THE AIR QUALITY CHALLENGE IN CHINA and ASIA

SUMMARY

Global Warming as measured by increasing carbon dioxide levels is a major issue in China, and current air quality levels due to Particulates (PM2.5), Sulphur Dioxide and Nitrogen Oxides are causing serious health problems in China. In September 2016, China announced that it will ratify the Paris Climate Change agreement and so help reduce Global Warming in the long term. This means a major investment on moving away from coal combustion. Indeed, on January 5th, 2017 (UK Press Statement January 3rd, 2017), the Chinese government announced a 400billion€ investment on clean energy generation by 2020. Coal combustion and vehicle emissions will remain under the spotlight over the next decade in China.

The Chinese authorities are likely to base their own Air Quality legislation on the EU approach, yet each industry sector may well be separately controlled as detailed emissions inventories are developed.

The Air Quality problems in Asia are the same as in China with very high levels of PM2.5 and NOx but there is less concern about SO2 emissions.

The objective of this technical Position Paper is to propose a way forward in improving (primarily Chinese) Air Quality by highlighting the need for accurate emissions inventories and air quality modelling. In particular, the European Solvents Industry Group (ESIG) has a wealth of experience to offer in reducing ozone in Europe and is ready to share this experience. This experience can be used to help China and Asia to alleviate their Air Quality problems.

Our recommendations for China and Asian Air Quality challenges are based on a four step approach used in Europe:

- Detailed emissions inventories have been established in each city and each country by careful measurement and monitoring of the major pollutants including Sulphur Dioxide, Nitrogen Oxides, both man-made and biogenic VOCs, Particulates (PM2.5) and Ammonia.
- A multipollutant economic model - initially the RAINS model and then the GAINS model to include Carbon Dioxide - has been used to predict the most cost-effective way forward in reducing emissions in each country.
- The European Commission, liaising with industry and scientific establishments, has proposed Air Quality Directives based on GAINS, which call for reduction of all air pollutants on a country by country basis.
- By careful monitoring of all pollutants, the European Commission continually reassesses progress in improving Air Quality in each EU country and city.

Success will be achieved more easily if legislation is harmonized for China and Asia.

For Solvent VOC reductions, the same definition of Solvent-the IPCC definition - "*A solvent is a volatile organic compound where the vapour pressure is 0.01kPa or more at 293.15K or having a corresponding volatility under the particular conditions of use*" - should be used in China and Asia.

Control of air pollution from individual plants rather than products will be more effective.

INTRODUCTION

China, with a population of 1.5 Billion people, is the world`s largest economy.

It is now accepted that Global Warming is the real challenge worldwide, and governments are looking to improve Air Quality and reduce Global Warming.

China is no exception with the Chinese President Xi Jinping being proactive on environmental protection, scientific innovation and health indicators. The Chinese are concerned about human health and are working to reduce pollution dramatically.

Global Warming is being tackled world-wide with emphasis on reducing carbon dioxide as detailed in the Paris Climate Change Agreement of 2016. For China, the emphasis is now to reduce dependence on coal-fired power stations which had been increasing very rapidly. China has installed on-line Sulphur Dioxide detectors in power stations with NOx detectors. The most recent measure is the pledge made in January 2017 by the Chinese Government to invest 400Billion€ by 2020 on clean energy generation (UK Press Statement January 3rd 2017).

The Air Quality challenges in China are the reduction of Sulphur Dioxide, Particulates (PM2.5), Nitrogen Oxides and VOCs where the latter two contribute to ozone formation. There is a massive cocktail of pollutants in Chinese cities reminiscent of major European cities in the 1950s.

One accepted concern is the enormous number of motor vehicles in Chinese cities and in January 2017 alone, there was a 200mile plume of smog in Beijing due to traffic queues and smoke from coal combustion.

The Ministry of Environment Protection announced new Regional Air Quality Regulations in 2010. These Regulations are now in force and affect all cities and industries. The pollutants to be controlled include Sulphur Dioxide, Nitrogen Oxides, PM2.5, and VOCs. The Ministry of Environmental Protection is proactive currently measuring levels of pollution in 86 cities on a daily basis. an Air Pollution Index has also been established where ozone is also included.

The purpose of this Position Paper is to provide suggestions on how to examine the challenge of Air Pollution in China and Asia and generate ideas for improvement. It is important to learn from European experience in reducing Air Pollution, and the European Solvents Industry Group (ESIG) is willing to share the initiatives we have taken over the past two decades to reduce ozone.

COAL BURNING IN CHINA

(Global Warming as Carbon Dioxide, Sulphur Dioxide, PM2.5 & Nitrogen Oxides)

The principal problem has been the use of coal of poor quality, high in sulphur content, for electricity generation in power stations. Although use of coal for cooking and heating is in decline, China still relies on low- cost home- produced coal. Coal usage, at over 3 billion tonnes / annum, represents nearly 75% of all energy consumption.

Certain types of poor coal quality are now banned, with Sulphur Dioxide and Nitrogen Oxides in slow decline.

Power generation from other means is being encouraged including hydroelectricity, solar power and nuclear energy with the plan to generate 30% of all electricity by non-coal combustion in 2020. This will be the most effective way of reducing Carbon Dioxide levels and so eventually reduce Global Warming.

In addition, cleaner coal is being used in cities and power plants which have desulphurization facilities. Older plants which are inefficient and over-polluting are being phased out.

From the early 2000s, China began replacing coal by gas for domestic heating, and each city has had to publish an air pollution index.

In Beijing, (PM2.5) and NOx are now the major pollutants. Indeed, PM2.5 pollution is the most intense in the smaller cities near Beijing. Photochemical smog is now almost a daily occurrence in Beijing and Shanghai.

VEHICLE EMISSIONS

(Global Warming (CO_2), Nitrogen Oxides, and VOCs)

The rapid increase in motor vehicles in China over the last twenty years is now causing real concern, with vehicles now exceeding 250 Million and increasing by 20Million annually. The Chinese Government is now imposing Euro norms on vehicles to reduce emissions which account for at least 25% of Nitrogen Oxides in China as a whole and make a large contribution to Carbon Dioxide. Government officials are encouraging the use of natural gas to minimize the pollutant cocktails from coal combustion pollutants and vehicles.

Cities will have to restrict gasoline and diesel vehicles-possibly using hybrid or electric vehicles. It is interesting to observe the increased use of bicycles again as cities become grid-locked.

It is important to note that China follows EU legislation closely as seen from new car pollution regulations where new vehicles built in China need to conform to the very latest EU Norms (EURO VI and beyond).

SOLVENTS AND PAINTS (VOCs)

China is the largest consumer of solvents world-wide, increasing at a rate of 5-6% annually. The challenge of VOC emission control is putting the spotlight on paints, expected to grow to almost 22 Million tons in 2020, and industrial processes related to solvent manufacture are increasing in China.

Research work by Chinese scientists (1,2) working with the International Institute for Applied Systems Analysis (IIASA) highlights a VOC Inventory for all man-made VOCs in China, and, this further illustrates that China is exploring more detailed VOC controls. The GAINS Model for China is being used by Chinese Institutions with IIASA staff assisting when required. Other Integrated Assessment Models are being developed by Chinese scientists. The scientific approach in China is a major factor in the process as is the study of existing European legislation.

VOCs combine with NOx to form ozone in sunlight, and it is in ozone control where the European Solvents Industry Group has taken a lead. In 1999, the Solvents Emissions Directive was introduced after close cooperation with legislators in the European Commission, scientific bodies such as IIASA, and also ESIG. Emissions limits were applied to solvent plants and installations. This Directive called for a 67% reduction in solvent VOCs by 2008 which has been achieved (3). The end result has been a small reduction in European Ozone as quantified in an ESIG Position Paper published in 2009 (4).

It is important to appreciate that industry, scientific establishments and legislators must work closely together to achieve real success in improving Air Quality.

The alternative approach by governments imposing Product Directives on industry does not bear fruit. The case of the Product Directive introduced in 2004 (6) (for Decorative Paints and Vehicle Refinishing Products), imposing water-based paints on the European Paint Industry, has been shown to have had no real impact on European Ozone (5).

The technical experience contained in the 2009 ESIG Position Paper on Solvent VOC Emissions Controls (4) can be applied to improve ozone values in China and Asia.

It is critical to have a harmonized framework of legislation as in Europe rather than individual controls in each canton in China and each country in ASIA. Furthermore, it is important to use the same definition of Solvents-the IPPC (Intergovernmental Panel on Climate Change) definition: *"A volatile organic compound is any organic compound having at 293.15k a vapour pressure of 0.01kPa or more, or having a corresponding volatility under the particular conditions of use."*

This definition, as used in the EU Industrial Emissions Directive, provides clarity and a solid scientific basis for regulating emissions from Solvents.

OTHER COUNTRIES IN ASIA

MALAYSIA and THAILAND

These countries are affected by forest fires. However, PM2.5 and Ozone remain the major challenges in terms of Air Quality. Again control of vehicle emissions is encouraged.

SINGAPORE

A major problem is haze from Indonesia.

INDIA

Major Air Quality problems are Sulphur Dioxide, NOx and PM2.5. Residential combustion of biomass and vehicle pollution are the important issues, and the cocktail of pollutants is reminiscent of the London Smog in the 1950s.

THE WAY FORWARD

Global Warming

Reduction of Carbon Dioxide is a first priority when undertaking to reduce Global Warming. This can only be achieved by improved coal combustion processes and investment in cleaner energy generation, as well as traffic control, which China is already tackling.

Improved Air Quality

Emissions Inventories

Given that the Air Quality problems in China and Asia are the high levels of PM2.5, Sulphur dioxide (particularly in China and India), and NOx, the first step could be to generate a detailed emissions inventory for each city and region in each country. Once this has been achieved, air pollution can be tackled systematically by reducing each major pollutant in turn. This has been the European approach which has proven successful.

For major point sources, these emissions can be calculated using the formula:

Emissions=Emissions Factor x Activity Level x Control Factor

For coal-fuelled power stations, Sulphur Dioxide can easily be calculated and a control factor estimated based on new technologies and cleaner coal.

There are detailed European Inventories (3) such as CORINAIR which give information on each type of point source including airports, paper pulp production plants, and refineries.

For mobile sources, this same equation can be used for each type of vehicle where the emissions factor is in g/km, the activity level would be a distance factor and the control factor would be the efficiency of the emissions control system. The emissions factor is directly related to the Euro Norm that the vehicle has passed in manufacture. Knowledge of the vehicle distribution then enables the total vehicle emissions to be calculated for each city and region.

This detailed breakdown of emissions for each sector will provide a means of monitoring emissions reductions in each sector and, importantly, provide detailed emissions input data for Air Quality Models.

Air Quality Modelling and the GAINS Integrated Assessment Model

Once accurate emissions inventories are established, the next phase is to use an Air Quality Model to determine the most economic strategy for reducing Air Pollution in each city and region of each country. There is no point in trying to reduce all emissions at once. A sensible strategy is to identify the most severe air pollution problem and then determine the most cost effective way of dealing with the problem.

The GAINS Model (7) developed by IIASA has a proven success record, having been used in Europe for over 20 years. GAINS is an Integrated Assessment Model which examines multiple effects such as Global Warming, Acidification, Eutrophication, PM2.5 and ozone formation. Importantly, the relative costs of different emissions control strategies are calculated giving legislators and industry a clear cost effective way of reducing Global Warming and improving Air Quality. The most recent publication “Towards Cleaner Air” published in mid- 2016 by UNECE (8) illustrates how Air Quality has improved in Europe over the past 25 years and lists the remaining challenges as PM2.5 and NOx reduction. The GAINS Model is a major success story in Europe.

GAINS is already being used to predict how PM2.5 can best be reduced in China and Asia.

As soon as PM2.5 is reduced, attention will turn towards ozone reduction in China and Asia, and it is here where ESIG has made significant contributions in Europe by VOC control. A proactive approach to develop Solvent VOC Inventories (9) has served the EU well and this expertise can also be adapted to China and Asia in the years to come. However, ESIG observes that several definitions of “solvent” are being used in China and Asia. This not only leads to confusion, but causes the Solvents Businesses extra cost as they adapt their products to new regulations.

ESIG recommends the IPPC definition of Solvent be adopted in all regions of China and Asia. It is critical to have harmonized legislation as in the European Union.

Different controls in each canton in China and each Asia country will damage the seed corn of Industry. As already mentioned, the most effective controls should be applied to Installations, and not Products, and it is here that the European Solvents Industry can help and ensure we play our part in improving Ozone in Asia and China.

Working together, industry, good science (GAINS) and legislators provide the key to success in reducing Global Warming and improving Air Quality in China and Asia.

REFERENCES

1. Klimont, Z. et al "Anthropogenic Emissions of non-methane VOCs in China" Atmos. Env. 36 (2002) 1309-1322
2. Wei et al "Emission and Speciation of non-methane VOCs from Anthropogenic Sources In China" Atmos Env. 42 (2008) pp 4976-4988
3. Pearson, J.K. "Improving Air Quality" SAE ISBN 0-7680-0236-2 2001
4. Solvents Emissions Directive 1999/13/EC which was taken up in the Industrial Emissions Directive (2010/75/EC) and integrated with the IPPC (Industrial Pollution Prevention Directive).
5. ESIG Position Paper: The Ozone Challenge, 2009
6. Directive 2004/42/EC dealing with Decorative Paints and Vehicle Refinishing
7. Amann, M. "Final Policy Scenarios of the EU Clean Air Policy Package" IIASA TSAP Report #11 2014
8. Maas, R. and Grennfelt, P. "Towards Cleaner Air "UNECE 2016
9. ESIG Position Paper: Solvent VOC Emissions Inventories Position Paper, 2015

John Pearson, Jose Antonio Ruiz, and Luc Turkenburg. April 2017