well in respecting the Solvents Emissions Directive, so also must the EU27 address their commitments in respecting the National Emissions Ceiling Directive by meeting their NO_x ceilings for 2010 resulting in lower ground-level ozone levels.

Conclusion

The independent modelling work described in this paper shows that the Solvents Emissions Directive has been successful in reducing ground-level ozone (up to 7.9 ppb reduction) in the UK. Given the European nature of the Harwell Model and the emissions inventories used (EMEP[1] and NETCEN[2]), these same reductions can be assumed to apply across Europe.
It should be noted that this study reinforces the conclusions of the two previous independent modelling works in 2006 of INERIS and TNO that demonstrated the early success of the Solvents Directive in improving ground-level ozone.

Decorative paints have contributed to a 0.9 ppb ground-level ozone reduction over the period 1990-2005 which includes the early stages of the Paints & Varnishes Product Directive of 2004. This reduction is within the ozone measurement precision.
Moreover, a complete elimination of solvents from decorative paints would only result in a predicted further ground-level ozone reduction of 0.2 ppb, which is minimal.
ES-VOC-CG members believe that the 2010 VOC ceilings for paints and varnishes in the Product Directive (2004/42/EC) represent the practical limit of what is technically feasible without compromising quality and choice across the EU.
Further elimination of *any* VOCs from decorative paints will only lead to extremely small reductions in ground-level ozone which are impossible to measure and impose unnecessary costs on the Industry.

Given that almost all member states have reduced their VOCs levels in line with the NEC Directive and the solvents business has played its full part in reducing emissions in line with the Solvents Emissions Directive, the onus is now upon the EU27 to reduce their NO_x ceilings in order to achieve further reductions in ground-level ozone by 2010.

Acknowledgement
The European Solvents Industry Group would like to thank Professor Richard Derwent for carrying out the computer runs related to the Harwell Trajectory Model and his invaluable comments on European Air Quality.

[1]EMEP = European Model & Evaluation Program
[2]NETCEN = National Environmental Technology CENtre

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REFERENCES

(1) Directive (2002/3/EC) relating to ozone in ambient air.
(2) Directive 2001/81/EC on national emissions ceilings for certain atmospheric pollutants.
(3) Council Directive (1999/13/EC) on the limitation of emissions of volatile organic compounds to the use of organic solvents in certain activities and installations
(4) Directive 2004/42/EC on the limitations of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products
(5) European Topic Centre on Air Quality, NILU, "Assessment of Tropospheric Ozone" 25th June 2008

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ANNEXES

Annex-1: CHIMERE & LOTOS EUROS Models

In 2006, ESIG (European Solvents Industry Group) commissioned two model runs and examined the results of a third independent model (Harwell Trajectory model by Derwent), to project ground-level ozone following certain VOC regulatory measures.
These two models were:

- the Chimere Model developed by L'Institut National de l'Environnement Industriel et des Risques (INERIS) and used in French Government scenarios, and
- the LOTOSEUROS Model developed by Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek (TNO) in the Netherlands.

The results showed that any additional reductions in VOCs from solvents which were technically feasible will deliver minor improvements on ground-level ozone levels (< 1% reduction).
Furthermore, removing all solvent emissions (a non-realistic scenario) would have an average reduction on ground-level ozone of only 5%.
This work also showed that the Solvents Emissions Directive was proving successful.
In some urban areas with high NO_x levels, the reduction could be higher, but in some remote areas, hardly noticeable at all. Real effects on ground-level ozone are also closely linked to NO_x reduction.

Annex-2: Trans-boundary Air Pollution

Trans-boundary air pollution has a huge impact on air quality in Europe, particularly from other regions in the Northern hemisphere. Asia in particular contributes to ground-level ozone in Europe which has been estimated to increase by some 3 ppb by 2010 using modelling work done by the International Institute for Applied Systems Analysis (IIASA). "Solutions" reported in 2005 (6) that background ozone seemed to be increasing at the rate of 0.5 ppb per annum due to non-European emissions.

Most recent work (2007) by the International Institute for Applied Systems Analysis (IIASA) using the Greenhouse gases and Air pollution Interaction and Synergies (GAINS) model, which combines the effects of global warming and air pollution, indicates that European ground-level ozone and global warming can only be reduced by further controls on European NO_x and carbon dioxide over the next 12 years to 2020. This will put pressure on combustion processes and heavy diesel transportation in the future.
The work also concluded that there was no further need to reduce VOCs from Solvents to meet ground-level ozone and carbon dioxide targets in 2020.

(6) Solutions, ESIG, Issue 14 / June 2005 - http://www.esig.org

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Annex-3: The Harwell Photochemical Trajectory Model

The computer runs used real meteorological data provided by the Met Office for the year 1999 and 5-day back trajectories. The meteorology and speciation were held constant and runs were carried out using VOC, NO_x, SO_2, CO, isoprene and CH_4 emissions from the NAEI and EMEP for each year between 1990 and 2005. Emissions for 2010 were taken from the NEC and Gothenburg Protocol base cases from EMEP.
As such, the model is using European Emissions Inventories. over the period 1990-2008 in line with VOC and NO_x emissions reductions and can identify the contribution to ground-level ozone reduction from the solvents business.

Such a model has several advantages viz:

- The trajectory begins in Austria passing over Europe and ground-level ozone is formed along its path before reaching the UK five days later,
- The model used has adopted the 1999 meteorology, thus smoothing out the annual effects of weather patterns over the 1990-2008 period,
- It has been the model on which UK Ozone Policy is based,
- It has been tested against reliable ozone measurements in the UK,
- The European solvents composition is very similar to that of the UK,
- The emissions inventories used (EMEP for Europe) and NETCEN for the UK are well proven and respected.

[1]EMEP = European Model & Evaluation Program
[2]NETCEN = National Environmental Technology CENtre

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