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LEGISLATIVE COUNCIL

PANEL ON ENVIRONMENTAL AFFAIRS

SUBCOMMITTEE ON ISSUES RELATING TO AIR, NOISE AND LIGHT POLLUTION

Air Quality Modelling in Hong Kong

This paper gives an overview of the air quality modelling practices used in Hong Kong in general and one of the most commonly used air quality models, i.e. "Pollutants in the Atmosphere and their Transport over Hong Kong" (PATH) in particular..

Air Quality Modelling

2. Air quality modelling makes use of air quality models to estimate how a certain air pollutant emission would affect the air quality at a certain location, taking account of the characteristics of the relevant air pollutant emission, meteorological information, chemical reactions, topography and the background air quality. Our modelling practices are comparable with the best practices adopted by regulatory agencies in advanced countries such as the United States Environmental Protection Agency (USEPA). We have also issued a number of guidelines to guide project proponents in their air quality modelling for assessing the air quality impacts of development projects. A list of these guidelines is at **Annex**.

3. In line with international practices, our air quality impact assessment usually adopts a three-tier approach that focuses on the following emission sources –

(i) Tier 1 –emissions from a proposed project under the assessment;

(ii) Tier 2 – sources that have a significant contribution on the receptors identified in the project, usually within 500m of the project boundary; and

(iii) Tier 3 – those sources that are not covered by the first two tiers (i.e. the background sources). These include emissions in the Pearl River Delta region and beyond.

The three tiers of emission sources call for different air quality models to estimate their air quality impacts. The air quality impacts of the emission sources of all the three tiers will be added up to give rise to the overall air quality impacts.

Air Quality Models

4. An air quality model is essentially a mathematical formulation of the physicochemical processes that an air pollutant will undergo after its emission into the atmosphere. When a polluted air mass goes over complex terrains, models capable of simulating complex three-dimensional wind fields will have to be used. For near-field assessment, the models will have to be equipped with the appropriate simulation capabilities. Despite their diversity, air quality models could be divided into two categories according to the way they represent air particle movement and dispersion, namely Lagrangian model or Eulerian model.

<u>Lagrangian Models</u>

5. Lagrangian models simulate dispersion of air pollutants based on the observation of the trajectory of a particular air parcel that moves along with the wind. When developing these models, regulatory agencies have usually built in some conservative formulations. It is a common international practice to model the impacts of Tier 1 and Tier 2 emission sources by Lagrangian models. Different Lagrangian models have been developed for assessing the air pollution impacts of industrial and vehicular sources, etc.

6. The following Lagrangian models developed by overseas regulatory authorities are commonly used in local air quality impact assessments –

Air Quality Model	Issuing Regulatory Authority	Applications
ISCST3	USEPA	Emissions from chimneys, stockpiles, conveyors, unpaved surface in a construction site, tunnel portals, etc.
Caline 4	Department of Transportation, State of California, U.S.A.	Tailpipe emissions from vehicles
FDM	USEPA	Fugitive dust emissions from open areas
Ausplume	Victorian Environment Protection Authority, Australia	Sub-hourly averaged concentration of air pollutants like odour
AERMOD	USEPA	A newer formulation to replace ISCST3 and FDM described above.

Eulerian Models

7. Eulerian models simulate dispersion of air pollutants based on the observations made at a fixed location of the movement of air parcels. Their calculations work on a 3-dimensional grid framework. This type of models is well equipped to simulate air pollutant dispersion involving multiple interacting pollutants from sources over a large region with complex topography. However, they require large volume of input data for their calculations and thus considerable computing resources. Because of such constraints, Eulerian models are usually used in the prediction of the background air pollutant concentrations averaged over a grid of several kilometers (i.e. for Tier 3 sources) or the evaluation of the potential benefits of air pollution control policies on a macro scale.

The PATH Model

8. PATH is an Eulerian model specifically designed to simulate air quality over the whole Pearl River Delta region including Hong Kong. It was constructed by a consultant engaged by the Environmental Protection Department in 2001 from modules commonly accepted in the international modeling community to cater for Tier 3 emission sources or macro-scale air quality modelling. Currently, the most commonly used PATH's concentration output is averaged over a square prism of a base of each side 1.5km and a height of 20m each.

9. The structure and the scientific algorithms of PATH are comparable with other Eulerian models used elsewhere. It comprises three major components –

(i) Meteorological Module (MM5) to generate weather information based on meteorological data from other larger scale weather simulation models. It makes use of the best large-scale model that has incorporated available measurements (e.g. European Centre for Medium Range Weather Forecast) to provide meteorological data for air quality modelling. The meteorological data will be used by Lagrangian models to estimate the air quality impacts of Tiers 1 and 2 emission sources. Using a common set of meteorological data could ensure consistency amongst the three tiers of air quality modelling explained in paragraph 3 above;

(ii) Emission Module (EMS-95) to process emission information for simulation by the next module. Its emission database covers major emission sources in Hong Kong, the Pearl River Delta region and farther areas covered by the PATH model; and

(iii) Chemistry Transport Module (SAQM) to simulate the atmospheric physicochemical processes and calculate pollutant concentrations from outputs of the two preceding modules.

10. During its development, PATH was validated by the consulting team. Two internationally renowned air modelling experts[1]conducted peer-reviews and concluded that it is scientifically robust and suitable for use in Hong Kong for air quality assessment.

Further Developments in Air Quality Modelling

11. We keep in view the latest developments in air quality modelling and upgrade our modeling tools and methods as necessary. At present, we are upgrading PATH by incorporating state-of-the-art modules including WRF (Weather Research and Forecast) for meteorological simulation, SMOKE (Sparce Matrix Operator Kernel Emissions) for emission processing and CMAQ (Community Multiscale Air Quality) for physiochemical calculations. We are also expanding the geographical coverage and refining the spatial resolution of PATH for enhancing its estimation on the background air quality (i.e. Tier 3). Upon completion of the validation of the new system, we will invite local and international experts to review the updated PATH model.

12. We are also monitoring closely the development of state-of-the-art Lagrangian models by leading agencies in the US and UK for Tiers 1 and 2 assessments and will issue modeling guidelines for their applications in the local environment.

Environment Bureau/Environmental Protection Department
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[1] Professor Roger Pielke (Colorado State University) and Dr P.K. Misra (Ontario Ministry of the Environment) provided expert input throughout the development of PATH and endorsed the use of PATH for air quality studies in Hong Kong.

Annex

Guidelines issued by EPD for Air Quality Modeling

The following guidelines have been issued and can be downloaded from http://www.epd.gov.hk/epd/english/environmentinhk/air/guide_ref/guide_aqa_model.html -

1. Guidelines on Choice of Models and Model Parameters (Latest Revision: March 2000)

2. Guidelines on Assessing the 'Total' Air Quality Impacts (Latest Revision: March 2013)

3. Guidelines on the Use of Alternative Computer Models in Air Quality Assessment (Latest Revision: March 2013)

4. Guidelines on Estimating Height Restriction and Position of Fresh Air Intake Using Gaussian Plume Models (Latest Revision: March 2000)

5. Guidelines on the Estimation of PM2.5 for Air Quality Assessment in Hong Kong (Latest Revision: May 2012)

6. Guidelines on the Estimation of 10-minute Average SO2 Concentration for Air Quality Assessment in Hong Kong (Latest Revision: May 2012)