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SUMMARY

The AirINFORM project focusses on improving air quality (AQ) information for the sake of communication and governance. The key pieces of legislation considered during the project were:

1. The “12th Five-Year Plan on Air Pollution Control in Key Regions” clause which obliges the most polluted regions to set up heavy pollution weather “Monitoring, Early Warning and Emergency Response Systems” and publish timely information on the air quality (AQ). Later this was included in the 2013 Air Pollution Prevention and Control Action Plan of the State Council (article no.’s 23, 29, 30, 31).


3. And to a lesser extent the general 2013 Air Pollution Prevention and Control Action Plan of the State Council, which puts the pilot cities under huge pressure to reduce their emissions significantly and demonstrate the impact using air quality modelling tools.

The recommendations provided are based on project experiences in the three partner cities Urumqi, Yangzhou and Taiyuan and general exchanges with the Environmental Governance Programme (EGP) component 2 team and the EGP-National Party Congress workshop on the 16th April 2014. The recommendations are split into two key areas (1), AQ Communication including use of the Air Quality Index and (2), using AQ models to provide AQ information. First some general observations are made.

General

Make policy more specific with current and future targets sharply defined, setting uniform standards across the country.

Provide support/guidance on policy implementation. Air quality is a very complex domain. Actions on individual policy aspects are not likely to be effective. Provide guidance on the context and the interrelatedness of various policies and actions and assure that the full depth of the issues at stake is understood at the implementation level.

Define what is Best Available Technology (BAT) across the country and set emission ceilings for provinces and monitor annual progress.

Provide capacity building by organising exchange mechanisms. This could involve foreign expertise but there is also ample scope to learn from each other/from more advanced cities/regions within China.

Communication

Do not regard communication as a simple supply of information (because it is in the legislation) but use it as a part of air quality management, as a support to achieve common goals. Ask yourself what you want to achieve with information/communication and verify if the approach you have chosen will achieve just that. The internet is full with information: are you sure that what you are adding is being found, being understood and being believed?
If the (local) government wants to be considered an authoritative source of information it should *market* its information attractively, persuasively and aggressively by being easier to understand, more complete, more correct, etc. than other information suppliers. To assure that government becomes the preferred source of information and a credible partner in *dialogue* the best possible communication techniques should be used.

*Engage (local) communication specialists* or even (private sector) marketing experts to make yourself heard and understood. Consider associating NGO-s or other non-government parties to assure part of the communication. They may be more experienced in certain niches or be considered a better information source by some of the target groups.

Air quality communication efforts are often (not only in China) technology driven but sometimes with too much attention given to the high technological aspect of the information supply chain. It is as equally important to reach out to those people who are not yet aware or able to avail of this media, using *additional communication channels* (radio, TV, newspapers, brochures, June 5th Environment day, etc.) and providing simple but relevant information to raise awareness.

In many EU countries and elsewhere there is *open access to environmental information*. Information is audited (procedures vary from country to country) to assure its reliability. There is an active civil society using this information to further inform the public, assist them in using the information and act (as a government counterpart) in the governance process.

In China, for the time being, *NGO’s and others need to be encouraged to use the information that is available and to contribute to the development of a civil society* that can act as a government counterpart. The Ministry of Environment Protection’s (MEP) department of Education and Communications should play a role in this and increase and improve government air quality communication. It should provide support (training on communication skills, ready-made material and campaigns, etc.) to local government technicians on communication issues.

In general the *AQI daily calculation grid* is suitable given the current level of air pollution. However some improvements can and should be made. On the calculation grid:

- The grids for PM\(_{10}\) and PM\(_{2.5}\) should become mutually consistent. This has various operational advantages and if PM\(_{2.5}\) is adjusted to PM\(_{10}\) it will not change the overall AQI level.

- After this is done proper PM\(_{10}\) and PM\(_{2.5}\) hourly calculation grids should be developed. The current practice of measuring PM hourly concentrations against a daily average grid sometimes produces very high hourly AQI values that are not reflected in the official daily AQI report. From a communication point of view this is very awkward. From a calculation point of view measuring hourly concentrations against a daily average grid produces biased results (mainly AQI-s that are too high).

Further tweaks to the hourly calculation grid can be made for NO\(_2\) and O\(_3\), *but it is very important to make a good PM hourly grid*. On the communication messages associated to the AQI: we suggest to revise and improve them. Especially the recommendations to stay indoors could be reconsidered as they don’t seem very practical and appropriate.
It is desirable that enterprises report their emissions in a uniform way across the country and not just total emissions but also emission per unit of output. If this kind of emission information is published some kind of auditing to assure correctness is necessary. Credible and detailed emission data is also necessary for modelling (see next section) and without them it is virtually impossible to implement and monitor the emission control policies (e.g. article 44 of the Environmental Protection Law).

**Air Quality Information Using Modelling**

The Monitoring and Early Warning parts of the “Monitoring, Early Warning and Emergency Response Systems” are generally referred to as the monitoring and forecasting parts of AQ management. Air quality models are a core component of these systems. According to the European Air Quality Directives (AQD) the use of modelling tools is promoted across the whole spectrum of AQ management from monitoring, to forecasting, to assessment and planning. During the AirINFORM project a newly developed AQ monitoring and forecasting system was established for Yangzhou. Alongside the implementation, the use of AQ models to measure the impact of air quality plans as required in the 2013 Air Pollution Control Action Plan was discussed. Based on these aspects the following policy recommendations are made:

- Currently in many areas it is not ‘high pollution weather’ but ‘high pollution’ that should be policy priority number 1.
- Modelling of general emission reduction policies, in addition to the forecasting/warning, should be a top priority.
- The expansion of monitoring capacity should be implemented in coherence with modelling. Only a combination of monitoring and modelling (assessment) can provide comprehensive information for decision-making. A modelled situation analysis and the models in use ideally dictate the (future) monitoring requirements.

**Specific to Implementation of the Systems**

- There is need for temporal and spatial AQ information to supplement the AQI in order to allow interested public understand the values origin;
- Much more support to local Environmental Protection Bureau (EPB)’s in understanding and implementation of complex air quality information (emergency response) systems is required
- Establish a platform (on air quality monitoring & modelling) for sharing and exchanging experiences and information on national and provincial level. A supporting organisation within or apart from the ministry could provide/coordinate these services (like the European Environmental Agency (EEA) supports the Directorate-General Environment of the European Commission in Europe (DG Env)).
- When applying models for policy support, the type of model should be selected based on the fit-for-purpose criteria. Simple statistical models for both spatial mapping and forecasting may be a better reliable and cost efficient option in an operational setting in contrast to complex deterministic air quality models.
• To assist in implementation of action plans aimed at reducing air pollution, *capacity building* and the acquisition of *scenario modelling tools, reliable emission data* (of all sectors, not just the industry and power) and *data on the cost of emission* reduction strategies are needed

• Furthermore, to facilitate modelling at the city scale for the assessment of future situations and new projects the government or a government designated institute could annually provide *modelled background concentrations* for the country as well as *future emission scenarios*. 
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<tr>
<td>AQ</td>
<td>Air Quality</td>
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<tr>
<td>AQD</td>
<td>European Air Quality Directives (AQD)</td>
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<td>AQI</td>
<td>Air Quality Index (New Chinese version)</td>
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<td>BAT</td>
<td>Best Available Technology</td>
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<td>CAEP</td>
<td>Chinese Academy for Environmental Planning</td>
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<td>CLRTAP</td>
<td>CLRTAP/Gothenburg protocol</td>
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<td>CNEMC</td>
<td>China National Environmental Monitoring Centre</td>
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<td>CTM</td>
<td>Chemistry Transport Model</td>
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<td>DCMR</td>
<td>Environmental Protection Agency Rijnmond</td>
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<td>DG Env</td>
<td>Directorate-General Environment of the European Commission</td>
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<td>EEA</td>
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<td>EGP</td>
<td>Environmental Governance Programme (EU-China)</td>
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<td>EPB</td>
<td>Environmental Protection Bureau</td>
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<td>EMC</td>
<td>Environmental Monitoring Centre</td>
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<td>EMEP</td>
<td>European Monitoring and Evaluation Programme is a scientifically based and policy driven programme under the Convention on Long-range Transboundary Air Pollution (CLRTAP) for international co-operation to solve transboundary air pollution problems.</td>
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<td>FYP</td>
<td>Five Year Plan</td>
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<td>IAQI</td>
<td>Individual Air Quality Index</td>
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<td>IIASA</td>
<td>International Institute for Applied Systems Analysis <a href="http://www.iiasa.ac.at/">http://www.iiasa.ac.at/</a></td>
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<td>LIBOVITO</td>
<td>Beijing LIBOVITO Environmental Technology Co.</td>
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<td>LOTOS- EUROS</td>
<td>LOng Term Ozone Simulation - EURopean Operational Smog model is an Eulerian grid model developed in the Netherlands <a href="http://www.lotos-euros.nl/general.php">http://www.lotos-euros.nl/general.php</a></td>
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<td>MEP</td>
<td>Ministry of Environment Protection</td>
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<td>NEC</td>
<td>National Emission Ceilings</td>
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<td>NO2</td>
<td>Nitrogen Dioxide</td>
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<td>NOx</td>
<td>Nitrogen oxides as NO2</td>
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<td>O3</td>
<td>Ozone</td>
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<td>OPAQ</td>
<td>Operational Prediction of Air Quality tool</td>
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<td>PM</td>
<td>Particulate Matter</td>
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<tr>
<td>PM2.5</td>
<td>Particulate Matter up to 2.5 micrometers in size</td>
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<tr>
<td>PM10</td>
<td>Particulate Matter up to 10 micrometers in size</td>
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<tr>
<td>PMCoarse</td>
<td>Particulate Matter fraction between PM10 and PM2.5</td>
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<td>PPAB</td>
<td>Partnership Project Advisory Board</td>
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<td>SAEP</td>
<td>Shanxi Academy for Environmental Planning</td>
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<td>SO2</td>
<td>Sulphur Dioxide</td>
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<td>VOC</td>
<td>Volatile Organic Compounds</td>
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The AirINFORM project relates to the first two Aarhus Convention elements: access to information and public participation. In a governance context, information is not just for the sake of information but it serves a second purpose. AirINFORM works on information for the sake of communication:

- to improve air quality management, e.g. communication of reliable AQ information to scientists, decision makers and to the public to assure that everyone is aware of their role and has the correct information to play their part in reducing air pollution.
- to reduce exposure to high air pollution situations, e.g. communication to the public that allows them to adapt their behaviour.

The aim of this report is to provide some policy recommendations based on our project experiences of the above topics, both locally, within the local partner cities of Urumqi, Yangzhou and Taiyuan, and centrally, during our policy workshop exchanges with the EGP component 2 team and various central stakeholders (MEP, China National Environmental Monitoring Centre (CNEMC), Ministry of Commerce, People’s Republic of China (MOFCOM)).

We are therefore focussing on policy concerning air pollution information, and in particular on improving air pollution information in cities and communication thereof to the public.

In the next chapter (2), we provide a brief overview of air pollution policy in the EU and China, as collected during this project and the main differences between them. In chapter 3 we focus on air pollution policy with respect to communication and try to ascertain the key differences (or gaps) between the EU and China situations. At the end we present some recommendations on how the Chinese policy could be improved based on our experiences. This approach is followed in Chapter 4, but then we are focussing on policy related to the use of air quality models to provide the best available air quality information.

Supporting information is provided in the annexes. In the first annex (Annex A: Different Ways of Looking at Environmental Management in the EU and in China: the Role of Emission Policy and Emission Standards.), further information on the how Environmental Management concerning emission policy is handled in the EU and in China is given. In the next two, additional information relating to Chapter 3 can be found. The last four provide some case study examples of air quality assessment and planning studies in the Netherlands and Belgium.
2.1. INTRODUCTION

Before we start it is important to take a look at how the related environment policy is generally handled in the EU and China. One notable difference is that in the EU the environment is ‘managed’ whilst in China it is ‘protected’. Though this seems a minor semantic difference it is a rather different way in thinking with considerable consequences. Protection is a defensive concept. It suggests that something is disappearing/threatened if not protected. Hence the concept of ‘GDP or environment’ or ‘jobs or environment’. For at least 40-50 years we know that this is a false thesis, a wrong way of looking at the questions at stake.

One should not be drawn into this false discussion. Management of the environment treats the environment as a resource, like other resources, money, labour, raw materials, etc. who’s use needs to be planned. If someone discharges a pollutant into the air, for the factory it is a convenient way to use the resource ‘air’ to get rid of the pollution. However, if the resource ‘air’ is afterwards no longer suitable for breathing the use of that resource by millions of others is compromised.

In the protection concept stopping pollution is a cost to a factory for the benefit of the goal of protection. In the management concept one weighs the cost to the factory to the cost of society (not being to breath healthy) and decides what a wise, economically efficiently, etc. use of the resource ‘air’ would be.

A second reason why it is important not to speak about ‘protection’ but about ‘managing’ or ‘planning’ is the fact that the latter are forward looking activities. One can forecast the need for the availability of a certain resource and analyse who has to reduce which emission, where, with what percentage. By setting a target emission, performance standards and national or regional ceilings, progress can be monitored. As we will read later, this approach has a significant impact on the air pollution policy and therefore the way that the local cities manage air pollution.

2.2. AIR QUALITY POLICY IN THE EU

The Directorate-General for the Environment (DG ENV) is one of the more than 40 Directorates-General and services that make up the European Commission. Commonly known as DG Environment, its main role is to initiate and define new environmental legislation and to ensure that agreed measures are put into practice in the EU Member States. The DG also helps Member States comply with the legislation, and investigates complaints made by EU citizens and non-governmental organisations.

The core of European Union (EU)’s current air pollution policy is set out under the EU’s 2005 Thematic Strategy on Air Pollution. It sets out ambitious but cost-effective objectives and measures for European air quality policy to 2020. Compared to previous strategies, the legislation
was made simpler, amalgamating, the legislation into key directives focusing on air quality assessment and management, emissions and pollution sources. The basic principles concerning the assessment and management of air quality are set out under two air quality directives (the 2008 Directive on Ambient Air Quality and Cleaner Air for Europe (CAFÉ) and the 2004 Directive on heavy metals and polycyclic aromatic hydrocarbons in ambient air). They also set pollutant concentrations thresholds that shall not be exceeded. In case of exceedances, authorities must develop and implement air quality management plans. (source: http://www.eea.europa.eu/themes/air/policy-context).

Regarding emissions of air pollutants, the EU directive 2001/81/EC on National Emission Ceilings for certain pollutants (NEC Directive) imposes emission ceilings (or limits) for emissions of four key air pollutants (nitrogen oxides, sulphur dioxide, non-methane volatile organic compounds and ammonia) that harm human health and the environment.

Internationally, the issue of air pollution emissions is also addressed by the United Nations Economic Commission for Europe (UNECE) Convention on Long-range Transboundary Air Pollution (the LRTAP Convention) and its protocols (UNECE, 1979). The Gothenburg 'multi-pollutant’ Protocol to the LRTAP Convention (UNECE, 1999) was amended in 2012 to include national emission reduction commitments to be achieved in 2020 and beyond, including fine particulate matter.

Aside from the NEC directive, there are numerous sector-specific emission reduction legislation aimed at controlling pollution at the source. Some of the most important pieces of legislation regarding are:

- Euro standards for road vehicles (e.g. EC, 2007);
- The EU Large Combustion Plant (LCP) Directive (EC, 2001a);
- The EU Integrated Pollution Prevention and Control (IPPC) Directive (EC, 1996), which sets out the main principles for the permitting and control of installations based on an integrated approach and the application of best available techniques (BAT) which are the most effective techniques to achieve a high level of environmental protection, taking into account the costs and benefits. By setting standards of Best Available Technology (BAT) across the EU, it assures that all member states face the same regulation to avoid that a company moves its activities to an area with less strict regulation.
- The Directive on industrial emissions 2010/75/EU (IED) was adopted on 24 November 2010 and published in the Official Journal on 17 December 2010. It entered into force on 6 January 2011 and had to be transposed into national legislation by Member States by 7 January 2013. The IED replaces the IPPC Directive and the sectoral directives as of 7 January 2014, with the exemption of the LCP Directive, which will be repealed with effect from 1 January 2016.

Thanks to the EU’s Thematic Strategy on Air Pollution substantial reduction in emissions between 1990 and 2010 was achieved which has broadly solved the EU acid rain (acidification) problem. Further the main health impacts, from particulate matter, have been reduced by around 20%
between 2000 and 2010. However despite the improvements air pollution still causes significant health problems and is the number one environmental cause of death in the EU. There still are substantial breaches of the air quality standards (2008), in particular for particulate matter (PM10) and for nitrogen dioxide (NO2).

The air quality policy underwent a thorough review from 2011-2013. The European Commission concluded that although it is coherent, a better match must be ensured between source controls, ceilings and ambient air quality standards to ensure effective compliance. Based on the conclusions of the review the European Commission adopted the Clean Air Policy Package for Europe in December 2013 which sets out new air quality objectives to further improve Europe’s air quality by 2030. The 2008 air quality standards are being kept as several member states still face difficulties in meeting these standards. Civil society requests for tightening of standards (towards WHO levels) have not been honoured. The EU has realised that air quality standards can only be met with strict emission policies and it is in this domain that progress was made.

It includes a proposal for a revised NEC Directive, with new national emission reduction commitments from 2020 and 2030 for the current four pollutants and two additional ones (fine particulate matter and methane) and a proposal for a new Directive on Medium Combustion Plants, to limit emissions of nitrogen oxides, sulphur dioxide and particulate matter from medium sized combustion installations.

The EU also realised that just making a policy is not enough to clean up the air, those who have the responsibility to implement need the capacities to do so! Thus the review also included a research of implementation issues that face member state cities. The findings of this research are presented in the Air Implementation Pilot project (EEA report 7/2013, ISSN 1725-9177). One general finding of the review was that implementation of air policies at local level varies considerably across Europe and significant support is still required to understand the dynamics at local level. Some of the issues discovered apply to the current situation in China as well: the need for good emission inventories, for support on air quality modelling, for support on the assessment of the effectiveness of measures.

Further information on the Clean Air Policy Package for Europe review can be found at http://ec.europa.eu/environment/air/review_air_policy.htm.

Information is very important during the development, implementation and evaluation of air quality policy. The European Environment Agency (EEA), whose task is to provide sound, independent information on the environment, provides supports to the European Commission and member countries during review, development and evaluation of its air quality policy. To ensure that timely and quality-assured data, information and expertise is available from across Europe, the European environment information and observation network (Eionet) was established. The EEA co-ordinates this network which comprises of the EEA and its member and cooperating countries. It consists of the EEA itself, a number of European Topic Centres (ETCs) and a network of around 1 500 experts from 39 countries in up to 400 national bodies dealing with environmental information. This knowledge is made widely available through the EEA website and forms the basis of both thematic and integrated environmental assessments.
Finally, the EU air pollution strategy also comprises of steps to modernise the reporting of air quality data. This is handled by the INSPIRE Directive (2007/2/EC) which sets about establishing an Infrastructure for all Spatial Information in the European Community (INSPIRE). The goal is to ensure that the spatial data infrastructures of the individual Member States are compatible and usable in a Community and transboundary context. The Directive requires that legally binding common Implementing Rules (IR) are adopted in a number of specific areas (Metadata, Data Specifications, Network Services, Data and Service Sharing and Monitoring and Reporting). It sets out a roadmap to have all spatial data sets conformant by 2020. This directive has implications on how member states monitor, report and exchange air quality in accordance with the ambient air quality Directives.

2.3. Air Quality Policy in China

The Chinese central government issues a comprehensive air quality management plan every five years. This is called the Five Year Plan (FYP) on Air Pollution. The current one is the 12th Five-Year Plan on the Prevention and Control of Air Pollution in Key Regions (2013 – 2017). This is the first comprehensive plan on air pollution control in China. To understand how this air policy evolved in China, it is worthwhile reflecting on how air quality policy developed in China from the early 1970’s.

Stage ONE: 1973 -1990

In 1973, the first national integrated emission standard “Emission Standards for Three Industrial Wastes” is declared after the State Council convened the first national conference on environment protection. These efforts marked the initiation of air pollution prevention and control in China, with the focus on industrial sources. During this period, concentration standards for discharge outlets remained the key control measure against air pollution, improving de-smoking and de-dusting of industrial spot sources.

During the 1980s, energy consumption drastic increased and urban SO2 pollution deteriorated. Regional acid rain emerged in the southwest and south of China. Under these circumstances, the MEP starts the SO2 pollution control. In September of 1987, the People’s Republic of China Air Pollution Law was promulgated, which identified the priority of reducing coal-smoke type pollution.

In the late 80s, the air pollution governance switched from point source control to integrated control in cities. Main work conducted in this stage includes: development of urban air pollution prevention and control plan, closure and relocation of heavy polluters, facilitating technology modification and integrated resource use in industries, improving energy efficiency and restructuring the energy mix. This delivered some positive effects in curbing the fast deterioration of urban air pollution.

Stage TWO: 1991-2000

However this positive impact of controlling selected urbanised ‘industrial’ emission concentrations was barely noticeable considering the total amount of regional emissions that were and are still pushing the concentrations drastically above air quality standards. To tackle this problem, China
started piloting a programme of Total Emission Control. The 9th National FYP of Environment Protection put forward the requirement to facilitate Total Emission Control. In 1996, the State Council issued Several Decisions on Issues of Environment Protection which set forth targets of atmospheric pollution control to be met during the 9th FYP period. These included stipulating limits for particular total pollutant discharges, and industrial discharges and setting targets for designated environment function zones in 47 key cities.

To ensure targets are well-met, China developed the National Major Pollutants Emission Control Plan for the 9th FYP Period, which specified that the national smoke and dust, industrial dust and SO2 of 2000 to be controlled to the level of 1995. In the period of the 9th FYP, conditions were still premature to drive desulfurization and de-dusting of thermal power plants, therefore the most progress was mainly made in the area of integrated treatment and control in urban cities. By means of effective emission tightening over central heating, gas supply and non-power SO2, sulphur dioxide from low-stack and dispersive sources were largely reduced. However, SO2 from the power sector in the period of time continued to increase considerably.

Stage THREE: 2001-2010

Early in 1995, the National People’s Congress adopted the then newly revised Air Pollution Law, which specified that regions with acid rain problems, (or susceptible to acid rain) or severely polluted by SO2 should be assigned with specific acid rain and SO2 control targets. In 1998, the State Council approved the program on zoning these two target types. In 2001, the 10th FYP Acid Rain and SO2 for the two control type targets were developed, which set forth the objectives to reduce SO2, smoke dust and industrial dust, in total by 10% and SO2 in “two type of control regions” by 20%. In the 10th FYP period, the main measures adopted in those controlled regions included limiting the use of coal high in sulphur, promoting desulfurization in power plants and targeting other key SO2 sources. These measures where supported by regulation and economic means such as the pollution pays principal (fee charging), permitting and trading. The zoning of the 2-type control areas facilitated the control of acid rain and SO2, marking a consensus shift from the city level towards regional control. Due to insufficient prediction of economic growth and energy consumption and late construction of treatment facility, SO2 targets set in 10th FYP were not completed. In addition, because of distant transportation of high-stack pollution and pollutant conversion, acid rain is not well solved with SO2 abatement in controlled areas alone.

To make up for the shortcomings of the 10th FYP, in the 11th FYP a nationwide SO2 control programme was initiated with a target reduction of 10%. To ensure it is met, the Chinese government adopted a series of measures as follows: 1) target specific provinces and electricity groups - progress of the measures should be publicized by provinces and six major power groups and reported to the State Council and failure to meet targets would result in harsh punishment 2) introduction of advanced technologies to produce more cost-efficient equipment in China; 3) development of incentive policies such as subsidises for using de-sulphured fuels and the polluter-pays principle. The 11th FYP delivered significant progress in SO2 abatement: 14.3% reduction exceeding the target and in terms of environmental effect, acid rain has been controlled to a certain degree, the frequency of occurrence is reduced and polluted and heavily-polluted scale have been stabilized.
CHAPTER 2 LEGISLATION & IMPLEMENTATION

Stage FOUR: 2011–Now

Due to the increasing nitrate (NO$_3^-$) and sulphate (SO$_4^{2-}$) concentrations found in the measurements during the 11th FYP, for the 12th FYP, NOx was added as another pollutant to control. Furthermore, a target of 8% reduction in the total amount of SO2 emissions and 10% of NOx emissions was suggested for the next five years. Since the 10th and 11th FYP’s focused more on acid rain and SO2 emissions from key industrial point sources, the effects of urban air quality improvements were weakened to some extent. The emission abatement policy of the 12th FYP was therefore adjusted and its scope broadened to include contributors with a larger impact on the air quality in cities such as coal-burned boilers, industrial furnaces and mobile source, etc.

Given the fact that the long-implemented control in total emission does not hold local governments accountable for air quality, and SO2 and NOx targets are not aligned towards solving PM2.5 and PM10 concentrations, decoupling the efforts and air quality effects emerged. To further refine the planning, the Chinese government issued the 12th FYP for Air Pollution Prevention and Control in Key Regions. According to the plan 13 key areas were identified as key areas for urban air quality improvement based on their pollution transportation features and air quality. They are required to reduce their SO2 and PM10 concentration levels by 10%, NO$_2$ by 7% and PM2.5 by 5% in these places. To ensure compliance, a comprehensive abatement plan for SO2, NOx, PM and VOCs was developed. This stipulates respectively, a 12%, 13%, 10% and 11% reduction to be achieved by the end of the five years. Specific sources of each pollutant are identified and the scope of efforts was expanded to include coal burning power plants, industrial point sources, fugitive dust, kitchen fumes, straw burning, vehicle and off-road machineries.

As the beginning of 2013, China endured a wide-reaching (middle and east) intensive outbreak of PM pollution (haze). As a result of the persistent public outcry to improve the air quality the State Council brought forward the launch of the Air Pollution Prevention and Control Action Plan. It tightened air quality targets on the basis of the 12th FYP and stipulated targets for 2017 compared to 2012, as follows:

- PM10 levels nationwide, and in key cities should be reduced by 10%
- PM2.5 by 25%, 20% and 15% or more in Jing-Jin-Ji (JJJ; Beijing-Tianjin-Hebei Urban Agglomeration Area) and its surrounding areas (Shanxi, Inner Mongolia, Shandong), Yangtze River Delta Area and Pearl River Delta and areas facing compound and heavy pollution;
- Beijing to control its annual PM2.5 average to around 60 μg/m$^3$.

At present, the Ministry of Environment Protection are working to distribute the national targets to provinces and sign accountability commitments with the most polluted provinces and cities such as Beijing, Tianjin, Hebei and 6 surrounding provinces. As a result, they will be responsible for enforcement, supervision and performance appraisal for the implementation of the Action Plan. The Action Plan (issued Sept 2013) provides only guidance; therefore provinces are obliged to develop their own multi-pollutant synergetic reduction program, to ensure the action is specific to various sources, so that the pre-determined air quality improvement will be reached.
2.4. **General Recommendations for Air Quality Legislation in China**

- Over the past years new air quality and general environmental legislation has been developed. This legislation is often general, setting out intentions and ambitions. In the EU legislation is more specific, and more forward looking, setting explicit standards to be achieved in the future. This allows entrepreneurs to timely plan their adaptation strategy. It also provides a forecasted insight in the future state of the environment. **Make policy more specific with current and future targets sharply defined setting uniform standards across the country (e.g. emission performance standard rates for each sector).** Refer to Annex A: Different Ways of Looking at Environmental Management in the EU and in China: the Role of Emission Policy and Emission Standards. for further information on how the environment is managed in the EU.

- In the AirINFORM domain we found that policy implementation was somewhat fragmented or incoherent (e.g. the link between monitoring and modelling is weak or absent, as is the link to emissions and modelling) and that the experience with the use of air quality information in a governance context is generally limited (information is published sometimes seemingly without a notion of what the publication has to achieve). The EU had a similar experience. They realised that even after almost two decades of ambient air quality policy many cities still had problems meeting the air quality limit values (EEA report 7/2013, ISSN 1725-9177). Some of the issues discovered apply to the current situation in China as well: the need for good emission inventories, for support on air quality modelling, for support on the assessment of the effectiveness of measures.

- The strong focus on emission reduction that the EU has realised is needed has been seen in recent Chinese policy documents. The main difference, as was mentioned at the beginning of this chapter, is the fact that the EU policies are much more explicit in setting standards both in ceilings for member states (Chinese equivalent are the provinces) as well as future vehicle standards, future standards for shipping emissions and the across the board application of BAT for industrial plants. **It is recommended to define what is Best Available Technology (BAT) across the country and set emission ceilings for provinces and monitor annual progress.**

- Like the EU, the Chinese government should provide support/guidance to provinces, cities and regions on policy implementation. Air quality is a very complex domain. Isolated actions on individual policy aspects are not likely to be very effective. **Provide guidance on the context and the interrelatedness of various policies and actions** and assure that the full depth of the issues at stake is understood at the implementation level.

- **Provide capacity building by organising exchange mechanisms.** This could involve foreign expertise but there is also ample scope to learn from each other/from more advanced cities/regions within China. With the rapid changes regarding AQ policy formation in China, we have heard very recently that MEP already plans to organise annual training for local EPB’s. Nevertheless, the recommendations given in this document regarding the type of capacity building required should be noted.

- **Establish a platform (on air quality monitoring & modelling) for sharing and exchanging experiences and information on national and provincial level.** A supporting organisation apart
from the ministry could provide/coordinate these services (like the EEA supports DGENV in Europe).

Isolated policy actions examples:
- changing the calculation of the AQI without an adequate analysis of the communicative goal of the AQI
- installing AQ monitoring stations without an analysis of where best to locate them to get the most useful information (e.g. the policy was to increase the number of monitoring stations: the better policy would have been to improve the information supply. More data does not necessarily mean more/better information
- declare pollution fees (polluter pays) without an analysis whether the fee is high enough to deter pollution (it was not).
3.1. INTRODUCTION

Air quality communication is currently primarily seen as providing information to the public and warning them of adverse pollution conditions. AirINFORM assists in getting the best possible information, in a timely manner to the main stakeholders. Secondly it assists in raising awareness to create a situation where the public participates in solving air quality problems by adapting their behaviour, putting pressure on polluters, etc..

This section deals with communication issues in general and some specific attention is paid to the AQI that was revised in 2012.

3.2. LAWS AND/OR REGULATIONS BEING ADDRESSED

Communication has a relation to several ongoing activities in the domain of public disclosure legislation though the treatment here is fairly general and mainly related to specific legislation. When it comes to the Chinese AQI we refer to technical Regulation (HJ 633—2012) in which a new air quality index (AQI) that includes PM$_{2.5}$ and ozone was defined. Since the publication of HJ633-2012 the implementation of it has undergone some changes in 2014. More specifically, the averaging time for the real-time AQI report for PM was changed from a 24h moving average to a proper hourly average. Something that amongst others, AirINFORM had recommended in its first policy report.

3.3. RECOMMENDATIONS

Communication in general

Communication should not be regarded as a simple supply of information (because it is in the legislation) but as a part of air quality management, as a support to achieve common goals. In order to use communication as part of air quality management it has to be effective. In order to establish this, one has to be clear about what one wants to achieve with information and communication and to verify if the approach chosen will achieve just that. Remember, the internet, TV, newspaper, etc. is full with information: it is important to verify if what is being added is being found, being understood and being believed.
The case of the severe protests over PX factories shows that a part of the population did not trust the proposed plant could be operated cleanly and safely. In the EU PX plants (or other plants) generally don’t face this level of protest. This has two reasons: authorities and industries have a track record of clean and safe operations; and open communication on the risks, the measures taken to manage them, the monitoring program installed, the public concerns raised, etc. Managing the dialogue with the public is an integral part of the industrial licensing process in Europe. In the end this communication approach creates trust in the authorities/the government, and people are more willing to accept the government promise that the risks involved in the construction of a new plant are well controlled and not excessive.

Good and reliable information is indispensable for the development of local emission abatement policies, it is necessary to show the public that the government is doing something to improve the air quality and hence their health, it helps people to understand that the choices they individually make (energy use, transport, heating, etc.) have consequences for the air they breathe.

Communication is a two-way process. Just the supply of information is one-way and is not likely to lead to governance. For communication to be effective both parties have to understand each other and trust each other. Apart from the official Chinese government websites and apps there are several alternative air quality information sources. This is a sign of an open (and mature) information supply system and it is common in other countries as well. If these alternative information sources are just stressing other aspects, promoting their own view, etc. this contributes to a useful public debate on the environment. However it is also a challenge: the official (local) government sources have to compete with the other sources to make sure that their message is found and heard.

The (local) government operates in a competitive information ‘market’. And like any other market for goods, to be successful the product has to liked, one has to make the right publicity, etc. To be heard and be a dominant player the (local) government should market their information attractively, persuasively and aggressively by being easier to understand, more complete, more correct, etc. than other information suppliers. That is the only way to assure that (local) government becomes the preferred source of information and a credible partner in dialogue (assuming that this is what the (local) government wants). This is no easy task if one is not a marketing or communication specialist. Since air quality is a complex technical domain, one will see that the air quality information supply is often done by air quality specialists/technicians. This happens in China but also elsewhere. So it is recommended to engage (local) communication specialists or even (private sector) marketing experts with more experience with communication in competitive settings.

In many countries the civil society plays an important role in air quality awareness, information supply, public debate, etc. Sometimes NGO-s receive (local) government (financial) support to perform this role because it is considered more effective, credible, etc. Also in this case the ultimate responsibility for the availability of correct (audited) information remains with the (local) government. For the time being it seems that a large responsibility rests with the Chinese authorities to not only provide the facts but to also assure the other aspects of air quality communication (raising awareness, encourage the emergence of civil society).
A specific point of concern in China are a number of websites or apps that do not only provide a different view, but also different ‘facts’. E.g. some websites and apps use different (and sometimes erroneous or incomplete) AQI-s and this might confuse the public. The (local) government could make an effort to inform the public that different AQI-s exist and that each AQI produces different results. This way one can avoid being accused of ‘cheating’.

Apart from the very vocal people that use apps, websites, Weibo etc. that need to be addressed using fancy communication tools there is also a large part of the population that knows much less about air pollution and might not even be aware that it is an important health issue. Air quality communication efforts are often (not only in China) technology driven/biased (too much attention on high tech information supply). However one also has to reach out to those people that are not yet aware, using additional communication channels (radio, TV, newspapers, brochures, Environment day, etc.) and provide simple but relevant information to raise awareness. AirINFORM experienced this during surveys in the project cities and made some steps in providing simple educational material.

The philosophy of the EU’s Information network EIONET is: “An essential part of improved governance is the creation of a credible, legitimate, relevant and accessible evidence base to ensure that policymakers are basing their decisions on sound information”. EIONET/EEA plays a role in collecting and disclosing information, and transforming raw data in indices maps etc. that are easier to understand and use by non-specialists. In many EU countries and elsewhere there is open access to environmental information, information is audited (procedures vary from country to country) to assure its reliability. There is an active civil society using this information to further inform the public, assist them in using the information and act as a government counterpart in the governance process. The context in which information is made available in Europe and elsewhere is currently rather different from China. Just making the information available is a very important step, but only a first step towards governance. In China, for the time being, NGO’s and others need to be encouraged to use the information that is available and to contribute to the development of a civil society that can act as a government counterpart.

Comparing the Chinese and the EU situation reveals two actions that would be necessary: (1) establishment of an organisation within MEP or closely linked to MEP that publishes air quality monitoring data, emissions data, meteorological data and easily to understand indicators based thereon; (2) secondly the MEP department for education and communication (if necessary) reinforced with specific specialists familiar with raising awareness has to make sure that public ‘education’ on air quality is started and/or improved. Local government technicians involved in communication should be able to refer back to them for specific communication support.

Disclosing information, raising awareness, etc. with the aim to foster public participation and governance is a way to make air quality management more efficient and to avoid that the whole burden of AQ management rests on the government. Because in that situation also the whole blame for environmental problems rests with the government. Public participation and governance provides a platform to discuss and to balance for example the desire for power supply, and the nuisance of a power plant; the desire to get rid of one’s waste, and the emissions of a waste incinerator; etc. Public participation can and should be used to put pressure on gross polluters but
also to show that public choices/ambitions have consequences. In many European cities traffic related air pollution is a major problem and it is a consequence of (amongst others) the public’s crave for mobility.

The action plan on air pollution prevention and treatment has a number of important provisions on disclosing emission data (25) and information management and standardisation (23). It is desirable that enterprises report their emissions in a uniform way across the country and not just total emissions but also emission per unit of output. Credible and detailed emission data is also necessary for modelling (see CHAPTER 4) and without them it is virtually impossible to implement and monitor the emission control policies (e.g. article 44 of the environmental protection law). Reporting and publishing of emissions per company in sufficient detail contributes to data quality as it allows the public, NGO-s, universities, etc. to compare companies and industries and to do their checking. Knowledge of emissions per unit of output (or per unit of fuel) will lead to benchmarking and pressure on substandard producers. It is also a prerequisite to get green procurement initiatives started both by government and other enterprises as well as individuals. Power companies in Europe promote themselves by stating how clean they are to attract customers. In that respect clause 23 of the action plan on air pollution prevention and treatment on standardisation is important. If this kind of emission information is published some kind of auditing to assure correctness is obviously necessary. This could be done by government or by government appointed institutes or companies. Ultimately modelled concentrations or concentration trends should match monitored observations and trends.1

More information can be found in the Annex B: Communication: The Purpose of Air Quality Communication at the back of this document.

**AQI and AQI calculation**

The AQI is technically a modern index suitable for the Chinese situation. However, the AQI use and the messages associated to it should be reconsidered. If (see above) the government wants to be a credible communication partner it should give relevant (and to the point) advice. This could be improved. In Deliverable 2.3 we advise to reformulate the AQI messages in terms of policy instead of behavioural advice. Amongst others this advice was motivated by a long period (several weeks) of elevated pollution where the current advice was to stay indoors. No one will ever do so, so the advice is not practical. Besides, except during ozone episodes staying inside is not a good advice (unless one has high quality air treatment installed), Indoor air quality will be as bad (or even worse!) as outdoor.

We suggest using messages like high – low pollution, meets the standard – exceeds the standard etc. If pollution is high the most relevant behavioural advice is to reduce physical labour (anything that makes you breath faster) and if you experience problems to consult a medical doctor. Even without the AQI message suggesting to stay indoors, people might think that staying indoors is a

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1 E.g. EEA in its 2012 report ‘Air quality in Europe’ remarked that reported downward emission trends were not in tune with observed concentration trends. This could be either due to mistakes on the emission side or poor understanding of the behaviour of secondary pollutants. Though these comparisons are complicated they are the ultimate check on the understanding of the AQ assessment system and/or the quality of the data (emissions and monitoring).
way to protect them. Therefore we suggest to add information on indoor air quality to the AQI messages.

Of course one can always discuss exact class boundaries and whether each pollutant is given the appropriate weight but since the AQI is used as a communication instrument to convey the relative degree of pollution we didn’t focus on these issues of ‘absolute correctness’. Instead we looked at consistency, e.g. do the daily and hourly AQI produce consistent results? Do the PM grids fit the occurrence of the two PM species in China? Taking the daily AQI report and the PM$_{10}$ iAQI calculation grid as a point of departure recommendations can be made.

- PM$_{10}$ and PM$_{2.5}$

The AQI breakpoint grid for PM$_{2.5}$ should be made consistent with the PM$_{10}$ grid using the relation between PM$_{10}$ and PM$_{2.5}$ as it occurs in China. This has two advantages:

- The iAQI-s for PM$_{10}$ and PM$_{2.5}$ provide additional information on the nature of the particulate pollution (predominantly coarse or fine pollutants (or evenly distributed) as the grids are no longer biased to either of the two pollutants (on average).

- If one of the two pollutants is missing, it is less likely that the resulting AQI will be biased. Since PM$_{10}$ is missing more often than PM$_{2.5}$ in the current situation either no AQI is available to inform the public or the AQI could be upward or downward biased (depending on where in the scale the concentrations are.

Making the iAQI grids for the PM species consistent does not affect (on average) the level of the AQI report (see Deliverable D2.3 part III). The ratio PM$_{2.5}$/PM$_{10}$ to be used for the country is 0.56. This is in line with ratios found elsewhere in the world.

- Daily or hourly AQI

The daily and hourly AQI reports currently produce different results. It is possible and desirable to improve the consistency between the hourly and daily AQI reports.

The current hourly index is dominated by PM whilst in the daily index NO$_2$ and O$_3$ play a role as well. This is mainly due to the fact that an inappropriate PM iAQI-grid is used: the AQI grid from daily averaged PM measurements. We strongly recommend changing this and making a proper hourly AQI grid for PM.

The hourly grids for NO$_2$ and O$_3$ would also need to be redefined to make them more in line with the true behaviour of the data. This will increase their occurrence in the hourly AQI and make the hourly AQI more consistent with the daily AQI reports.

Since the start of AQI the government has decided to change from the use of a 24h moving average PM concentration to the use of hourly concentrations. This was a very wise decision as it improves the timeliness of the air quality information. It also makes sure that what the people experience is in line with the AQI that is shown. However **one more step is needed**: the use of a proper hourly AQI grid for the PM species. Currently the hourly AQI is sometimes too high because an inappropriate grid is used. For more information see Deliverable D2.3 part III.
More information can be found in the Annex C: AQI as a Communication Tool at the back of this document.
4.1. LAWS AND/OR REGULATIONS BEING ADDRESSED

In this chapter we examine the EU and Chinese policy regarding the use of air quality models, and come up with some suggestions on how the Chinese policy can learn from the EU’s experience in this area.

4.2. PURPOSE OF DIAGNOSTIC MODELLING IN AIR QUALITY MANAGEMENT

Firstly let’s recap why we need air quality models and then we can see how this is handled in a policy context. Air quality problems are technically complex and need an integrated diagnostic approach, comprising of monitoring as well as various types of numerical modelling tools. The key applications for these air quality modelling tools may be categorised as follows:

- **Assessment** of prevailing pollution levels. Analysis of historical air quality measurement data is often the first primary method of assessment. The use of models in conjunction with this measurement data can add valuable information for decision makers. Models can be used to produce air quality maps with full spatial coverage of the region of interest. This also allows new or unknown hotspots which are not yet monitored to be identified. Assessment of historical pollution levels provides an analysis of trends over past years which can be used as a starting point for development of abatement strategies.

- **Source apportionment.** In order to develop effective mitigation strategies, it is essential to know where the pollution is coming from. Source apportionment modelling tools can be applied to define the most important contributing sectors (transport, industry, ...) in the region.

- **Operational air quality forecasting.** Similar to weather forecasts, operational air pollution forecasts can be used for warning purposes when episodes of heavily polluted air are expected. Operational forecasts are run in near real time and typically forecast up to 4 days ahead. The operational aspects (providing frequent (e.g. 3 hourly) timely forecast information) impose extra requirements (processing capacity, data storage etc.) on the modelling framework.

- **Projections** of air pollution for the mid or long term future (typically 10 to 15 years ahead) which take into account expected emission trends for those time horizons. Those trends can be based on a business as usual policy or include more ambitious emission reduction targets.

- **Scenario analysis:** assessment of the impact of specific measures in order to define the most effective and cost-efficient abatement strategies. These scenarios could involve various emission projections based on various emission reduction measures (e.g. low emission zones, cleaner industry...) that could be implemented.
4.3. RELATED EU LAWS AND/OR REGULATIONS

The EU Air Quality Directive (2008/50/EC) recognises the potential of modelling tools and encourages the use of AQ models for the applications mentioned i.e. in combination with monitoring for AQ assessments (assessing the current AQ situation and identifying the sources), AQ forecasting (to warn the public when pollution episodes are expected) and investigating actions to reduce emissions (planning). Thus it encompasses the whole air quality management spectrum from monitoring, to forecasting, to assessment and planning. Prior to this directive, air quality assessment and reporting was largely based on measurement data. During the last decades, air quality modelling was mainly used by the academic and research community. Only sporadically, models were used for air quality compliance monitoring. The release of the EU Air Quality Directive in 2008 gave more incentives to national, regional and local authorities to use models for policy support, including the conduction of air quality predictions for the various future scenarios.

Many different types of modelling approaches exist (Gaussian and non-Gaussian, parameterised models, statistical models, dynamical models, Lagrangian particle models...etc.) each with its specific purpose and temporal and spatial focus. As a result some models have been developed for the continental to regional scale and are mainly used to support European policy and investigate long range transport phenomena. Other modes are oriented towards the regional to urban or local spatial scale and are applied by local authorities. The wide variety of models that exists these days in Europe is a consequence of the fact that Europe has never employed a unified approach to air quality modelling as was done e.g. in the US. This is still the case today. Member states, regions or cities are completely free to the use the (set of) models that suits best their specific needs. However, in order to obtain a harmonised approach in air quality modelling over Europe, the Forum for Air Quality Modelling in Europe (FAIRMODE) was established in 2008 as a joint action of the European Environment Agency and the European Commission’s Joint Research Centre (JRC). FAIRMODE is created for exchanging experience and results from air quality modelling in the context of the Air Quality Directives and for promoting the use of modelling for regulatory purposes in a harmonized manner between Member States. Its main objectives are:

- To provide a permanent European Forum for air quality modellers, particularly addressing model users;
- To study and set-up a system (protocols and tools) on the quality assurance and the continuous improvements of air quality models operating at spatial scales from national to urban and local;
- To provide guidance on the use of air quality models and input data (including fit for purpose) for assessing current and future air quality within the framework of implementing the EU’s Air Quality Directives;
- To promote capacity building activities aiming at ensuring an optimum use of the proposed common methodologies and guidance and to promote good practice among the EU Member States and the EEA member countries;
• To make recommendations on future priorities, research activities and other relevant initiatives to secure Air Quality improvements.

FAIRMODE plays a very important role in supporting the model users and air quality managers that build their policy on modelling results by providing a harmonized framework for applying air quality models in the legal context of the Air Quality Directive.

Some specific case studies of the application of models in Europe are provided in annexes D to G. The first two focus on the use of modelling for AQ predictions for two areas: the Rijnmond Region in the Netherlands (Annex D: Air Quality Assessment in a Large City In The Netherlands) and Antwerp, Belgium (Annex E: The Multi-Scale Character of Air Pollution: Impact of Local Measures in Relation To European and Regional Policies – A Case Study in Antwerp, Belgium). This is followed by a description of ATMOSYS which is an example of an Air Quality Management System for Policy Support in Europe (Annex F: ATMOSYS, An Air Quality Management Dashboard System: An Example of an Air Quality Management System For Policy Support in Europe). Finally, we end with some considerations to bear in mind, when choosing a chemical transport modelling tool for regional scale modelling (Annex G: Considerations when Choosing a Chemical Transport Modelling Tool For Regional Scale Modelling).

4.4. THE CURRENT APPROACH BEING USED IN CHINA

4.4.1. FOCUS ON AIR QUALITY FORECAST

On review of the key Chinese AQ legislation (2013 Action Plan on Air Pollution Prevention and Treatment as mentioned in Chapter 1), it appears that the focus of the AQ management in China is primarily on monitoring & forecasting. Various clauses in the action plan refer to improve environmental monitoring and emergency response (e.g. clauses 23, 29, 30, 31): “Set up Monitoring, Early Warning and Emergency Response System, to Adequately Address Heavy Pollution Weather”. The implementation target dates vary from 2014 to 2016; the most polluted regions being targeted first.

AIR POLLUTION PREVENTION AND CONTROL ACTION PLAN²

(29) Establish the monitoring and warning system. Ministry of Environmental Protection shall strengthen its cooperation with the meteorological departments to set up heavy pollution weather monitoring and early warning system. The Beijing-Tianjin-Hebei, Yangtze River Delta, the Pearl River Delta regions shall build up their regional, provincial, and municipal heavy pollution weather monitoring and warning system by 2014. Other provinces and provincial capitals shall complete by the end of 2015. Well conduct the trend analysis of heavy pollution weather process, improve the consultation and judgment mechanism, improve the accuracy of monitoring and early warning, and publish monitoring and warning information in time.

² English Translation, October 2013 provided by Clean Air Alliance China, China Clean Air Update, Issue II, 2013
Emergency plan. Cities with air quality below the standard shall formulate and improve their episode plans and publish them to the society. It is needed to identify main responsibility body, clearly define the emergency organizations and their responsibilities, set up procedures for early warning, forecasting mechanism and response, implement emergency treatment and safeguard measures, etc. According to different pollution levels, the decision will be made to limit production or shutdown the enterprises, control motor vehicles and dust, close primary and secondary schools and feasible meteorological intervention measures. It is also necessary to carry out the heavy pollution weather emergency drill.

Whilst this seems quite logical given the air quality situation in China and the public outcry over the past few years to be correctly informed of air pollution episodes, from a management point of view it is not. A focus on forecasting is important for emergency response but will not contribute to an in-depth understanding of the causes of the air pollution problem and the most effective measures. We observed that so far very little effort is spent on assessment, future projections and scenario analysis. This part of AQ management seems to be at a very early stage in China. However, these aspects are as relevant in order to establish a complete comprehensive air quality management system and develop a coherent and effective air quality strategy.

4.4.2. Focus on the regional scale

Most of the air quality model applications that are currently running in China focus on the regional scale. Typically, such a model output has a spatial resolution of 5 to 20km and covers the whole country or at least and entire province. The advantage of these models (such as CMAQ, CAMx...) is that they have included an advanced description of the atmospheric chemistry and aerosol processes. Therefore such a model is, in principle, a suitable tool to simulate concentrations of particulate matter, ozone... in the ambient atmosphere. Given the domestic regional transboundary PM$_{10}$ (and PM$_{2.5}$) problem in China, this seems to be a logical approach for forecast applications and regional scenario analysis. However, in practice, it turns out that the setup of a robust, reliable and well validated regional chemistry-transport model\(^3\) (CTM) is a very complex and complicated task. Experiences in Europe have demonstrated that although many regional AQ models are readily available via a download from the internet, it is by far not straightforward to setup and configure such a model. First of all, experienced air quality modellers with good knowledge of meteorology, chemistry and physics are required to configure the model for the region of interest. Apart from the expertise of the modeller, reliable input data is an essential requirement to arrive at meaningful model output. Such input data consists of:

- Meteorological data at a spatial resolution relevant for the application. Data has to be available in a 3D gridded format at a high (3 or 6h) temporal resolution.

- Emission data for all sectors at the spatial resolution of the model application accompanied by relevant time profiles. Emissions data has to be available for the main (precursor) pollutants NO$_x$, SO$_2$, VOC, NH$_3$ (ammonia), PM$_{2.5}$, PM$_{coarse}$

\(^3\) [http://en.wikipedia.org/wiki/Chemical_transport_model](http://en.wikipedia.org/wiki/Chemical_transport_model): a chemical transport model (CTM) is a computer numerical model which simulates atmospheric chemistry
- Boundary conditions at the borders of the simulation domain which provide lateral input in the simulations.

**Each of these three input data sets is critical for the success of overall application.** If one of the inputs contains falls or incorrect data, it is very likely that the overall application produce unreliable results. Rubbish-in gives rubbish-out.

Even when meteorology and boundary conditions are well validated and quality checked, in most cases the emission inventory turns out to be incomplete. This is still the case in Europe where there is a long track record in compiling emission inventories. These incomplete emission inventories still give rise to important underestimations of the modelled PM concentrations. In many of the Chinese CTM applications we have seen during the AirINFORM project, an incomplete emission inventory was also at the origin of a severe underestimation of the PM concentrations. In the long run, there is only one solution: **invest heavily in compiling reliable and complete emission inventories.** This is a labour intensive and lengthy process but in the end it is the only way forward to setup a reliable modelling system and an air quality management strategy.

It is our understanding that Chinese policies related to the regional plan and research and technology promotion will contribute to the continued development of regional and local air pollution control models to facilitate the establishment of modelling capability and systems (source: IGES Policy Report No. 2013-02 “Major Developments in China’s National Air Pollution Policies”). Any such policies should consider the points raised above.

In the short run, data assimilation techniques can be helpful to increase the quality of the modelled concentrations. Data assimilation or data fusion techniques combine model output with measurement data in order to produce a so called “analysed map” which in most cases comes closer to the observed concentrations. The data assimilation techniques can be applied to improve the quality of assessment maps as well as to introduce bias corrections in air quality forecasts.

### 4.4.3. Alternative approaches

As mentioned above, due to the severe regional PM problem in China, the current air quality policy regarding air quality models seems to focus on forecast simulations at the regional scale. Although this is very important, at the **urban scale**, important **local hotspots** may arise on top of this regional background. These local hotspots in the vicinity of important roads, street canyons or industrial facilities are not captured by the regional CTM’s. To model these urban or local air pollution features, other types of models are required. Up to now, it appears that only very preliminary steps are made in China to model the urban scale of air pollution. However, since many people live in the cities, this is a scale which should not be forgotten and should become a priority in the coming years.

Given the current lack of input data (mainly complete emission inventories) for setting up a robust and reliable CTM’s in China, statistical approaches can be a good and cheap alternative. **Statistical models** can only be applied for specific purposes such as forecasting mapping or source apportionment. Their main advantage however it their limited need for input data. Many statistical
CHAPTER 4 USE OF MODELS FOR AIR POLLUTION POLICY SUPPORT

applications only rely on monitoring data in combination with a limited set of meteorological variables or socio-economical drivers such as population density or land use. Their limited dependency on input parameters results in most of the cases in a much more robust and reliable modelling system. Many applications in Europe but also China demonstrate that the quality of those statistical models is very high and outperforms the classical CTM’s for the specific purposes mentioned above (forecasting, mapping...).

In order to meet the current needs of the Chinese cities, within AirINFORM an ‘Operational Prediction of Air Quality (OPAQ)’ system based on those statistical techniques was developed and implemented in the pilot city of Yangzhou. The aim of this system is to provide near-real-time and forecast air quality maps that can be used to inform the public on the quality of the air in the city in a spatially explicit manner. Before this system, Yangzhou Environmental Monitoring Centre only reported the ‘old’ average AQI values for a couple of measurement locations. In the other AirINFORM pilot cities other types of modelling systems are being established, but with the same end result to provide air quality forecast and warning systems for the authorities and the public.

4.5. RECOMMENDATIONS

1. As mentioned above an integrated air quality management system combines the use of monitoring data with modelling tools. The expansion of monitoring capacity should be implemented in coherence with modelling. Only a combination of monitoring and modelling is able to provide comprehensive information with a full spatial coverage of the region of interest. Models provide complementary information to monitoring data which allows evidence based decision-making. A model analysis can reveal new air pollution hotspots which are not measured yet and the models in use ideally dictate the (future) monitoring requirements. This should be included as a requirement in one of the relevant AQ legislations (without having a thorough knowledge of all AQ legislation at this stage it is difficult to say which one)

2. The core component of the early warning and emergency response systems are complex integrated AQ modelling systems. During our discussions with the local governments it was evident that much more support in understanding and implementation of these complex emergency response systems is required.

3. When applying models for policy support, the type of model should be selected based on the fit-for-purpose criteria. It is well known that robust tools are essential in an operational context like the early warning or emergency response systems. In addition to the complex deterministic air quality models, simple statistical models for both spatial mapping and forecasting can do an excellent job in an operational setting. They are conceptually relatively simple, require limited input data but have high quality output (currently the most performant models available). Despite their excellent skills for specific applications (mapping, forecasting), statistical models are not suitable to diagnose the cause of high pollution weather and to identify effective abatement strategies.
CHAPTER 4 USE OF MODELS FOR AIR POLLUTION POLICY SUPPORT

4. The emphasis on high pollution weather is important but is currently not the highest priority. High pollution weather or pollution episodes are relevant policy targets when the overall air quality is good and incident management has to take place. **Currently in many urban areas it is not ‘high pollution weather’ but ‘high pollution’ that should be policy priority number 1. Development of emission reduction policies, in addition to the forecasting/warning, is a top priority.** It is the overall pollution burden that is a concern and once that is lowered, specific incident management becomes important. For the time being: pollution reduction = episode reduction.

5. Any country (including China) with an action plan to reduce air pollution concentrations by certain % targets by definite deadlines needs to improve assessment and scenario analysis to identify and monitor how best (reduction quantity & cost efficiently) to achieve this. The models, the emission data and the understanding of these concepts were found lacking at local and regional level. Most of the knowledge seems to be still at an academic level. **Capacity building and the acquisition of the scenario modelling tools, reliable emission data (NB: of all sectors, not just the industry and power) and data on the cost of emission reduction strategies are needed.** This requires collaboration between different disciplines (air quality, emission inventorying, meteo, industrial economists, planners) and different regions as air pollution is a transboundary phenomenon.

6. Chemistry Transport Models (CTM’s) are essential to gain insight into the complex physico-chemical nature of the air pollution phenomenon and to diagnose what causes a specific situation. However those complex models are more demanding in terms of input data and personnel skills and in general have a lower performance than statistical tools. **CTMs are only recommended for specific studies and (currently) not for routine or operational use.**

7. Acquiring all relevant information for scenario analysis is a challenging task. **To facilitate local scenario modelling for the assessment of future situations and new projects the government or a government designated institute could annually provide a set of modelled background concentrations for a base year and projections under a certain policy option.** In the Netherlands this is the case and both last year’s concentration map as well as a projection of a 10 to 15 years concentration map is provided annually. This way local authorities do not have to run complex CTM’s, acquire appropriate boundary conditions etc. They can relatively easily add individual local projects to the officially supplied backgrounds.
ANNEX A: DIFFERENT WAYS OF LOOKING AT ENVIRONMENTAL MANAGEMENT IN THE EU AND IN CHINA: THE ROLE OF EMISSION POLICY AND EMISSION STANDARDS.

Introduction

A difference in the way the environment is handled between the EU and China is the fact that in the former it is ‘managed’ whilst in China it is ‘protected’. Though this seems a minor semantic difference it is a rather different way in thinking with considerable consequences. Protection is a defensive concept. It suggests that something is disappearing/threatened if not protected. Hence the concept of ‘GDP or environment’ or ‘jobs or environment’. For at least 40-50 years we know that this is a false thesis, a wrong way of looking at the questions at stake.

One should not be drawn into this false discussion. Management of the environment treats the environment as a resource, like other resources, money, labour, raw materials, etc. who’s use needs to be planned. If someone discharges a pollutant into the air, for the factory it is a convenient way to use the resource ‘air’ to get rid of the pollution. However, if the resource ‘air’ is afterwards no longer suitable for breathing the use of that resource by millions of others is compromised.

In the protection concept stopping pollution is a cost to a factory for the benefit of the goal of protection. In the management concept one weighs the cost to the factory to the cost of society (not being to breath healthy) and decides what a wise, economically efficiently, etc. use of the resource ‘air’ would be.

A second reason why it is important not to speak about ‘protection’ but about ‘managing’ or ‘planning’ is the fact that the latter are forward looking activities. One can forecast the need for the availability of a certain resource and analyse who has to reduce which emission, where, with what percentage. By setting target emission, performance standards and national or regional ceilings, progress can be monitored.
1.1 Jobs and Environment: evidence of reducing emissions and assuring economic growth

The graphs on the left show the economic production in the Netherlands as an index relative to the year 2010 (2010 = 100). The line shows a steady increase except for the world-wide economic crisis in 2008/9 when production dropped. Data on local industrial production is not readily available in a long time series. Rotterdam being the largest industrial area in the Netherlands (with about 5% of the national employment and generating about 10% of national GDP) shows a similar evolution.

The graph below shows the historic evolution of the concentration of pollutants in the Rotterdam area. Not all pollutants were monitored from the beginning (1970) and the levels at which they occur are quite different. For that reason the graph shows a relative index where the concentration in the first year of monitoring was set at index = 100.

The graph shows an almost monotonous decline for the concentrations of most pollutants over a 40 year period, despite increasing industrial production and power generation in the area. For NO2 and Black Smoke growing production led to more or less stable concentrations in the first 15 years but from 1990 onward the trends have been strongly downward whilst production increased.

Apart from falsifying the thesis that it is ‘economy or environment’ this example also provides a potential answer to reduce Not in My Back Yard (NIMBY) discussions. Often it will be possible to expand production capacity without adding additional pollution by agreeing at the same time on modernisation and emission reduction. In Rotterdam this has often been a convincing argument.
1.2 Planning the use of environmental resources

The EU has a history of policy modelling. These are studies that link future emission scenarios to expected changes in concentrations in various countries and regions. The costs of emission reduction (per sector) is known, as well as the likely benefits in terms of health improvements, agricultural production etc. This way the most efficient choices can be made. Overall European policy translates into national policy and national emission ceilings (NEC). In the Netherlands this is further translated into emission evolution per sector and future concentrations maps are made on an annual basis. This allows us to plan ahead and see if the policies agreed upon are likely to have the desired impact.

See for example tables with various forecasted emission scenarios for the UK (report AEA/ENV/R/3337, 2012). The scenarios explore the impact of assumptions on future economic growth, fossil fuel prices, agricultural activity and degree of implementation of the UK’s existing climate change measures on the national emission totals.

<table>
<thead>
<tr>
<th>Table 0-2</th>
<th>All scenarios for 2025 by pollutant (kilotonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>NH₃, PM₁₀, PM₂.₅, NOₓ, SO₂, NMVOCs</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>NH₃, PM₁₀, PM₂.₅, NOₓ, SO₂, NMVOCs</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>NH₃, PM₁₀, PM₂.₅, NOₓ, SO₂, NMVOCs</td>
</tr>
<tr>
<td>Scenario 4</td>
<td>NH₃, PM₁₀, PM₂.₅, NOₓ, SO₂, NMVOCs</td>
</tr>
<tr>
<td>Scenario 5</td>
<td>NH₃, PM₁₀, PM₂.₅, NOₓ, SO₂, NMVOCs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2-3</th>
<th>UK Emissions of Nitrogen Oxides (NOₓ) 2005 to 2030 (kilotonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector</td>
<td>2005</td>
</tr>
<tr>
<td>Combustion in energy industries</td>
<td>495.62</td>
</tr>
<tr>
<td>Industrial combustion</td>
<td>261.73</td>
</tr>
<tr>
<td>Industrial process emissions</td>
<td>11.00</td>
</tr>
<tr>
<td>Other stationary combustion including domestic heating</td>
<td>128.82</td>
</tr>
<tr>
<td>Fugitive emissions from fuels</td>
<td>3.14</td>
</tr>
<tr>
<td>Transport</td>
<td>678.23</td>
</tr>
<tr>
<td>Waste</td>
<td>1.26</td>
</tr>
<tr>
<td>Other</td>
<td>0.32</td>
</tr>
<tr>
<td>Total</td>
<td>1580.10</td>
</tr>
</tbody>
</table>

Air pollution is a transboundary process (hence the international agreement in the Gothenburg protocol / NEC in the EU) so Chinese national emission targets would have to be translated into regional/provincial obligations. Large scale modelling will reveal which province contributes how much to another province. Data on modelled source receptor matrices in the EU are available through EMEP (EMEP is a scientifically based and policy driven programme under the Convention on Long-range Transboundary Air Pollution (CLRTAP) for international co-operation to solve transboundary air pollution problems: http://www.emep.int/).

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4 http://uk-air.defra.gov.uk/assets/documents/reports/cat07/1211071420_UEP43_%282009%29_Projections_Final.pdf

See for example the table below, a part of the table from appendix B in the EMEP 2014 report (See: http://emep.int/publ/reports/2014/EMEP_Status_Report_1_2014.pdf).

Figure: Example of EU ‘blame matrix’ for nitrogen deposition. Horizontally it shows how much each country contributes to itself and others and vertically from which country the deposition originates. The case for Great Britain (GB) is highlighted as an example.

`Blame matrices’ and ‘emission ceilings’ demonstrate that agreements between countries (EU) or provinces/regions (China) are useful policy instruments to deal with transboundary problems. In the above example for Great Brittan the total pollution contribution from abroad is even larger than the local sources. This demonstrates that in the EU international (in China inter-provincial) agreements on emission reductions are needed to address air pollution and deposition problems.

Reports on the total emissions per country (see example below) that show which countries are meeting their targets and which are lagging behind (and hence also causing problems for their neighbours).

Table: Example national emission ceilings report showing who has met his obligations according to the Gothenburg Protocol (GP) and who hasn’t. (Emission in Gigagram (Gg) per year; source www.ceip.at/fileadmin/inhalte/emep/pdf/2012/Status_GP_2012_NOx_NMVO.pdf)

<table>
<thead>
<tr>
<th>NOₓ</th>
<th>2010 emissions [Gg]</th>
<th>GP ceilings [Gg]</th>
<th>Distance to ceiling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>221</td>
<td>181</td>
<td>22%</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>115</td>
<td>266</td>
<td>-57%</td>
</tr>
<tr>
<td>Croatia</td>
<td>71</td>
<td>87</td>
<td>-19%</td>
</tr>
<tr>
<td>Cyprus</td>
<td>18</td>
<td>23</td>
<td>-22%</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>239</td>
<td>286</td>
<td>-16%</td>
</tr>
<tr>
<td>Denmark</td>
<td>129</td>
<td>127</td>
<td>1%</td>
</tr>
<tr>
<td>Finland</td>
<td>167</td>
<td>170</td>
<td>-2%</td>
</tr>
<tr>
<td>France</td>
<td>1,080</td>
<td>860</td>
<td>26%</td>
</tr>
<tr>
<td>Germany</td>
<td>1,323</td>
<td>1,081</td>
<td>22%</td>
</tr>
<tr>
<td>Hungary</td>
<td>162</td>
<td>198</td>
<td>-18%</td>
</tr>
<tr>
<td>Latvia</td>
<td>34</td>
<td>84</td>
<td>-60%</td>
</tr>
<tr>
<td>Lithuania</td>
<td>58</td>
<td>110</td>
<td>-47%</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>46</td>
<td>11</td>
<td>320%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>276</td>
<td>266</td>
<td>4%</td>
</tr>
<tr>
<td>Norway</td>
<td>184</td>
<td>156</td>
<td>18%</td>
</tr>
<tr>
<td>Portugal</td>
<td>186</td>
<td>260</td>
<td>-28%</td>
</tr>
<tr>
<td>Romania</td>
<td>272</td>
<td>437</td>
<td>-18%</td>
</tr>
<tr>
<td>Slovakia</td>
<td>89</td>
<td>130</td>
<td>-32%</td>
</tr>
<tr>
<td>Slovenia</td>
<td>45</td>
<td>45</td>
<td>0%</td>
</tr>
<tr>
<td>Spain</td>
<td>890</td>
<td>847</td>
<td>5%</td>
</tr>
<tr>
<td>Sweden</td>
<td>161</td>
<td>148</td>
<td>9%</td>
</tr>
<tr>
<td>Switzerland</td>
<td>79</td>
<td>79</td>
<td>0%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1,106</td>
<td>1,181</td>
<td>-6%</td>
</tr>
<tr>
<td>United States of America</td>
<td>—</td>
<td>6,897</td>
<td>—</td>
</tr>
<tr>
<td>EU-15</td>
<td>7,219</td>
<td>6,671</td>
<td>8%</td>
</tr>
</tbody>
</table>

The EU runs an EU wide modelling service called EMEP for these studies that feed back into national policies. For actual policy modelling including economic aspects of emission reductions the EU relies heavily on the work of IIASA. The IIASA policy models use EMEP source-receptor matrices as input.

A countrywide modelling and policy modelling service would provide an important framework for regional/provincial emission policy making within the national framework.
1.3 Setting future standards

Hou and Geerlings, comparing environmental aspects of transport policy in a large Chinese port and the largest EU port (Shanghai and Rotterdam), note that in Rotterdam there is a whole list of future standards entering into force between now and 2020, whilst in Shanghai there are only current standards. They write:

“Why is standard setting an important tool? The setting of technical standards can be seen as an aid for the government for the cost-effective development of new technologies. An intensive use of this instrument looks desirable, as long as sustainability is underexposed compared with economic and sociological aspects. [...] Secondly, standards act as a constraint on behaviour. Environmental performance standards already cover a wide range of topics. It is likely that these standards will have the incidental effect of creating a commercial inducement to find the most cost-effective means of compliance.

Thirdly, well-defined standards have the advantage that they define the total playing field: all competitors in the market are influenced by the same constraints. [...] Finally, imposing standards in the total market creates the opportunity for manufacturers to internalise the costs of measures to be taken into the price of the product.”

And indeed what is relevant for transport applies to all sectors, having clear future standards gives entrepreneurs the time to adapt their production process, to time upgrades in conjunction to necessary maintenance, etc. if there are costs associated to clean production the more efficient producers will survive whilst excessive capacity will, by price mechanisms, be gradually forced out of production. Country wide standards on emissions per unit of fuel (the best available technology) assure a level playing field between the different EU countries that compete for investment from multinationals. Similar unwanted competition between provinces can be avoided by defining BAT ranges for China.

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5 PORT RELATED TRANSPORT MANAGEMENT AND THE GOVERNANCE OF AIR POLLUTION; a comparative study on emission standards between China and Europe and the position of ports. Forthcoming.
1.4 Evidence that standard setting is necessary to enforce innovation (emission reductions)

Setting standards/legislation is the only way to reduce emissions. Sometimes companies voluntarily reduce their emissions if innovation brings other gains (e.g. efficiency, reputation) but in most cases legislation is the main driving force. This can be illustrated by graph and the table below.\(^6\)

**Table: Evolution of the ratio NO\(_x\)/CO\(_2\) (g/kg) for the Rotterdam port industrial area (2008 data).**

<table>
<thead>
<tr>
<th>Sector</th>
<th>1990</th>
<th>2005</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy/industry</td>
<td>2.0</td>
<td>0.9</td>
<td>0.6</td>
</tr>
<tr>
<td>Road transport</td>
<td>20.0</td>
<td>7.5</td>
<td>1.1</td>
</tr>
<tr>
<td>Shipping (forecast 2006)</td>
<td>23.0</td>
<td>21.9</td>
<td>22.4</td>
</tr>
<tr>
<td>(forecast 2010)</td>
<td></td>
<td></td>
<td>15.1</td>
</tr>
</tbody>
</table>

**Figure Relative evolution of the ratio NO\(_x\)/CO\(_2\) for the Rotterdam port industrial area (1990 = 1)**

The table shows the amount of NO\(_x\) emitted per unit of CO\(_2\). In this example we take NO\(_x\) as indicator for pollution and CO\(_2\) as indicator for fuel use and hence intensity of an activity. The table shows that the stationary sources (energy, industry) have the lowest NO\(_x\) emission per unit of fuel. This was the case in the 1990’s and this advantage is predicted to remain into the future (2025). This can be explained because stationary source tend to have a continuous process that can be relatively easily tuned to minimise emissions.

Secondly the stationary sources were the first ones to be regulated after the periods with major industrial pollution in the 1950/60’s.

The table also shows that in 1990 the pollution per unit of fuel was quite similar for mobile sources (road transport and shipping). However from that time onward both sectors evolve quite differently: Road transport is land based and of crucial importance for urban air quality. Authorities clearly have an interest in regulating vehicle emissions and because of the EU collaboration this could be achieved relatively easily (limited number of countries). International shipping was hardly regulated (takes almost every country in the world to agree) and didn’t show any trend of reducing shipping emissions per unit of fuel. Taking the forecast in 2008 into consideration the emission reduction was estimated to be absent over a period of 35 years, despite the fact that reduction

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\(^6\) Based on data from Rotterdam Climate Initiative, Netherlands Environmental Assessment Agency (PBL)
technology was available (as can be seen from the other sectors). In 2008 after a long and laborious process IMO agreed on some measures to curb shipping emissions and this is anticipated to finally reduce shipping emissions (a bit)\(^7\). The graph shows how the performance of the different sectors evolve over time. It is clear that the most heavily legislated sector shows the most improvements.

**Conclusion:** The example shows that technology to reduce emissions is available and that it takes legislation and enforcement to assure that it is applied.

\(^7\) For another example: the EU legislated the S-content in shipping fuels in its coastal waters per 2007. This led to a measurable reduction of the SO\(_2\) concentrations per 2007. See: Velders et al.
ANNEX B: COMMUNICATION: THE PURPOSE OF AIR QUALITY COMMUNICATION

The purpose of providing air quality information is **to be accountable, for risk communication** and **to raise awareness**. Currently it is mainly seen as providing information to the public and warning them of adverse pollution conditions (e.g. risk communication). Communication should be treated as part of air quality management: communication should:

- Demonstrate that the government is taking up its role in reducing air pollution and explain what the policies and actions are (and thereby generate support for these policies and actions) and what the public might expect from these policies. This communication aspect is of crucial importance for the trust in an authority or government with the duty to issue licenses and do inspection. After all by issuing a license the authority states that in their view the operations can be performed in a sufficiently safe and clean manner. If the issuing authority is not being trusted (as competent, impartial, etc.) each new economic development with an environmental impact might meet resistance. The ‘Not in My BackYard’ sentiment could be strong and hard to deal with.

- Raise awareness by explaining where air pollution comes from and that every individual contributes to it by their consumption choices, in particular mobility, heating, energy use. The general public is not only a victim of poor air quality but also a source and hence part of the solution. If this awareness issue is not addressed the whole burden of cleaning up the environment will rest with the government and the sentiment that government is not (sufficiently) doing its job can be strong.

- Risk communication can assist in reducing exposure and hence the consequences of pollution. Risk communication is complicated: warnings often come too early or too late and in any case the message is negative (something is wrong). Therefore it is useful to not only issue a warning but also provide information on what is being done (by the government) and what people can do themselves. This helps to create support for often very disruptive and unpopular measures (such as traffic bans, factory shutdowns, etc.).

**Government** communication in general

Almost any communication takes place in a very competitive ‘market’. The amount of information available is enormous: if one wants to achieve his communication goals one has to make sure that one’s information is being found, else the efforts are in vain.

The quality of the environment including air quality has become a topic of public debate in China (and elsewhere) so a government/public authority is always competing with other information providers. In the case of air quality in China there are ‘new media’ such as several private websites and apps, Weibo, the US Embassy information feed, etc. In addition there are ‘old media’ such as the national and international press, reports, brochures etc. In general governments cannot simply provide their information thrusting that, since they are the authority, they will be believed. Governments have to make an effort (‘fight’) for the attention of their citizens to ensure that their message is the one that is being heard, believed and retained!
In the Netherlands there is a recent experience (2010) of government communication gone completely wrong: public health authorities proposed and prepared a vaccination campaign addressing parents in a rather old fashioned way a letter to the parents telling them to send their children for vaccination. Immediately on the internet a lively discussion arose on the pros and cons (mainly cons!) of vaccination. Since the government relied on their old fashioned paper communication just saying: believe us we know best, the sometimes bizarre stories on the internet remained unchallenged. In the end many people didn’t turn up, vaccines were not used and a lot of money was wasted.

The lesson to be learned is not to just trust on your authority but to engage directly in the debates using the appropriate media. During one of our workshops we learned that in China Shanghai EMC actively follows debates on internet and if relevant participates. This is an example of the proactive attitude that is needed for successful communication.

In essence the example also shows that communication is a two-way process. The sender has to learn the information needs the way people want to be informed, the level of knowledge, etc. and the perceptions of his intended audience. The only way this can be achieved is by soliciting feedback. This involved questions like: was the information well received, understood, to the point, etc.; and even more importantly do you consider me as a credible source of information? Communication is aimed at establishing mutual understanding and trust. In the business world were success partly depends on successful publicity and marketing, the marketing agencies do study the impact of their publicity campaigns. Governments should do the same with their communication campaigns.

Since ‘the public’ is not homogenous in the way they want to be addressed, in their level of knowledge, in their attitude towards the government a communication specialist will distinguish different target groups that are approached in different ways. E.g. at the two extremes there is on the one hand the very vocal group that use apps for their information, that participates in discussions on the environment on Weibo, etc. and there are people who don’t even know that air pollution is a problem that affects them, that don’t use a smartphone, etc.

In many countries and many cities it is often the air quality scientists who become responsible for communicating the AQ information to the public. They are typically not communication experts and therefore it is recommended that they are supported by true communication or even (private sector) marketing experts. Regular government communication support staff is often not used to (and hence not particularly experienced in) delivering messages in a highly competitive context.

A second risk of highly educated air quality specialists being responsible for air quality communication is that they take for granted that everyone is interested in air quality and everyone uses the same high tech communication means (computer, internet, smartphone). Above the target group concept was mentioned. In AirINFORM we learned from an awareness campaigns in Yangzhou city that indeed a part of population was not very interested in, not concerned about air pollution for them the AQ communication needs to be simple, not technical. The public awareness events (square event, questionnaire and monitor centre visit) showed that substantial parts of the public do not understand air quality communication that is too technical. The public does not understand what the complex terminology means and from which source air pollution originates. As a response simple information material was developed (animations) that can be shown at
schools, at local TV, etc. that explain the basics: Why is air pollution bad for you? Where does it come from? What can you do yourself? What are we doing?

**Being accountable**

A government is responsible for the health and well-being of its citizens and derives (part) of its legitimacy from their success in this respect. So, communication plays an important role in explaining what the government does and what the public might expect at which time from the government. This applies both to air quality policy in general as well as during emergencies (during risk communication). If a (local) government is not successful in explaining what is happening and why they might be criticised by the public, the public might lose their confidence in the authorities, etc. It is therefore very important that (local) governments take their communication seriously and that they provide correct, attractive, appropriate and convincing information.

As mentioned elsewhere in this chapter, the Chinese authorities face competition from several sides in their AQ communication. Apart from improvements in the communication method they should also look at the content of the messages as improvements are possible. Two points of attention are suggested:

- the wording of the AQI messages (discussed more extensively in the chapter on the AQI)
- the common expression of ‘high pollution weather’. Though unfavourable weather conditions do play a role, the air pollution originates from excessive emissions. All communication should acknowledge this and air pollution should not be communicated as a natural phenomenon/natural hazard.

**AQ Risk communication**

In recent years, serious regional haze occurred in China, which puts significant pressure on communication of the risks involved. How to handle the communication aspect is a relatively ‘new’ issue for China. The key lesson learned from this project about the risk communication, is that the city authorities, as well as communicating the ‘bad effects of air pollution’, need to take action to improve the situation, to explain to the public what they are doing and inform the public what they can do to help improve the situation.

Some cities have published their emergency plans for severe air pollution day, e.g. elementary school students reduce the outdoors sports or stay at home, the odd and even license plate rule. However, the risk communication can be further improved. The messages to the public could be more precise and informative. In many cities the AQ forecasts still require significant improvement in order to be used as a timely tool. In the future, risk communication should include more detailed information (by hour and by region). This was acknowledged by CNEMC (Mr WANG) during a project workshop: China needs to publish AQI forecasting information as soon as possible; improve the recent 24-hour AQI for particulate matter to Nowcast AQI to avoid the lag effect.

Currently there is a lot of emphasis in the communication on the direct immediate effects of air quality (short-term behavioural advice). However currently, it most cases the air pollution problem can only be improved with long term policies and legislation. A communication strategy and a slightly adapted wording of the AQI messages, that focusses more on the long term exposure
seems more appropriate. Once pollution levels have come down and the nature has changed from structural to episodic, the current system can be re-instated.

**Public awareness**

Raising public awareness of air quality and the sources of air pollution is very important for China. Based on Europe’s historical experience of air pollution control, the key sources of air pollution will change once sources begin to reduce due to legislation and policies. For example, in most of Europe’s cities, traffic is currently the major source of urban air pollution. But this is only after air pollution from point sources (industry, power plants etc.) was significantly reduced. Thus the Chinese government needs to explain in simple terms how these sources contribute to the problem and send a message to the public that the public is not only a victim but also at times an important source of the air pollution.

During the AirINFORM communication workshop Mr. WANG said that “for public awareness, one key urgent aim is create more trust with the public”. The public need to understand the story behind the complex AQ problem! MEP has a department of Publication and Education and the project suggests that this department could team-up with CNEMC to initiate a unified AQ information strategy across China and supporting local EMC-s with their communication.

In addition to the development of information material and information strategies the department could assure/facilitate training and exchange visits between the various EMC-s so that they can learn from each other’s experience or from more experienced EMC-s. It is advisable to associated marketing specialists, at least initially, as that is the sector with the most developed skills in this domain.

**AQ Communication experiences in some EU countries**

EU legislation gives the general principles on access to environmental information (‘Aarhus legislation’) and the way this is actually implemented varies from one country to another. The air quality legislation provides specific instructions on the levels of pollution when the public needs to be informed. In most countries the publication of ambient air quality data on the internet (either pure data or an AQI) is the way to implement these obligations. The way China publishes its AQI is similar to the way this is handled in many EU countries.

One of the major differences between EU and China on the access to information is the public access to emissions data nationally and for big plants individually (http://prtr.ec.europa.eu/). Also the possibility to access/download hourly monitoring data and many other environmental data is different. In general this is possible in various countries and at the EU level this is assured by the European Environment Agency (www.eea.europa.eu/about-us).

Making information available (AQI, emissions) is the first step towards environmental communication. The main difference between the EU and China is the large civil society that is active in the EU that uses this information and plays a role in raising public awareness putting pressure on both polluters and governments if they are not active (enough) in solving problems. These NGO-s are often privately sponsored but often also receive (local) government support as they play an active role in achieving a common goal: a healthier environment. Though this varies
from country to country and is subject to changes over time (depending on the political colour of the government or the economic tide) it is not uncommon that governments subsidise NGO-s to do their work. Occasionally this results in a situation where the NGO criticizes the very government that pays them.\(^8\) The civil society plays a useful role in educating the public, raising awareness, etc. in particular where people might distrust the government’s motives/position it can be very useful to associate NGO’s to assure part of the communication as they might be considered a more credible source of information. Teamwork of NGO-s and authorities to improve trust in the message is also a solution.

In the Rotterdam port-industrial area there is a platform (‘platform nuisance and safety’) that discusses industrial nuisance. The meetings are organised by local NGO-s, representatives of the industries, the EPA and the public health authority. The meeting is chaired by a local politician. Everyone can contribute agenda items and questions are dealt with by a combination of subject matter specialists supported by a communication expert. The fact that all angles and stakes of a problem are covered in the organisation of these meetings gives them the necessary legitimacy.

The Dutch NGO ‘Defense for the Environment’ has been quite active in making people aware about traffic and air pollution. E.g. they have a benchmarking competition: the ten dirtiest streets in the Netherlands, they organise cycling tours along so called ‘coughing routes’ to draw the attention to the exposure of cyclists, etc. The top ten dirtiest streets action annoyed several city authorities and has hence led to improvements. The NGO employs amongst others subject matter specialists (health, environment, legal) and so-called ‘campaign leaders’ responsible for developing catchy activities, educational material, etc. that draws public and media attention.

To facilitate the work of NGO-s active in the Rotterdam area, DCMR (the regional EPA) publishes more than the bare (legal) minimum of information. We assure that public information on sources (individual companies, and sectors such as traffic, shipping and industries) are available in easy to understand formats.

An example of an international NGO that started back in 1982 (at the time fighting acid rain – hence the name of their publication ‘Acid news’) and that is still active is ‘The Air Pollution & Climate Secretariat’ (http://www.airclim.org/). They provide good information on air quality (and nowadays climate) policies, background information, they issue newsletters have a collection of fact sheets, etc. This is a credible organisation that plays an important role supplying environmental information and in the lobby for clean air. Needless to say, the industries have similar (lobby) organisations that do studies and spread their information and views on environmental issues. To give just one example: CONCAWE (www.concawe.eu/Content/Default.asp) is an organisation representing the oil refineries in Europe.

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\(^8\) In the Netherlands the NGO ‘Defense of the Environment’ enjoyed government subsidies for awareness programs for a long time. In 2013 they were party in a court case over speed-limits against the ministry that subsidizes their activities.
The detailed findings of this study, can be found in the document “Air Quality Communication with Special Reference to the AQI”, *Parts I and III of the AirINFORM Deliverable D2.3*.

An air quality index (AQI) is a communication tool. It is also a technical way of aggregating a lot of different, often complex information, and making it ‘simpler’ and clearer for communicating purposes. In this project we have focused on the use of the AQI as a ‘communication tool’ and how this affects the technicalities of making an index.

**Short findings:**

- The new Chinese AQI comprises of the relevant air quality pollutants. The AQI calculation grid generally resembles the US-grid. For the higher concentrations the grids are consistent; at the lower end the US AQI is stricter. Compared to other indices worldwide the appreciation differs, no index is the same. The fact that the Chinese index strongly resembles the US index but is not fully identical is a source of confusion (sometimes exploited by non-government websites and apps).

- The concentration range covered by the AQI is very wide; this is still needed given the occasionally extremely elevated concentrations that occur in China. One could even consider adding an extra band.

- The Chinese AQI is designed and used to provide health and behavioural advice to the public to deal with short-term exposure to air pollution. This is a valid communication objective. However given the current air pollution levels in China, one could question whether it is the most appropriate objective. This leads to awkward communication messages, e.g. the short-term peaks last quite long! *A re-think of the air quality communication strategy could be useful, as it will improve the credibility of the government communication messages (and hence the government role in air quality management).*

- The fact that health and behavioural advice is one of the key communication objectives of the AQI makes it necessary that the AQI information is current (last hour) or even better is forecasted. The current averaging times for PM (24-hours) should ideally be revised to 1 hour. It has come to our attention that some cities (e.g. Shanghai) have stated to experiment with this in the course of 2014. The next step (*and urgently needed*) is the development of proper hourly grids for PM.

- In any case the ‘health effect’ messages (and the accompanying mitigation measures proposed), associated with the AQI bands need a careful review. Ideally the authorities should not only issue statements but also take short-term actions pertinent to the situation reported and communicate on their likely impact.

- Whether the AQI band breakpoints need revision and how the accompanying texts could be revised depends on the communication objectives of the authorities. Several lines of thinking are proposed in the document. Some suggestions by the author of the report are included at the end of this chapter.
• Considering the fact that the current air pollution problems are more inherent than temporal, communication materials aimed at raising awareness, monitoring policy, etc. could be developed in addition to an AQI used for communicating the status of the hourly and daily air quality.

**Key recommendations:**

• Reflect on communication as part of the government’s air quality management strategy and the role the AQI can play, given the current air quality situation.

• Apart from the governmental authorities, many other sources of air quality information exist online and via apps. This information is not always consistent. It is recommended that the authorities be very active in supplying air quality information to make sure that they are/will be seen as the dominant supplier of air quality information within China. This enhances the consistency of the information supply to the public. This implies using all relevant communication channels (news media, internet, apps, and social media) and ensuring that the information is clear, complete and attractive. In the document suggestions are made and examples are cited that can assist in making interesting communication packages.

• Worldwide, indoor air quality is an important concern. In areas where outdoor air pollution is elevated and the public might (erroneously!) seek to protect themselves by staying indoor, it is important that those responsible for issuing information and advice on outdoor air quality are aware of the relationship between the two. Ideally it is recommended to make a more complete air quality information package by including indoor air quality messages in addition to the AQI. This integrated approach would be quite innovative as in most cities across the world these messages are handled by two separate departments/organisations. Most likely they are sent independently (different channels, different timing), integral behavioural advice is not given. The important point to note is that - for effective supply of information - there should be some co-operation between those responsible, especially if one recommendation is functionally related to the other.\(^9\)

• Given the fact that PM is one of the most health-related air pollutants in China and worldwide, examine the possibility of providing more information on particulate pollution. This seems to be the ‘hottest issue’ in China. The AQI uses the principle that the highest pollutant determines the AQI. This is a common and valid approach but it could be expanded by providing some additional information on the nature of the pollution when PM is elevated. We suggest making the calculation grids for PM\(_{10}\) and PM\(_{2.5}\) consistent with the ratio in which they occur. E.g. the PM\(_{2.5}\) daily grid should be 0.56 *the PM\(_{10}\) daily grid. This way PM\(_{10}\) and PM\(_{2.5}\) iAQI-s should be quite similar on average. If in certain places or at certain times they differ a lot this is an indication that the PM pollution is mainly coarse (e.g. fugitive dust) or fine e.g. of (photo)chemical nature.

**An update of the Chinese AQI could involve the following steps:**

In the order of importance (approximately):

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\(^9\) In the document ‘Air Quality Communication with special reference to the AQI’ (ref D2.3, Part I), Box 13, pg. 59 some examples of Indoor-Outdoor AQ communication practices are given. For example Hong Kong EPB has sections on their website both on outdoor and indoor AQ. This reflects the importance of the latter (see indoor air quality) and is a first step to integrated communication.
1. Change the messages of the AQI bands to ensure that there cannot be a false impression that staying indoors is a way to protect yourself. The message should cover (advisable to consult an air pollution and health expert for the exact messages):
   - Avoid physical activity/activity that makes you breath faster
   - If you have an indoor environment with filtered air with high quality filters (such as ....) spend as much time as possible in that environment
   - Use masks of the appropriate type (such as ...) in the appropriate way
   - Consult a physician concerning adapting medicine use

2. Provide information on indoor air quality and ventilation behaviour. This should be made available as general information together with the AQI as one information package. (Reference to this information should be highlighted during extreme air pollution episodes, ideally in conjunction with a mass media awareness campaign.)

3. Change the general wording of the AQI bands to make them less behavioural oriented and more policy oriented (e.g. meets/exceeds/exceeds by far the standard for short term exposure). Providing short-term health advice is currently not a priority. If Beijing is an example for other Chinese cities, the air quality is too bad for short-term exposure strategies to be relevant. This implies that air quality communication and the AQI should also be framed relative to general pollution reduction rather than protection of oneself from pollution peaks (which are currently unavoidable!).

4. The concentration range that is currently covered is appropriate but I would add an extra band (>500). This way the index is never ‘off the scale’ and the worst category occurs less frequently.

5. Start reporting AQI-s grouped by land use or exposure type: urban background, roadside, industrial, etc. At any given time a city would then be characterised by 1 to 3 AQI figures, providing a more comprehensive view of the sources of the air pollution, and the levels of pollution to which the public is actually exposed.

6. Develop information on the nature of the PM pollution (is it mainly coarse, mainly small, etc.). This is facilitated by the suggestion under 8, though this is not even necessary. Combine this with information on haze, sand etc. (See sample image at the end)

Several subsequent alternatives exist which I have grouped into 3 main options (indicating my preference from a to c):

7.a Further ‘Chinesify’ the AQI by changing the name; dividing the scale by 2 to get a range from 1-250 to stress that it differs from the US.
   This ‘complete’ overhaul also provides the opportunity to make improvements to the calculation grid (as under 8 and 9) and overcome some

7.b Make sure that the breakpoints of the US and Chinese AQI are identical: the advantages of a different PM$_{2.5}$ grid don’t outweigh the fuss and the ‘suspect’ publicity of the confusion. (Note that this

7.c Make sure that the breakpoints and the wording of the US and Chinese AQI are identical: the advantages of a different AQI don’t outweigh the fuss and
An ex C: AQI as a Communication Tool

of the disadvantages of the US grid that acted as an example for the Chinese. Combined with suggestions 3. and 4. this should make clear that the Chinese AQI is not a ‘fake US AQI’ but an AQI in its own right

8.a Harmonise the PM$_{10}$ and PM$_{2.5}$ and breakpoints to assure a constant ratio over all bands. This can be done by adapting PM$_{2.5}$ to PM$_{10}$ as this is the oldest pollutant in the AQI/API system; or by adapting PM$_{10}$ to PM$_{2.5}$. From a consistency point of view there is no preference.

8.b Harmonise the PM$_{10}$ and PM$_{2.5}$ and breakpoints to assure a constant ratio over all bands. Do this by adapting the PM$_{10}$ breakpoints to the revised US PM$_{2.5}$ breakpoints. This way one can’t be accused of being too lenient on the most health relevant pollutant currently in the index.

8.c In path c.: just stick to the US AQI

9.a,b Develop grid breakpoints for hourly concentrations for all pollutants e.g. for PM$_{10}$ and PM$_{2.5}$. Revise those for NO$_2$ and O$_3$ as the current ones don’t seem very consistent to the daily grid. See document Part III. (For NO$_2$ and O$_3$ this is less important but it would still improve the AQI. Preferably all changes to the calculation grid that are considered should occur at the same time.)

9.c In path c.: just stick to the US AQI

10.a,b Provide an online AQI calculator that shows all AQI-s in use in the Chinese territory (Chinese & US AQI, RAQI, HK API (or its successor). This helps to make people aware of the difference between the various AQI-s available and stresses the openness of the authorities. This would also encourage users to ‘play around’ with the tool, increasing their awareness of AQI’s and the differences therein.

10.c Also in this case it is a useful/nice educational tool to make AQ interesting, though it is strategically less important.

11. Develop other AQI products e.g. for year averages (both AQI summary and a distance to policy target index), produce AQI maps, etc.

<table>
<thead>
<tr>
<th>Urgency of the recommendations</th>
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</thead>
<tbody>
<tr>
<td>• Suggestions 1 and 2 are both important and urgent issues.</td>
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<tr>
<td>• Suggestion 9 is equally important now that the averaging times for PM have changed.</td>
</tr>
<tr>
<td>• Suggestion 8 is less important than 9 but ideally it should come before 9 (otherwise one keeps on changing the AQI)</td>
</tr>
<tr>
<td>• Items 3 to 7 require reflection on communication priorities</td>
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</tbody>
</table>
10 and 11 are useful additional products, some of which exist already. E.g. many websites in China currently have a map. The project made an AQI calculator that compares several Chinese, US and European AQI-s. It could be widely published.
ANNEX D: AIR QUALITY ASSESSMENT IN A LARGE CITY IN THE NETHERLANDS

This section describes the way in which air quality information is collected and used in the Rijnmond Region in the Netherlands. The Rijnmond is the Netherlands' main industrial area and has Europe’s biggest port. The area is approximately 800 km² and has a population of 1.2 million inhabitants. So it is small compared to Chinese cities/regions. In fact the whole country of the Netherlands is smaller than most Chinese regions.

**The purpose of air quality assessment**

Air quality assessment takes place with various spatial and temporal resolutions and for different purposes. The regional EPA is mainly responsible for assessing the air quality relative to legal limit values and for informing the public. Compliance to legal limit values has to be reported annually and if not, an action plan has to be made. Secondly, when new projects are proposed (roads, plants, residential areas, port extension, etc.) their likely impacts on the environment have to be assessed. Forecasted emissions are used to calculate what the new situation will be and permission to execute the proposed plan depends (amongst others) on the compliance with air quality limit values. All these compliance issues are assessed on a year average time scale because that is the period specified in the legislation.¹⁰

In addition to reporting the air quality and the screening of plans and projects there is the obligation to timely inform the public on (adverse) air quality. This occurs on an hourly (or daily) basis. Apart from the obligation to inform the public, air quality communication is often a strategy to raise awareness on air quality issues. It is fairly widely accepted and documented that communication is an important pillar in environmental policy.¹¹ To achieve this, attractive interactive information is needed so often cities make an effort to supply more/better information than the legal minimum.

**Emissions**

Though most assessment focuses on the prevailing concentrations (air quality), compiling, monitoring and reporting/publishing emissions are equally important. Without proper and detailed emissions it is only possible to run statistical (interpolation, forecasting) models but it is impossible to run diagnostic air quality models for policy development and scenario analysis. Reporting and communicating emissions also allows the public to understand what causes the poor air quality.

**Monitoring or modelling?**

The two go hand in hand and one is not useful without the other:

- One cannot monitor everywhere so one has to model what occurs in between the monitoring sites;

¹⁰ NB this includes shorter averaging time criteria such as NO₂ hourly values that are only allowed to occur 18 times a year or PM₁₀ daily average concentrations that cannot be exceeded 35 times a year.

¹¹ It is the combination of legislation and information that improves the environment. Legislation is generally only effective if it gains popular support and acceptance. Without this legislators are less inclined to make the legislation and inspectors are reluctant to enforce it.
One cannot monitor the future so to be able to timely inform the public, to assess the impact of plans or policy scenario’s models are indispensable;

Models need good emission databases but even the best emission databases are insufficient (temporal and spatial resolution, coverage of all sources, etc.) hence they always need calibration with measurements;

Measurements are more accurate than models and combining the two will give you the best of both worlds.

The amount of measurement sites needed and where to place them cannot easily be generally established and it varies per component. Sometimes legislation describes bottom-line criteria (one monitoring station for every xxx inhabitants or yyy km²). Aspects to take into consideration are:

a. What is the spatial distribution of the air pollution?
   - Low spatial gradients (PM$_{2.5}$, O$_3$) or high gradients (NO$_x$, EC, PNC)? The latter needs more monitoring sites.
   - How important is the background contribution? Often background stations are neglected as expensive equipment has to be placed in areas with relatively low levels of pollution. However, if background concentrations make up 50 % or more of the total concentration the uncertainty in the modelled total concentration will be considerably reduced if sufficient background stations are available.
   - If there are distinct types of exposure (roadside, urban background, industrial areas, port areas) than it is worthwhile to place monitoring sites in each type. This facilitates land use based models (e.g. RIO).
   - If geographical features determine dispersion conditions (e.g. a plain in between mountains), make sure to sample this.

b. What is the temporal resolution on which information is needed? Whether one needs short (hourly, daily) information or longer averaging time information depends on the models with which one wants to combine the monitoring data.
   - To warn the public for adverse pollution one needs high temporal resolution monitoring at least in the areas where the majority of the public is exposed.
   - To validate models for compliance reporting/checking passive monitoring (cheaper) but at more locations can be a useful way to collect information.

Models in use in the Netherlands/in Rotterdam

The models in use at the EPA Rotterdam and in the Netherlands differ for different purposes and according to temporal and spatial resolution. The table below summarizes the models. The numbers refer to further explanations below.
<table>
<thead>
<tr>
<th>Area resolution</th>
<th>Time resolution</th>
<th>Policy analysis (year average)</th>
<th>Year average (forecast/report/regulatory purposes)</th>
<th>Hour/day (report)</th>
<th>Hour/day (forecast)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 x50 km</td>
<td></td>
<td>EU and national policy studies [1]</td>
<td></td>
<td></td>
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<tr>
<td>10x10 / 5x5 km</td>
<td></td>
<td>National policy studies [2]</td>
<td>Modelled/interpolated maps of monitoring results (data assimilation) [3]</td>
<td></td>
<td>Smog forecast (PM$<em>{2.5}$ / PM$</em>{10}$ / O$_3$) [3]</td>
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<tr>
<td>1x1 km</td>
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<td>National, large scale concentration maps [4]</td>
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<tr>
<td>10 m</td>
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<td>Assessment of traffic related air pollution for compliance issues [8]</td>
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1. Policy analysis models at EU scale: Gains/Rains model analysing air quality (and health) consequences of various economic scenarios. For the dispersion part rains/gains is fed by source receptor matrices from an EU wide Eulerian dispersion model called EMEP using a European emission and land use database. The model is used to assess various abatement strategies, their costs and their likely impacts and is used to set EU policy (e.g. CAFÉ) and to prepare for the negotiations on transboundary air pollution (CLRTAP/Gothenburg protocol).

Gains/rains would be an interesting policy analysis model at the Chinese national scale to analyse emission reduction scenarios between provinces and regions. After all a lot of air pollution is a long range problem. The GAINS website mentions model availability for Europe, Asia and China, though access is password restricted. What exactly the capabilities in China are needs to be verified from the makers (IIASA). ([http://www.iiasa.ac.at/web/home/research/researchPrograms/GAINS.en.html](http://www.iiasa.ac.at/web/home/research/researchPrograms/GAINS.en.html))

**Local use/involvement:** this model is not used by regional authorities. The outcome of scenario analysis leads to emission reduction scenario’s (national emission ceilings) that create administrative boundary conditions for regional licensing and enforcement work.

2. For national/regional policy studies two types of models are used: a Lagrangian trajectory model combined with a Gaussian plume model (OPS$^{12}$); and a Chemical Transport Model (CTM)

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$^{12}$ OPS is a Dutch developed model. For more information go to: [http://pandora.meng.auth.gr/mds/showlong.php?id=73](http://pandora.meng.auth.gr/mds/showlong.php?id=73)
Annex D: Air Quality Assessment in a Large City In The Netherlands

The OPS model produces annual average output and has a very limited chemistry included. The Lotos-Euros model produces output at a much higher temporal resolution (1 hour/a few hours) and is particularly useful for the assessment of secondary pollutants (O₃, Secondary Inorganic Aerosols). Furthermore, it can be used to compare models and measurements at a much higher temporal resolution providing more points of comparison and allowing to compare modelled and monitored output for different wind directions. CTM-s are better equipped to study source apportionment. Nevertheless, the simple OPS model is still very much in use for all kind of policy studies mainly directed at primary pollutants¹³ (NOₓ, primary PM). When OPS is combined with measurements, adequate total concentrations can be easily obtained.

**Local use/involvement:** OPS is often used to compare various local development scenarios or to enhance resolution within the framework of models with a course resolution (e.g. detailed study of the Rotterdam port within a 50x50 EMEP pixel). Local scenario’s involving secondary pollutants are rarely made and if so they are requested at one of the national institutes that have a CTM running.

3. For public information, national authorities provide a national map on their website of the current air quality. This is based on actual air quality measurements combined with modelled map with a 7x7 km resolution. The model is a CTM that is run by the National Weather Service (KNMI). The model is also used to forecast smog situations and warn the public accordingly in the case of anticipated smog. The model relies on the same European emission database as under 1. For the Netherlands emissions at a higher spatial resolution are available. In addition to the reported maps (NO₂, PM₁₀, O₃) forecasted maps (up to two days) are provided for PM₁₀ and O₃. The information is available via a website and an app.

**Local use/involvement:** none. To make the information service more appealing a model with a higher resolution would be useful. See 7.

4. These calculations are mainly done with the OPS model. A national environmental institute provides annual concentration maps for the past year and a few forecasted years e.g. in 2013 they reported 2012, 2015, 2020 and 2030. The calculations are done using European emissions for the contributions from abroad and detailed national emissions from the Netherlands. For the forecasted emissions national and European scenarios are considered as well as the international agreements on emission reductions (Gothenburg protocol). The main attention goes to NO₂ and PM₁₀ because these are needed for regulatory purposes. The calculations have a 1x1 km resolution and are calibrated with measurements in the regional and urban background. This annual central supply of modelled maps is a very efficient assessment infrastructure. It assures that all kind of databases only need to be maintained once centrally, and that everyone in the country works with the same reference information and scenarios. Only local details need to be added to assess a new local development. These concentration maps serve as background concentration maps for other regulatory models (traffic, individual point or area sources).

¹³ A primary pollutant is an air pollutant emitted directly from a source.
Local use/involvement: DCMR frequently uses OPS to calculate local scenario’s for regional plans or using alternative emissions if it thinks that the local information is better than the national information.

5. Detailed regional concentration maps. For regulatory purposes detailed calculations to assess future projects are required and that is a specific model application. A Gaussian model including hour by hour chemistry (for NO$_2$) is used to calculate the consequences of all new point and area sources. Typically this is done for NO$_2$ and PM$_{10}$ and, when applicable, for odour. The model output consists of year average statistics (year average concentration, percentiles of concentrations and odour units). A period of 10 year hourly meteo is processed to obtain the percentile values and a ‘meteo independent’ average concentration.

Local use/involvement: this is exclusively a local application. The models for this legal purpose, as well as the meteo data, the background maps (see 4), etc. are prescribed by the Ministry for the Environment.

6. DCMR used to have a regional real time model combining a 100x100m spatial and an hourly temporal resolution (PM$_{10}$ and NO$_2$). It is currently out of order because we are contemplating the approach under 7 and 6 is no longer maintained. The model is basically a statistical model that scales and interpolates pre-calculated modelled concentration fields depending on actual meteo conditions, time of the day and day of the week. This is subsequently combined with actual measurements.

Though the model differs from the RIO-model$^{14}$, the approach is quite similar: use statistical spatial and temporal and meteorological relations to adapt predefined concentration fields and calibrate them in real time with actual measurements.

The advantages of statistical models are enormous: limited computational power is needed (despite high spatial and temporal resolution) and a hard to beat accuracy is achieved. On the downside: the model can’t be used for diagnostic purposes such as scenario assessment, etc.

Local use/involvement: This model was locally developed in collaboration with a science institute and was used for local information supply to the public. The 100x100m resolution allows the public to see approximately where they are (rather than having to relate to a few distant monitoring sites) and it shows the spatial structure of the main sources of air pollution: major roads, the waterways and industrial areas.

7. The model described under 6 provided hourly information. This is reasonable for public information purposes. Ideally a forecast should be available. A system combining the resolution under 6 and the (CTM) forecast mentioned under 3 is under development.

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$^{14}$ RIO takes it spatial information from land use. Often this is easily available in high resolution. For Urbis the spatial information was derived for a very detailed spatial emission inventory. This is a rather labour intensive approach and only works if high quality emission information is available (NB to some extend the emission information is derived from land use).
8. Apart from the compliance issues relating to point and area sources, roads are a main compliance concern in the Netherlands. In most cities, roads are the only significant local source of air pollution. Industries, domestic sources etc. are covered in the background concentration maps (see 4). To assess the contribution of traffic to air pollution a national model was developed where cities submit their traffic data online (intensity, fleet composition, max speed, degree of congestion) and the model determines a year average traffic contribution and a total concentration (NO\textsubscript{2}, PM\textsubscript{30}, PM\textsubscript{2.5} and soon EC). Off-line versions of these models are not common anymore but they still exist.

**Local use/involvement:** This model is typically used at a local scale though everything is automated and other than the traffic information nothing is required from the local authorities. Should the concentrations be too high (non-compliance) the authorities have to make an action plan. The model provides a few tools to test alternative scenario’s (change intensities, built a wind screen, etc.)

Other models

Some situations are rather complex to assess, e.g. the immediate surroundings of a tunnel entrance or exit, and ordinary modelling tolls do not apply. In this case CFD models can be used or a wind tunnel study can be done. This is very rare and has happened only a few times in the Netherlands in the past decade. This type of work is done by science institutes. Given the nature of the current Chinese air pollution these models directed to micro-management are not required for routine use.

**Summary of model use at regional level**

- **For compliance checking:** point/area or line source models with a high resolution (10m – 100m) based on Gaussian dispersion with limited chemistry. Results are year average characteristics.
- **For public information:** real time (hourly) statistical models combined with measurements with a fairly high spatial resolution (100m)
- **CTM-s:** rarely. If so, CTM results in commissioned studies; or real time CTM-output as large scale background information that enters a local statistical model.
- **Local modelling in the Netherlands relies heavily on central infrastructure (background modelling, EU/national emission databases).** This reduces the complexity and effort for local and regional modelling and provides a uniform framework (and standard) for Air quality assessment in the country. This could be an interesting approach for China as well. Apart from being efficient by centrally providing basic data infrastructure it also assures a common standard for the analysis of air quality problems.
INTRODUCTION

Today it is realized that many of the persistent air pollution hotspots are situated within urban agglomerations. However, due to the multi-scale character of the air pollution phenomenon, policies have to be developed at various levels to deal with this problem. At the local level city authorities can for example use urban development and traffic management plans to tackle air pollution exposure of their citizens. At the same time policy is developed at the European (e.g. EURO standards for transport) as well as the regional levels (e.g. congestion charge) to mitigate the same air pollution problem.

When the effectiveness of all these measures has to be assessed at the local scale, especially the attainment of the EU limit values at a given time horizon such as 2015 or 2020, methodologies have to be developed to deal with this multi-scale character of air pollution and its related policies. Policy impacts on the regional background as well as the impact of local actions plans have to be combined into one overall air quality projection.

METHODOLOGY

A coupled modelling framework has been setup to assess air quality at a high spatial resolution, including both regional changes as well as local variation of air pollution levels (Lefebvre et al, 2011a). The framework is making use of the traffic emission model MIMOSA, the Eulerian model AURORA and the bi-Gaussian plume model IFDM. The coupled modelling framework can be described as follows: road traffic loads are input for the MIMOSA emission model (Mensink et al., 2000). The resulting spatially and temporally distributed emissions are used in the bi-Gaussian model IFDM (Lefebvre et al., 2011b). These results for the local traffic contribution are coupled to output of the Eulerian dispersion model AURORA (De Ridder et al., 2008) which is calibrated with the land-use regression model RIO (Janssen et al., 2008). The overall integrated framework is described in detail in Lefebvre et al (2011a).

In the couplings of the model chain, care is taken of double counting of emissions and the complexities of the ozone-NOx chemistry. To avoid double counting of the emissions by the different models, IFDM concentrations related to the local emission sources are averaged over the grid cells of the regional AURORA model. This spatially averaged local contribution is then subtracted from the regional contribution. Afterwards the high resolution concentration pattern of the bi-Gaussian plume model is added again on top of a reduced regional background. The double counting corrections described above are applied on an hourly basis. In order to deal with the fast ozone-NOx chemistry, combination of different model results and the double counting corrections are performed at the level of NOx, NO and NO2 individually. In a final stage, use is made of the ozone background concentrations and local meteorology to calculate at an hourly basis an atmospheric equilibrium state for the different constituents.

This overall procedure results in hourly high resolution maps. The reliability of the model results is confirmed in a dedicated validation exercise in which NO2 point measurements at 50 locations in the city centre are taken into account (Lefebvre et al, 2013). The validation confirms that the maps can be used to calculate annual statistics and for compliance checking in the framework of the EU Directive.
ANTWERP CASE STUDY

The modelling framework described above is applied in an urban planning case for the city of Antwerp, Belgium. At present, the very busy ring road of Antwerp is responsible for a major fraction of the air pollution in the city. Under a business as usual scenario EU limit values will not be attained everywhere within the next 10 to 15 years. To cope with this problematic situation a number of tunnel scenarios for the ring road and alternative traffic reduction plans are evaluated with the overall aim to meet EU limit values everywhere in 2020.

In this exercise, NO$_2$ as well as elemental carbon (EC) are considered. The NO$_2$ concentrations are regulated by the EU Air Quality Directive. EC or soot is a fraction of the particulate matter and for this pollutant Europe has not (yet) established air quality standards. However it appears that EC has a clear link with traffic and is possibly one of the most harmful fractions of particulate matter.

The modelling exercise shows that the implementation of current legislation as detailed in European, regional and urban policy plans will have a clear positive impact on the air quality in large parts of the city of Antwerp (see Figure 1). However, it also becomes clear that on top of this business as usual scenario, a significant traffic reduction would be required in 2020 to achieve annual NO$_2$ standards at any location along the Antwerp ring road. Even for 2025, current legislation policies will not be sufficient and extra traffic reduction on the ring road will be necessary to meet European standards everywhere. Building on these findings, a number of tunnel and traffic management scenarios for the Antwerp ring road are examined. These scenarios include a complete covering of the existing ring road, short tunnel elements of 250m or 500m at strategic location of the ring road, the construction of an additional new ring road at the outer bounds of the city and a back casting scenario in which traffic volumes are reduced in order to meet European NO$_2$ standards everywhere.

In addition to those infrastructure scenarios, a sensitivity analysis is setup with regard to the absolute traffic volumes in each scenario. It’s well known that any model simulation for 2020 and beyond come along with significant model uncertainties related to e.g. economic growth. Since traffic volumes play a crucial role in the analysis, a sensitivity analysis with +20%, -20% and -40% traffic is performed. This analysis gives further insight into the uncertainty and robustness of the model simulations.

RESULTS

A complete coverage of the ring road does not solve the problems related to the compliance of the NO$_2$ limit values at any location. In the vicinity of the ring road this scenario gives rise is much lower concentrations, but at the exits and open sections of the tunnel (entry and exit complexes along the tunnel), this scenario leads to a significantly increase of concentrations. Since a number of those complexes are located in densely populated areas, this has negative impact on population exposure.

Furthermore, it becomes clear that short tunnels (250m or 500m) along the ring road also do not solve the air quality problem. Indeed those tunnels can locally improve the air quality, especially above the tunnel elements. Depending on the location concentrations just below or just above the European standards can be achieved. However, at the tunnel exits significant deterioration of local air quality is expected since traffic emission are not removed in the tunnels but simply moved to the exit locations (see Figure 2 and Figure 3). In this scenario it is therefore essential to select optimal strategic locations for the (short) tunnel elements so that the changes in air quality (both positive and negative) result in an overall reduced exposure of the citizens.
Finally, this study confirms that the most effective measures to improve the air quality are related to an overall reduction of traffic volumes. This could be achieved by the construction of a new second ring road (so called tangents) further way from the city centre. A reduction of about 40% of the traffic (and associated emissions) on the ring road provides a significant improvement in air quality, not only for the areas in the immediate vicinity of the ring road but also for large parts of the city.

Figure 1: Model simulations of NO2 concentrations in 2020 under a Business As Usual (BAU) scenario

CONCLUSION

A coupled modelling framework has been setup to evaluate the impact on future air quality levels of local measures in combination with European and regional policies. Based on these model simulations it can be concluded that current legislation will not be sufficient to meet European air quality standards in 2020 or 2025 at any location in the city of Antwerp. Especially locations along the ring road remain problematic. Further (local) measures will be required to solve the problem. Therefore a number of possible scenarios for the Antwerp ring road were evaluated. All tunnel scenarios can locally reduce the air pollution levels but the specific locations have to be selected carefully since tunnel exits do create additional hot spots and can increase population exposure. Further reduction of traffic volumes and related emissions are most effective in decreasing air pollution levels in the entire city.

The results of the air quality modelling exercise were part of a multidisciplinary and integrated urban planning project.
Figure 2: NO2 concentrations on a transect along the ring road (x-axis in meter along the transect, from South-West to North-East). Concentration simulations for 2020 under a BAU scenario (black, 2020 basis), a scenario with tunnels 500m in length (blue, 2020EUTR) and with tunnels 250m in length (red, 2020NLTR). Both tunnel scenarios refer to the use of small tunnels to partially cover the Antwerp Ring Road. EUTR = Europese TunnelRichtlijn (EU tunnel guideline); NLTR = Nederlandse TunnelRichtlijn (Dutch tunnel guideline).

Figure 3: Model simulations of NO2 concentrations in 2020 for the 500m tunnel scenario.
Annex E: The Multi-Scale Character of Air Pollution: Impact of Local Measures in Relation To European and Regional Policies – A Case Study in Antwerp, Belgium

References


ATMOSYS is an Air Quality Management Dashboard to support Environmental Protection Agencies (EPA’s) in Europe predict, assess and plan air quality. The services provided support EPA’s in making the right policy decision to improve their atmospheric environment and allow them to inform the public on the status of the air quality.

The system was developed thanks to funding support from LIFE+, the financial instrument for the environment of the European Commission.EU programme, (2010 – 2013)


The core goal of the ATMOSYS project was to set-up and evaluate an integrated air quality management dashboard that could be used for air pollution management and policy support in hotspot regions. The aim was to establish the system for the hotspot region of Flanders and to demonstrate its replicability and transferability to other hotspot regions in the rest of Europe.

The ATMOSYS air quality dashboard is composed of the following 3 main aspects of air quality management: Forecast, Assess, and Plan. ATMOSYS offers for each topic different possible solutions to provide the most relevant information. Each solution has a strong emphasis on quality and usability, depending on the city, region or country. ATMOSYS consists of a number of building blocks, each of which can be applied according to the specific needs and air quality conditions of the region of implementation. Once the needed building blocks are selected and configured, the ATMOSYS air quality management dashboard is the expert’s entry point to their own air quality management system. It allows experts and policy makers to monitor, assess, validate, analyse and improve the air quality situation.

Demonstration

Within the Life+ project the system was set up for the European hotspot region of Flanders (Belgium). Near real time monitoring data and model results (including data assimilation techniques) are made available by means of INSPIRE compliant ICT technology to offer a multitude of data about local air pollution in Flanders.

The ATMOSYS demonstration website [www.atmosys.eu](http://www.atmosys.eu) was established to demonstrate some of these building blocks which are incorporated in the air quality management system in Belgium. The website consists of 3 core parts:

- An [air quality forecasting service](http://www.atmosys.eu), together with an on-line validation tool
- An [air quality assessment service](http://www.atmosys.eu) providing an archive of historic air quality maps and tools that enable users to extract and analyse the data
- An [expertise section](http://www.atmosys.eu) that provides an overview of the scientific and technical developments during development of the system.

Building blocks

A schematic overview of the air quality management system is provided in the picture hereunder. It basically consists of three major parts:

- Front-end air quality management/monitoring dashboard, which is a web-based visualization/control system for air quality management, acting as the air quality expert entry point.
• Public information interface, which is the general public entry to the information that is made available (based on EPA expert’s opinion) to the public. ATMOSYS offers widgets to integrate visualisation components into the EPA’s existing public website.

• Back-end components, which are the core of the system and provide most of the modelling, validation, analysis and reporting functionality of the management dashboard.

The core components are listed as follows:

• System database, which integrates all data sources required for air quality management;
• Model component, which allow calculation of the current and near future state of the air quality;
• Decision support components, which provide support in deciding which measures to take when problems with air quality occur. This includes validation and analysis tools.
• Reporting component to fulfil the e-Reporting needs in line with over EU legislation.

ATMOSYS consolidates information and tools of more than ten years of air quality research and development, applied in one of European’s major air quality hotspots.

The system has been made generic enough so that it can be easily applied in other areas of Europe or worldwide.
Annex G: Considerations when Choosing a Chemical Transport Modelling Tool For Regional Scale Modelling

Peter Viaene, VITO  September 2014

Early 2014, the Flemish Environmental agency requested VITO to investigate the possibility to select a suitable chemical transport model (CTM) for use in Belgium. To start, two existing air quality model inventories were screened:

1. MDS - Model Documentation System van European Topic Centre database which contains 142 entries of which 34 are meso-scale models (http://acm.eionet.europa.eu/databases/MDS/index.html)
2. database maintained by the University of Hamburg with 110 entries of which 61 are meso-scale models (http://www.mi.uni-hamburg.de/index.php?id=539)

It should be noted that some of the entries in these databases concern different versions or specific applications of the same model and that also some of these models are either not available or have not been used outside the institute where they were developed.

If only 3D, models capable of describing photochemistry and aerosols on a regional scale are retained we end up with 22 models based on the two databases above most of which are European models. While the EMEP model (Simpson et al., 2012) is applied at the European level for a lot of the modelling required in support of European policy many countries still tend to have their own modelling tools. CHIMERE (Menut el at., 2013) in France and LOTOS EUROS (Schaap et al., 2008) in The Netherlands are well known examples of the latter. In contrast to this plethora of models in Europa, in the USA modelling is mainly done using either CMAQ (Byun and Ching, 1999, Byun and Schere, 2006) or CAMx (ENVIRON, 2014) with a smaller role for WRF/CHEM (Grell et al., 2005).

Several criteria can be used when choosing a suitable modelling tool. A first criterion, the model accuracy or validity, is related to the extent to which a model is capable of correctly describe the behaviour of pollutants in the atmosphere. It is clear that if a model is not able to correctly calculate observed concentrations it will be of little use. However other criteria which could be just as important in practical CTM applications are:

- model availability: A first requirement if you want to adopt a certain model is, of course, that this model is available for use by third parties. Model availability can be limited to the executable program for which a license fee is due or go as far as unrestricted access to the source code.

- model support: Is there a manual for the model? Are training courses organised? Is there a helpdesk or can users rely on the experience of a (large) user community? Also having the source code available can help in understanding specific model details.

- model applicability: What can the model (not) be used for? Which pollutants are handled by the model? What are the restrictions in spatial/temporal resolution also taking into account practical limitations to the available computer resources? Can the model only be used for assessments or can it also be used for forecasting and scenario (what if) calculations? Some models also have additional tools or capabilities for doing source apportionment studies (e.g. tagged species) or model sensitivity calculations (e.g. direct decoupled method).

- user friendliness: Is there a user interface to prepare model input data or analyse the model results? To what extent does the model help the user identify errors in his model setup? As a CTM produces vast amounts of output, powerful visualisation tools are very welcome if not essential to help a user to better understand the model results. But also other tools such as process analysis
can help unveil inconsistencies in a model setup which cannot be found by merely analysing concentration results.

As model validity was deemed primordial in determining the choice of the model, the results of several model inter-comparison projects were analysed in an attempt to identify a model that consistently performs ‘best’ in this respect. These inter-comparison projects were:

1. AQMEII (‘Air Quality Model Evaluation International Initiative’) involving 10 models - CHIMERE, POLYPHEMUS, CAMx, MUSCAT, SILAM, DEHM, CMAQ, LOTO-EUROS, AURAMS, WRF/Chem - that were used for large scale modelling for both a domain in the USA as in Europe (Rao et al, 2011);

2. The EMEP ‘ScaleDep’ modelling study for Europe in which for 5 models (EMEP / CHIMERE / LOTO-EUROS / RCG/ CMAQ) the effect of changing spatial resolution from 1° to 1/16° were compared for a European domain (Cuvelier et al. 2013);

3. EuroDelta: inter-comparison of EMEP, RCG MATCH, LOTO-EUROS, CHIMERE, TMS, DEHM results for ozone in 2001 on a European domain with a resolution of 0.5° (Van Loon at al., 2004);

4. CityDelta: for four cities (Berlin, Milan, Paris and Prague) model results for CHIMERE, EMEP, RCG LOTO-EUROS, CAMx and OFIS with a resolution of 0.5° and 4-5 km (Vautard et al, 2007);

5. CityZEN project: comparison of the 10 year trend (1998-2007) in O₃, NO₂ and PM₁₀ concentrations for the models BOLCHEM, CHIMERE, EMEP, EURAD, SOLOCTM2 and MOZART (Colette et al., 2012).

In general, it can be concluded from these examples that no single model provides the best results for all domains, periods and scales. However, this should be interpreted carefully as in many cases the inputs used by the different models such as emissions and meteorology in these inter-comparison exercises were found to be somewhat different. Observed differences in model results could therefore also be attributable to differences in model inputs. As a judicious choice of inputs is dependent on the experience of the user, the available data and the flexibility with which a model can use alternative input data, it could well be that model results are more determined by these factors than by the intrinsic capabilities of the models themselves.

References


