# AN INTRODUCTION TO URBAN AIR QUALITY

## — BACKGROUND

Urban air quality is a label used to describe air quality in cities and large towns where there is a particular concern about the exposure of populations to air pollutants. The effect of city infrastructure and layout on air flow patterns, and the large concentration of certain types of emissions such as domestic heating and transport, makes urban air quality non-compliances difficult to resolve. Each city may require a unique management approach to reduce population exposure.

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## Air Pollutants of Concern

The two main pollutants of concern related to Urban Air Quality compliance are particulate matter (PM) and nitrogen oxides ($NO_x$).

- **Particulate Matter (PM)**: Particulate matter is classified by particle size. The key classifications are: total suspended particulate matter (i.e., dust), $PM_{10}$ (less than 10µm in diameter), $PM_{2.5}$ (less than 2.5 µm in diameter), and ultrafine particles (less than 0.1 µm in diameter). PM is referred to as "primary" if it is directly emitted into the air as solid particles, and is called "secondary" if it is formed by chemical reactions of gases in the atmosphere. Common sources of particulate matter in urban areas include residential wood heating, coal burning, road dust, vehicle exhaust, vehicle tyre and brake wear and construction.

- **Nitrogen Oxides ($NO_x$)**: $NO_x$ is the generic term for mixtures of nitric oxide (NO) and nitrogen dioxide ($NO_2$) and is produced by combustion processes. Air quality limit values exist for $NO_2$ and not for NO or $NO_x$. NO is produced by combustion processes and reacts with ozone to form $NO_2$ in the atmosphere. $NO_2$ can decompose in sunlight so the mixture of NO/$NO_2$ is highly variable. Common sources of $NO_x$ emissions in urban areas are road transport, residential, commercial and retail heating/air conditioning systems, manufacturing industry and power generation.

# Determining Compliance

Air quality compliance is related to how close a pollutant concentration in a given monitoring network is to an air quality limit value. Monitoring stations provide a concentration of a given pollutant in a particular location for a specific time period. The measured concentrations may need to be averaged for specific time intervals so that they can be directly compared to published air quality limit values. In Europe, the air quality limit values are set for the protection of human health and are published in the Ambient Air Quality Directive[1]. For $NO_2$, the annual limit value in Europe (40 µg/m³) is much less than in other areas such as the United States (100 µg/m³)[2] and compliance is proving particularly difficult.

[1] Directive 2008/50/EC on ambient air quality and cleaner air for Europe: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0050&from=EN

[2] United States Environmental Protection Agency national ambient air quality standard for annual $NO_2$ is 53ppb: https://www.epa.gov/criteria-air-pollutants/naaqs-table

The location of monitoring stations, including the surrounding terrain and meteorological conditions, can greatly affect what they measure. Within very short distances, significant differences in measured concentrations can occur due to the complexity of air-flow in a particular area or street. More generally, traffic air quality monitoring stations situated to measure road-side concentrations will observe different concentrations to urban stations which are situated to measure typical suburban air quality. Rural stations are situated to provide an indication of the air crossing an urban area and measure background concentrations more representative of long-range pollution.

When assessing ambient air quality, consideration should be given to the size of populations and ecosystems exposed to air pollution. Therefore, Member States have to define boundaries for the purposes of air quality assessment and management which are referred to as air management zones. Each zone is equipped with one or more monitoring station. If the measured concentration at any station within an air management zone is above the associated air quality limit value, this is considered as a non-compliance of the whole zone which does not necessarily indicate the actual extent of the non-compliance.

# Common Assessment Methods

A robust assessment of urban air quality depends in part on having an accurate emission inventory, a forward forecast of emissions and plans for the city, and a solid portfolio of control scenarios. An emission inventory will give a perspective on the amount, location, height of primary pollutants emitted from the various sources. Short-term emission sources should also be considered in emissions inventories as they can have a significant impact on air quality. For example, a construction site may have emissions from equipment and operations that are temporary in nature but can be responsible for exceedances determined by measurement.

Air quality dispersion models use the emissions inventory and various other inputs to predict resulting air pollutant concentrations using mathematical simulations. Whereas ambient monitoring can only measure the concentration associated with existing emission sources, dispersion models are an effective tool to predict the effect on concentration of emission reductions that result from applying controls. Dispersion models are also useful to predict air quality concentration in areas that are not covered by ambient monitoring. In some situations, specialist models may be needed to accurately reflect air flow patterns in city streets where the street geometry, its junctions and enclosing buildings can dramatically influence air emission flow patterns and the resulting concentrations.

# Getting Started: Key Questions

**As a start, there needs to be an understanding of**:

- What is the contribution to urban air concentrations from sources inside and outside the urban area?
- How much emission is there from a given source category?
- How effective is an emission reduction from each source on Air Quality?
- What controls are available to reduce those emissions and what are the anticipated reductions associated with them?
- In what timeframe can those controls be applied and are they economically and technically feasible?
- For traffic sources in particular do measures that change drivers' behaviour (e.g., re-routing) result in emissions rising elsewhere?

# Emission Reduction Measures

The options available to a city authority may be limited if they have no legislative control to regulate the most significant emission sources or if background concentrations in air entering the city are already close to limit values. However, if a city's primary concern is particulate matter, effective reduction measures can include:

- Reduce solid fuel combustion (i.e., wood, coal).
- Urban planning to promote ventilation or reduce emissions in streets with poor ventilation.
- Actions on captive fleets (buses, taxis, waste collection vehicles, etc.) to reduce PM by technical measures.
- PM control for construction sites.

Where concerns are related to $NO_2$ or PM from traffic, effective measures often considered include:

- Use of low emission zones to restrict access for certain vehicles according to their emissions.
- Actively support the turnover of the vehicle fleet in order to accelerate the uptake of EURO 6/RDE compliant vehicles (e.g., through grants).
- Enforce checks on vehicle maintenance.
- Enforce the removal from the road of the most polluting and poorly maintained vehicles.
- Traffic flow improvement
- Speed limit reductions

Emission reduction measures need to be targeted to the specific situation that a particular city faces in order to be effective. In most cases a combination of measures will likely be needed by cities to reduce ambient concentrations and each city will require a unique combination of measures to address their specific circumstances.

## Helpful Links

The European Commission's Joint Research Centre (JRC) has published a catalogue of air quality measures available at: **http://fairmode.jrc.ec.europa.eu/measure-catalogue/**

For more information and other fact sheets visit **www.concawe.eu**

**About Concawe**

The scope of Concawe's activities has gradually expanded in line with the development of societal concerns over environmental, health and safety issues. These now cover areas such as fuels quality and emissions, air quality, water quality, soil contamination, waste, occupational health and safety, petroleum product stewardship and cross-country pipeline performance.

**Our mission is to conduct research programmes to provide impartial scientific information in order to**:
- Improve scientific understanding of the environmental health, safety and economic performance aspects of both petroleum refining and the distribution and sustainable use of refined products;
- Assist the development of cost-effective policies and legislation by EU institutions and Member States;
- Allow informed decision making and cost-effective legislative compliance by Association members.

Concawe endeavours to conduct its activities with objectivity and scientific integrity. In the complex world of environmental and health science. Concawe seeks to uphold three key principles: sound science, transparency and cost-effectiveness.