FINAL REPORT

An Integrated Modeling Framework for Supporting Airshed Environmental Management in the Windsor-Detroit Pilot Area

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March 2004

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EXECUTIVE SUMMARY

Airshed pollution associated with rapid social and economic development has been a critical concern facing governments around the world for decades. The pollution could not only pose a variety of impacts on public health, but also lead to significant consequences towards sustainable regional development. It is thus desired that the relevant air quality management systems be effectively planned and managed through an integrated systems-analysis framework. However, such a framework can hardly be established without effective forecasting and decision-support tools that can reflect a variety of complexities that exist in the airshed systems. Firstly, a large number of emissions source categorized into point, areal and mobile ones will affect the ambient air quality. Secondly, new pollutants will be generated through physical and chemistry reactions among different pollutants. Thirdly, meteorological factors such as wind, temperature and humidity will affect not only the diffusion and dispersion of pollutants but also the rates of atmospheric chemistry reactions. Fourthly, trans-boundary movements of pollutants will require joint actions by multi-lateral cooperation.

The above discussion is especially applicable to the Windsor-Detroit Region where the cities of Windsor and Detroit are two economically important areas in Canada and US. The emissions from the US side will account for the air pollution in the Canadian side. Although a number of investigations have been undertaken as guided by an International Joint Commission (IJC), insight is still unavailable regarding emissions sources, pollutant migration, mitigation strategies, energy policy and climatic-change impacts, healthy risk assessment, and interactions among different levels of government. Many questions remain to be answered, such as:

(1) How will pollutants from different sources affect the ambient air quality?
(2) Which economic sector will account for the majority of pollutant emissions in this region?
(3) Which sector will be chosen as the priority for emission mitigation?
(4) What are the potential impacts of an environmental or energy policy?
(5) How will the public's involvement affect the air quality management?
(6) What kind of risk needs to be considered in dealing with air quality management?
(7) How significant is the risk?
(8) How will climate change affect the environmental planning and management?
(9) How significant are the trans-boundary movements of pollutants?
(10) What action should we undertake to deal with the trans-boundary migration, by each alone or by joint actions?

Answers to the above questions will help decision-makers to gain insight into the air pollution issues in the study region. However, these answers can only be obtained through integrating various air quality simulation and optimization models, economic

models, and risk assessment models within a general airshed management framework. This view is echoed by Environment Canada who emphasized the growing need for an integrated air quality and economic activity models that can support policy and airshed-management decisions at the local, regional and international scales. The integrated airshed management system is thus desired to demonstrate the benefits and shortfalls of various policies and decisions.

Therefore, the objective of this research effort is to develop an integrated modeling system for ambient simulation, air quality management, risk analysis and decision support in the Windsor-Detroit Pilot Region. In detail, it consists of the following tasks:

(a) investigate emission inventory and ambient air quality in the region,
(b) propose air quality simulation models,
(c) build an inexact optimization model for supporting the management of emissions from various sources,
(d) construct an energy model for the planning and policy analysis of emissions from the energy sector under uncertainties,
(e) perform post-optimality analysis and multi-criteria decision analysis in dealing with various policy issues and public concerns,
(f) establish an integrated risk assessment, and
(g) bring in geographic information system (GIS) and expert system (ES) to form an integrated decision-support system that contains air quality simulation model, environmental management model, energy system planning model, post-optimality analysis, risk assessment, and other environmental and/or economic models.

The detailed research scopes are provided as follows:

(a) The framework will be developed aiming at providing an effective tool for the decision-makers in municipal, provincial, federal, and international levels in dealing with energy planning, transportation design and management, industrial operation and air quality management in the Windsor-Detroit area.
(b) The uncertainties associated with air quality simulation, air quality management, energy planning, and risk assessment will be addressed. The fuzzy set theory, stochastic modeling and interval analysis techniques will be applied to deal with these uncertainties.
(c) Regional climate change model and other downscaling techniques will be incorporated within the simulation and optimization models for generating integrated support for short and long-duration air quality management and planning.
(d) The interactive relationships between energy related activities and the relevant pollutant emissions will be investigated, where impacts of different air quality management policies on the energy sector will be highlighted.

(e) The developed framework will be applied to jurisdictions of not only the Windsor and the Detroit but also the Windsor-Detroit combination; this makes it possible for addressing the issue of trans-boundary transport of air pollutants.
(f) The flexibility of the developed framework will be enhanced by bringing in GIS and expert system; and
(g) Graphic user interfaces (GUI) will be developed to facilitate the convenience of data input and output, policies analysis, and system operation and maintenance.

This report consists of ten chapters. Chapter 1 is an introduction of the project. Chapter 2 is an overview of the study region. Chapter 3 presents a general framework for airshed management. Six major research components are described in the Chapters 4 to 9. The methodology of numerical air quality simulation is given in Chapter 4. Chapter 5 illustrates the formulation of the developed optimization model for air quality management, as well as a methodology for emission trading between different jurisdictions. The air quality management and planning associated with energy activities are presented in Chapter 6 where an optimization model is provided. Methods for post-modeling analyses (PMA) are offered in Chapter 7. Chapter 8 is about methods for environmental assessment. Chapter 9 presents a decision supporting system that incorporates expert system and GIS within the modeling framework. Chapter 10 is devoted to a summary of this project, which is followed by appendices.

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