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POLLUTION PROBE
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Policy Analysis Tools for Air Quality and Health

Report from the May 19, 2005 Workshop

Prepared by Stephanie Gower, John Shortreed and Quentin Chiotti

August 2005

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Executive Summary

On May 19, 2005, the workshop "Policy Analysis Tools for Air Quality and Health" was held in Toronto, Ontario. The workshop gathered expert stakeholders from a variety of backgrounds including health and environment departments of municipal, provincial, and federal government, academia, consulting firms, industry, and NGOs. The workshop asked these experts to consider three questions:

1. What is the public health significance of air pollution?
2. Are there available models and analyses to inform policy at some level?
3. What are the key policy questions that should be addressed by models and analyses?

While poor air quality does have an impact on human health, many uncertainties complicate achieving a clear understanding of the relationship. Evaluation of health impacts should consider a variety of health outcomes and should be done in a manner that considers social and interactive effects.

There are a variety of policy analysis tools available to inform policy at a variety of levels, and the most useful are those that address multiple pollutants or effects. However, there are still significant barriers which limit the use of these tools, particularly in the local context. These barriers include the complexity and inaccessibility of computer-based models, the limitations in available data, and the limitations imposed by the multiple, overlapping governmental jurisdictions in which air quality issues are considered.

Participants desired models that are able to identify good policy options, and are efficient and cost-effective to use. They were interested in tools that maximized the integration of information in a comprehensive way. Support for continuous improvement and continued stakeholder dialogue was also indicated.

Recommendation

A second, longer workshop should be held (tentatively in Fall 2005) to continue stakeholder dialogue and enable more in-depth exploration of policy analysis tools. This workshop would be national in scope, drawing from stakeholders and policy tools from different regions of the country. This workshop might also consider specifying the content/needs for a guidance document for the appropriate use of policy analysis tools, the possibility of a common analysis tool for use by municipalities, and the capabilities of the current model set.

The second workshop should include opportunities for health and environmental stakeholders to have direct interaction with modelers, and have hands-on experience with the suite of available policy analysis tools.

Acknowledgements

Pollution Probe and NERAM thank the following workshop sponsors:

Canadian Petroleum Products Institute
Dofasco
Environment Canada
Health Canada
Lakes Environmental
Ontario Ministry of Environment
RWDI
Toronto Public Health

The venue for the workshop "Policy Analysis Tools for Air Quality and Health" — Toronto Metro Hall — was made available by the City of Toronto through the efforts of Toronto Public Health.

The conference was organized by NERAM and Pollution Probe under the direction of a multi-stakeholder Planning Committee:

Jay Barclay, *Environment Canada*
Monica Campbell, *Toronto Public Health*
Walter Chan, *Ontario Ministry of Environment*
Quentin Chiotti, *Pollution Probe*
Anton Davies, *RWDI*
Murray Finkelstein, *McMaster Institute of Environment and Health*
Geoff Granville, *Canadian Petroleum Products Institute*
Eric Miller, *University of Toronto*
Glen Okrainetz, *Ministry of Water Land and Air Protection, BC*
Kim Perrotta, *Ontario Public Health Association*
John Shortreed, *NERAM*
Dave Stieb, *Health Canada*
Jesse Thé, *Lakes Environmental*

This document reflects the conference presentations and discussions and is not necessarily endorsed by the conference sponsors.

Further information on the workshop is available at www.irr-neram.ca and www.pollutionprobe.org/Happening/events.htm.

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Background

Introduction

It is now universally recognized that poor air quality has adverse impacts on human health, and research confirms that residents in some areas of Canada are exposed to levels of air pollutants that are associated with morbidity and mortality. However, the total impact of current levels and trends of air pollution alongside current policies and those slated to be implemented in the near future is not well known. Many questions remain about how best to integrate policy options and how well broad policy initiatives perform compared to targeted regulations. In general, it is necessary to confirm that air pollution reduction measures have resulted in decreases in exposure and adverse health effects. Additionally, it is beneficial to be able to quantify the magnitude of change in health impacts and predict the effects of future policy initiatives. This information is also helpful in identifying where future policy initiatives need to be focused, including measures directed at multiple air issues (e.g. smog, acid rain, climate change).

This workshop can be considered as a starting point for discussing policy analysis tools. The intention of NERAM and Pollution Probe has been that with support and interest of the participants at this workshop, a second national event may be held in the Fall 2005 to permit a broader treatment of the issues and more in-depth examination of specific aspects of available policy analysis tools.

Workshop Objectives

The primary purpose of the workshop is to facilitate communication between policymakers, scientists, modelers, and other stakeholders to identify critical policy needs, key issues, and gaps in knowledge for policy analysis. Broadly, the workshop objective is to explore participants' views on the following questions:

1. What is the public health significance of air pollution?
2. Are there available models and analyses adequate to inform policy at some level?
3. What are the key policy questions that should be addressed by models and analyses?

Pollution Probe and NERAM have endeavoured to provide a neutral and independent forum to consider the specification of analysis components (including emission sources, effects of emissions from all sources [and atmospheric chemistry during transport] on ambient air quality for specific locations, population exposures, health effects, and policy evaluation criteria).

Policy analysis is, of course, only one input into decisions on designing and implementing policies for improving air quality and health. Decision-makers also consider financing, fairness, equity, enforceability, public acceptance, technical feasibility, uncertainties, and other decision-making criteria besides cost effectiveness and efficiency based on the results of policy analysis tools.

Workshop Statement

The objective of the Statement is to provide guidance from the perspective of a group of scientists, regulators, industries and interest groups on a path forward to improve the interface between science and clean air policy strategies to protect public health. This workshop summary represents the main findings of three breakout group discussion sessions, supported by the perspectives of expert speakers. NERAM and Pollution Probe undertook a review process to ensure that the summary would accurately reflect the conference discussions, including documentation of supporting comments from the proceedings and inviting delegates' comments on a draft version of the summary. The comments received were editorial rather than substantive. The summary however, is not a consensus document and may not reflect the views of all conference delegates. Nonetheless, this documentation provides insight into stakeholder perspectives on issues underlying the development of strategies for clean air and health.

1. What is the public health significance of air pollution?

While consensus exists that poor air quality has an impact on human health, assessing the degree of its significance is complicated by uncertainties and requires knowledge about endpoints other than mortality. Evaluation of the impact of air pollution on health must occur within the broad context of public health and consider social and interactive effects.

2. Are there available models and analysis to inform policy at some level?

There is agreement that tools and approaches are available which can inform policy at various levels; the most successful of these are broadly applicable. However, aspects of model formulation and the political context in which policy is created and put into effect generate barriers for appropriate, meaningful use of these approaches and implementation of their results.

3. What are the key policy questions that should be addressed by models and analyses?

Models and analyses should be able to identify good policy options that are effective and cost-efficient. Interest was expressed in approaches that maximize the integration of relevant information.

4. Next Steps

Continued stakeholder dialogue and a more in-depth exploration of the issue of policy analysis tools for air quality and health will be beneficial. A broader national and more interactive meeting to be held in the Fall 2005 will be able to build on conclusions from this workshop and is a reasonable next step forward.

1. What is the public health significance of air pollution?

While consensus exists that poor air quality has an impact on human health, assessing the degree of its significance is complicated by uncertainties and requires knowledge about endpoints other than mortality. Evaluation of the impact of air pollution on health must occur within the broad context of public health and consider social and interactive effects.

A. While consensus exists that poor air quality has an impact on human health, assessing the degree of its significance is complicated by uncertainties and requires knowledge about endpoints other than mortality.

The health effects of poor air quality on mortality and morbidity have been consistently documented. Although the risks appear to be relatively small, the impact is significant when considered on a population basis.

Understanding the significance of air quality is complicated by various uncertainties. These include (i) data limitations such as the lack of appropriate monitoring data at the local level, particularly for communities outside large urban areas, and lags in data availability; (ii) the relative impact of risks on children, the elderly and health compromised people; (iii) lack of knowledge about exposure; and (iv) limited understanding of the causal attributes of pollution, including synergistic effects. With respect to particulate matter (PM) specifically, the role of various size fractions including ultrafines and the coarse fraction (with respect to asthma) is still unclear. There is still uncertainty about specific chemical constituents of particles, including metals and organic matter as well as air toxics that may adhere to particle surfaces.

There is a need to be aware of endpoints other than mortality to ascertain the full level of impact on a community, especially at the local level, where mortality numbers may be relatively small. The pyramid of health effects indicates that many more people may be affected by air pollution for less severe outcomes; however, most research to date has focused on mortality and hospitalization rates. Evidence for alternate endpoints such as low birth weight is emerging but still limited.

B. Evaluation of the impact of air pollution on health must occur within the broad context of public health and consider social and interactive effects.

Air quality must be considered within the broader context of public health rather than as a pollution control issue. Consideration must be given to social impacts such as commuting time, road rage, or quality of life, and interactive health effects, such as the significance of air quality episodes for physical activity, the combined impacts of heat and air quality, and the relative importance of outdoor and indoor air quality. The involuntary nature of exposure to air pollution may be considered as a social issue. More broadly, it is recognized that the importance of air quality as a public health issue should be considered within the context of other health issues facing Canadians.

2. Are there available models and analysis to inform policy at some level?

There is agreement that tools and approaches are available which can inform policy at various levels; the most successful of these are broadly applicable. However, aspects of model formulation and the political context in which policy is created and put into effect generate barriers for appropriate, meaningful use of these approaches and implementation of their results.

A. There is agreement that tools and approaches are available which can inform policy at various levels; the most successful of these are broadly applicable.

Various tools exist to help inform on the relationship between air quality and health. Those which link emissions to ambient air quality are increasingly able to make good use of available monitoring data, and inventories are improving over time with integration of technology such as Geographical Information Systems (GIS). Tools that link ambient air quality to health impacts (such as ICAP and AQBAT) are also available. As well, "one-off" tools have been created to answer a variety of specific questions which further demonstrate that the capacity for creating useful tools exists. Although situation-specific tools can be helpful, the most useful models are broadly applicable and identify "win-win" situations. Targeting sources with multiple pollutants and sources with the greatest potential for reduction is attractive, and most agencies and decision-makers are becoming more comfortable implementing policies that affect a broad range of pollutants or activities.

B. Barriers to meaningful use of available policy analysis approaches include

(i) complexity and inaccessibility — there is a need for a guidance document;
(ii) limitations inherent in data inputs, including emissions inventories and monitoring data;
(iii) inability to address the effects of air quality in a manner that reflects the different levels of policy and decision-making within and across the various jurisdictions that deal with air quality in Canada;
(iv) limited capacity to identify cross-cutting co-benefits; and
(v) procedural limitations inherent in moving from modeling output to the application of policy including difficulties interpreting endpoints.

(i) Complexity and inaccessibility — need for a guidance document

There is a desire for integrated models that can be manipulated and applied by people working to influence policy. However, the complexity and inaccessibility of most approaches limits their usefulness to non-experts. Understanding the tools is complicated by the wide variety of approaches, assumptions, and valuations used. There is a lack of knowledge and capacity for conducting appropriate analysis and interpreting the results, including what level of certainty is required to implement a policy based on modeling output. Furthermore, there are no established criteria for when to apply modeling.

There is a need for a **guidance document** to provide "best practices" to guide non-experts, providing advice on health impacts, interpretation of monitoring results, selection

of models and appropriate analysis, use of model results with other decision criteria, and treatment of uncertainty, particularly for small municipalities. Examples of issues facing municipalities include how to plan schools, roads, and trees in relation to residential neighbourhoods, how to assess residential land use decisions in relation to transportation emissions, and how to look at source-receptor relationships on a finer scale.

(ii) Limitations inherent in data inputs, including emissions inventories and monitoring data

The quality of input data remains an important limitation. While the advanced graphic capabilities and extensive built-in complexities of computer models make them appear to be sophisticated tools, the accuracy and usefulness of tools depends in large part on the input data used (or available). There is still broad uncertainty inherent in many of the model inputs. For example, many municipalities do not have access to adequate monitoring data, emissions inventories, or ambient air quality data at the resolution necessary to obtain relevant information from the models. Monitoring remains an important aspect of assessing air quality status, and criteria for interpreting monitoring results, including emission inventories, should be established. More monitoring of best practices is required both as a trigger to initiate policy interventions and to monitor policies that have been implemented, particularly for cumulative health effects.

(iii) Inability to address the effects of air quality in a manner that reflects the different levels of policy and decision-making within and across the various jurisdictions that deal with air quality in Canada.

Air quality issues encompass multiple jurisdictions, from municipal, to regional, provincial, national, and international. However, decision-making typically occurs discreetly within each of these jurisdictions. Most models are not equipped to deal with the various levels of policy and decision-making that occur within and across these jurisdictions. In general, the creation of models to date has been driven by a need at the national level (such as international conventions and agreements) and therefore does not address finer-scale/local problems. Specific issues include (i) ownership of data; (ii) authority to manage air quality problems and develop rules and standards; (iii) varying needs at different scales; and (iv) limitations on influencing actions in external jurisdictions.

(iv) Limited capacity to identify cross-cutting co-benefits

Many actions taken to mitigate the effects of poor air quality could also affect greenhouse gas (GHG) emissions. Conversely, many measures that reduce GHG emissions also reduce the release of other air pollutants contributing to smog, acid deposition and air toxics. Tools that link public health to climate change, energy policy, and decisions on land-use to identify cross-cutting co-benefits will be more attractive to decision-makers.

(v) Procedural limitations inherent in moving from output to application of policy including difficulties interpreting endpoints

The capacity of public health to respond to air pollution health impacts is limited by a lack of criteria for policy interventions, resources, and knowledge as well as the lag time for the development of new policies, their implementation and the monitoring/evaluation of outcomes. Mechanisms for linking air quality and health are improving to the point where health interpretation is adequate to inform policy formulation for many situations and cases. However, more information does not necessarily make it easier to implement policy — it is important that the output of tools be relevant to specific policy needs, and that the ability to interpret model output is adequate.

3. What are the key policy questions that should be addressed by models and analyses?

Models and analyses should be able to identify good policy options that are efficient and cost-effective. Interest was expressed in approaches that maximize the integration of relevant information.

Models and analyses should be able to identify good policy options that are efficient and cost-effective. Interest was expressed in approaches that (i) are comprehensive; (ii) are integrated, especially multi-government; (iii) identify barriers to existing options; (iv) are subject to continuous improvement; and (v) result from stakeholder dialogue.

(i) Development of comprehensive approaches

The relationship between air quality and health is multidimensional, and characterizing it requires an understanding of complex relationships between many variables. A comprehensive approach may evaluate multiple sources and pollutants including those from the transportation sector and residential emissions, which are often neglected in emissions inventories. It would examine both short- and long-term effects of exposure, and assess the implications of using threshold and non-threshold approaches to determine health risks. In addition, behavioural patterns and social trends should be incorporated. Increases in energy use will likely coincide with continued population and economic growth, and the number of vehicles per family and the number of vehicle kilometres travelled are projected to rise in many major urban centres, leading to further increases in transportation-related emissions. Currently, many tools assess benefits primarily in the context of fiscal competitiveness, ignoring the broader monetary costs associated with air pollution. A comprehensive approach would also consider the many social benefits of improved air quality and incorporate alternate methods of valuing the impacts of air pollution.

Analytical approaches should be able to evaluate the effectiveness of past and current policies that have been implemented, as well as those that are proposed or being developed. The latter may also include estimating the enforceability of a new policy. Approaches that are most effective are those that also help decision-makers communicate the projected/simulated impact of policy choices over the long-term in a clear and understandable manner. Finally, a comprehensive approach should be adequate for recognizing policy options that have been implemented elsewhere with success, e.g. the ban on two-stroke engines.

(ii) Development of multi-government (integrated) approaches

Because of the complexity of the relationship between air quality and health, many policy-related issues are connected with aspects of our physical and social environment, and thus must be considered within a broader integrated context. Air quality is an issue that can operate at various geopolitical scales including international, national, regional/provincial, and local. Air sheds do not recognize geopolitical boundaries, and there is growing evidence to suggest that air pollution and the trajectory between source and receptor is becoming global in scope,

requiring binational and international policy responses. Conversely, some air quality issues are highly localized in nature, and require a municipal or regional/provincial policy response.

The complexity of both the physical/social nature of the problem and jurisdictional control makes it difficult to identify at what level (scale) policies might be most effective or efficient. A multi-government approach (see Question 2) may improve integration and the effectiveness of policy implementation across regulatory jurisdictions. Components of multi-government might include management from an airshed perspective, or (to overcome uncertainty) deriving a national consensus on issues such as pollutants of importance, relative health impacts including use of value measures such as QALYs, and treatment of the elderly and other sensitive subpopulations. A multi-government approach could also look at non-traditional solutions including land use and transportation policy decisions, as well as the type and scale of energy supply, etc.

Integration across departments or ministries within specific levels of government should also be encouraged. Planning and infrastructure decisions for new urban areas or redevelopment of pre-existing areas can affect emissions, health risk exposure and ambient air quality in important ways. In this case government departments responsible for transportation, land use, municipal infrastructure, source water protection, agricultural production, etc. would need to be engaged. Valuation from both social and economic perspectives may act as a useful integrative tool that cuts across and binds together the different departmental and jurisdictional perspectives.

(iii) Identification of barriers to existing options

Useful policy analysis can help identify barriers to adopting existing cost-effective options, such as the failure of anti-idling campaigns. This may require consideration of available policy response options, public and political acceptability, communication of information, and different perspectives of various stakeholders (which may include differences due to the scale of stakeholder's activities — i.e., local versus international). There is a need to ensure that existing procedures and processes do not limit the effectiveness of policies considered. Approaches must also consider the capability of smaller municipalities and health departments, who need tools that can be understood and used within existing (and more limited) resources.

The output must be in a format that is useful to convince the public of the benefits of policies, and that the cost of implementation is reasonable and worthwhile. Policy decision criteria should guide the choice of health metrics (choice of metric influences the outcome). Policy objectives and appropriate policy response can guide implementation; multiple options can be used simultaneously.

(iv) Continuous improvement of modeling methods, including incorporation of new technologies, improved exposure assessment, and characterization of uncertainty

While current approaches are useful in many contexts, some areas needing improvement in the models were identified. As more information and technology becomes available (such as the improved spatial resolution that accompanies the use of GIS methods), they should be integrated into analytical methods or used to develop additional approaches.

Current methodological deficiencies include inadequate methods for exposure assessment. Most models rely on results from monitors located at various places in a community which may not be representative of the ambient concentrations that are actually experienced by members of the community. Further, the correlation between personal exposure to specific air pollutants with ambient levels is low.

Model outputs may appear inaccurately robust if they are presented without information about assumptions that were made in arriving at their output, and the uncertainties associated with various inputs. Methods are available and should be used to consider uncertainty in policy evaluations.

(v) Continued stakeholder dialogue

There is a need for continued interaction between policy makers, scientists, and representatives of different jurisdictions. Currently, information that may be highly relevant for developing key questions and identifying policy needs, such as a clear understanding the abilities, limitations and underlying assumptions of available models is not being effectively communicated. Continuous communication of clear and understandable information, as well as the sharing of knowledge, resources, and capacity should facilitate the development of new and useful models, and also ensure that models are not misused.

Finally, continued dialogue further requires that questions of interest to specific stakeholders will be asked in an open and transparent forum, and under conditions where sufficient resources will be allocated to the tasks at hand.

4. Identification of Next Steps

Continued stakeholder dialogue and a more in-depth exploration of the issue of policy analysis tools for air quality and health will be beneficial. A broader national and more interactive meeting to be held in Fall 2005 will be able to build on conclusions from this workshop and is a reasonable next step forward.

Building on the key issues identified in the first workshop, a second workshop should be held in Fall 2005 which will address health impacts of air pollution and related policy issues from a broader perspective. The second workshop should include opportunities for health and environmental stakeholders to have direct interaction with modelers and have hands-on experience with the suite of available policy analysis tools. The workshop will be planned as a two-day event, allowing for increased dialogue between stakeholders and opportunities for detailed assessments of available models, policy needs. In addition, the event may explore the viability and requirements for developing some type of comprehensive framework to assess the health impacts of policies. Components of the event might include (i) specification of contents/needs of the guidance document described in 2B, (ii) assessing capabilities of the available model set, and (iii) specification of transparency requirements, including rules of application and evaluation.

In order to maintain an interactive dialogue among all stakeholders, the specific format and content of the workshop will be determined with guidance from a small multi-stakeholder advisory committee. The advisory committee will be selected with the intent of engaging a high level of expertise across a wide range of interests and perspectives. (As was done for the "Policy Analysis Tools for Air Quality and Health" workshop held on May 19).

Workshop Participants

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Workshop Program

8:30 **Introduction —** John Shortreed, Executive Director, NERAM and Quentin Chiotti, Air Programme Director, Pollution Probe

Session 1: The Basics — Air Pollution Levels and Health Effects
Chair: Louise Aubin, Peel Region Health
8:45 **National Perspective —** Steve Clarkson, Director, Environmental Contaminants Bureau, Health Canadawith Peggy Farnsworth, Director, Transboundary Air Issues, Environment Canada
9:15 **Local Perspective: Toronto and Region —** Monica Campbell, Toronto Public Health
9:45 **Measuring the Health Impacts in Toronto and Hamilton —** Murray Finkelstein, McMaster Institute of Environmental and Health
9:55 **A Framework for the Workshop: Approaching the Three Questions —** Jay Barclay, Senior Policy Advisor, Environment Canada, Quentin Chiotti, Pollution Probe, John Shortreed, and Stephanie Gower, University of Waterloo
10:10 **Discussion**

10:20 **Coffee Break and Discussion of Displays**

Session 2: Analysis Examples and Issues — Health Impacts, Analysis Capacity and Policy Issues
Chair: Eva Ligeti, Clean Air Partnership
10:50 **GTA Initiative/Large Urban Areas —** Anton Davies, RWDI
11:05 **Minnesota Analysis —** Jesse Thé, Lakes Environmental
11:20 **Source Apportionment — J**eff Brook, Environment Canada
11:35 **AQBAT —** Dave Stieb, Air Health Effects Division, Health Canada
11:50 **AQI —** Phil Blagden, Meteorological Service of Canada, Environment Canada
12:00 **Discussion**

12:10 **Lunch**

Session 3: Policy Perspectives — What are the Analysis Needs?
Chair: Kim Perrotta, OPHA
1:10 **Statements of Analysis Issues Related to Stakeholder Policy Perspectives**
1:45 **Discussion**

Session 4: Breakout/Discussion Groups
Chairs: Anton Davies, RWDI, Jay Barclay, Environment Canada and Bruce Walker, STOP
Rapporteurs: Stephanie Gower, University of Waterloo and Richard Laszlo, Pollution Probe

3:30 **Coffee Break and Discussion of Displays**

Session 5: Health Impacts, Analysis Capacity and Policy Issues — Next Steps
Chairs: Quentin Chiotti, Pollution Probe and John Shortreed, NERAM
4:00 **Breakout Session Reports**
4:20 **Discussion of Three Questions**
4:45 **Next Steps — Fall Workshop**

4:55 **Closing Comments**

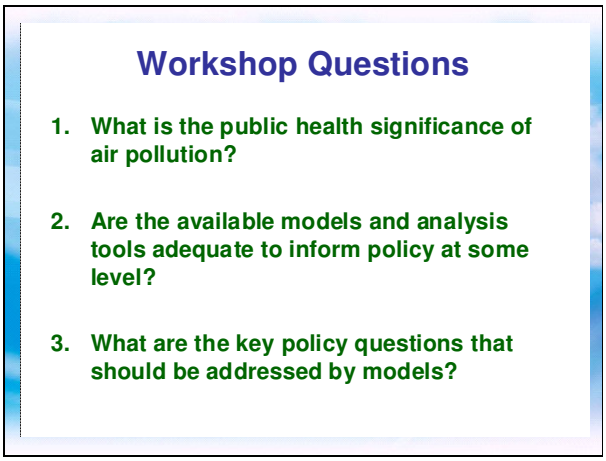
Presentation Summaries

(Note: Slides are extracted from the full presentation slide sets, which are available at www.irr-neram)

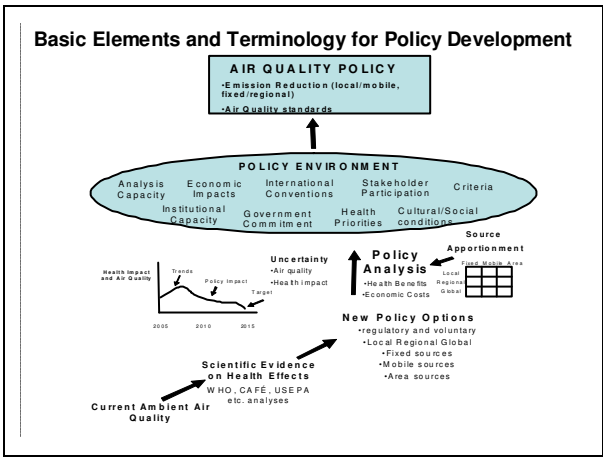
Workshop Framework

Jay Barclay, Environment Canada (Presenter), Quentin Chiotti (Pollution Probe), John Shortreed (NERAM), Stephanie Gower (University of Waterloo)

The framework for this one-day workshop is defined by three questions:

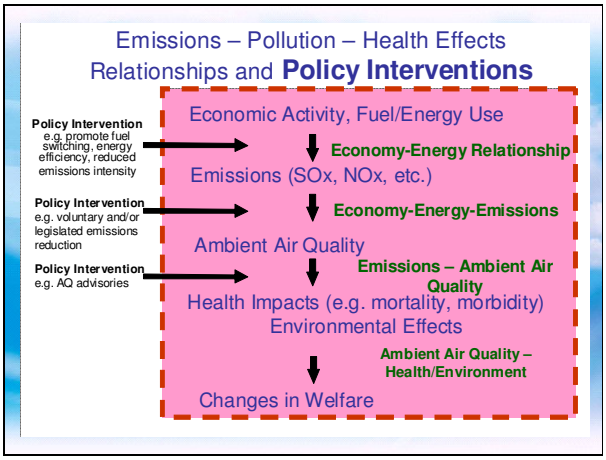


A policy analysis framework that was used in the NERAM Mexico 2005 colloquium to address the same issue at the international level may be useful:



There are many challenges associated with exploring the availability of good policy analysis tools: pollution occurs on a variety of scales from local to international, and at any given location may be attributed to a variety of sources. Areas of uncertainty include identification of key pollutants, source apportionment, trends (in emissions, policy impact, targets, and climate change impacts), health effects, vulnerable subgroups, the relative importance of indoor and outdoor air quality, and economic and environmental impacts. However, uncertainty does not justify inaction.

Broadly, we may need to consider how economic activity ultimately affects human welfare. There are a variety of relationships that can affect each other.



Policy interventions can occur at points in the causal chain where these relationships may be affected or altered.

A detailed list of generic interventions was prepared for the NERAM 2005 Mexico colloquium. It categorizes sources as global, regional and local sources (categories

represent both a class of government intervention that is possible, as well as the general structure of the source apportionment analysis modes which happen to have a similar structure) and also as fixed, mobile, and area sources — a classification which has proved useful in formulating policy interventions.

Some challenges faced for development of policy analysis tools may include predicting how changes in policy may influence individual and corporate behaviour and practices with respect to energy and materials use, particularly fossil fuel combustion, considering compliance with regulations, considering speed and effectiveness of policy adoption, and considering how policies on air quality may impact health in unexpected ways.
This workshop is intended to encourage thinking about and identification of attributes of useful policy analysis tools as well as gaps in current analysis capacity. It will also explore the need for further discussion of these issues in a broader context, perhaps at a longer workshop to be held in Fall 2005.

"The Basics" — Air Pollution Levels and Health Effects

Peggy Farnsworth, Environment Canada

Smog, which is composed primarily of PM (particulate matter) and ground-level ozone, affects human health, the environment, and the economy. A sustainable economy requires clean environments and healthy people.

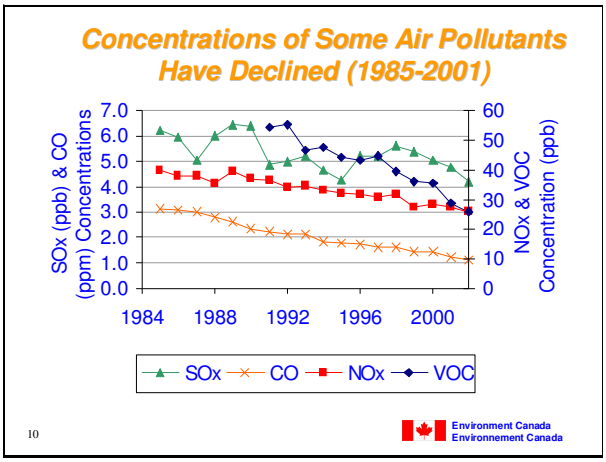
Clean air is a priority for Canadians: in June 2000 the Canada-Wide Standards (CWS) for PM and Ozone were endorsed by federal, provincial and territorial governments (except Quebec*). Recognized as a first step towards reducing smog levels and environmental effects and thereby improving human health, these standards established numeric targets for ambient levels to be achieved by 2010 of 30 µg/m^3 (24-hour average) for PM and 65 ppb (8-hour average) for ozone.

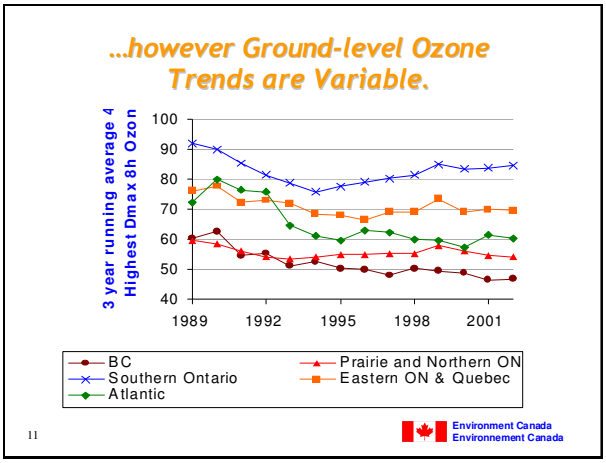
Environment Canada has taken the lead on the CWS, preparing multiple guidance documents and being involved in many joint initial actions under the CCME such as multi-pollutant emissions reduction strategies and

* Although Québec has not endorsed the CWS, Québec is committed to act in coherence with other jurisdictions in relation to the CWS.

alternative transportation. The federal government has invested over $210 million in air priorities, including establishing a Clean Air Agenda and a 10-year Vehicles and Fuels Agenda to reduce vehicle-related emissions.

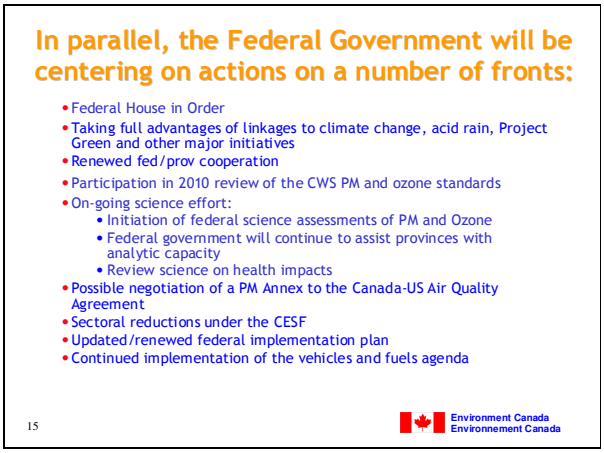
Environment Canada actions to date include declaring PM and Ozone and their precursors toxic and listing them on CEPA Schedule 1, publishing the federal implementation plan, negotiating the ozone annex to the Canada-US Air Quality Agreement, developing and implementing the 10-year agenda for vehicles and fuels, developing the VOC agenda, enhancing the air monitoring network, improving emissions inventories, collaborating on analytic pilot projects with provinces, and preparing annual reports on PM and ozone levels and trends. While concentrations of some pollutants including SO_x, NO_x, CO, and VOC appear to have declined recently, ground level ozone trends are variable.





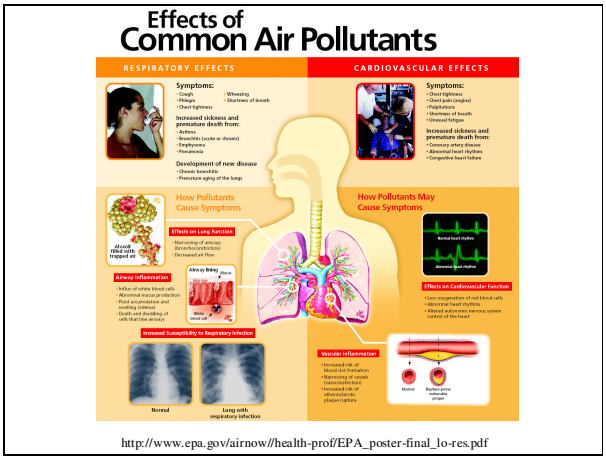
Based on the most recent air quality information (2001–2003), one in every three Canadians lived in communities with three-year averages above the $PM_{2.5}$ Standard and one in every two Canadians lived in communities with three-year averages above the ozone Standard. Since achievement of the Standards will be based on three-year averages, the 2010 metric will be calculated using 2008, 2009 and 2010 levels. In order for reductions to be in place by 2008, remaining jurisdictional implementation plans should be published as soon as possible.

The first five-year reports on progress towards CWS achievement are due over the next two years. The scope of the 2010 CWS review will be set by CCME, and Environment Canada looks forward to improved understanding of air pollution on a continental and hemispheric scale and the opportunity to maximize clean air benefits from major new policies/programs — both domestically and internationally.



Steve Clarkson, Health Canada

Air quality has been a concern since the first severe pollution episodes occurred in the 1930s–1960s in several urban centres including London, UK. Introduction of legislation occurred over time in many countries, and significant reduction of ambient concentrations occurred. Since then, a great deal of research has been completed investigating the relationship between air quality and health, with more information being available about short-term effects. Findings include significant respiratory and cardiovascular effects with more people dying and being admitted to hospital for heart and lung problems on days with elevated levels of air pollution.

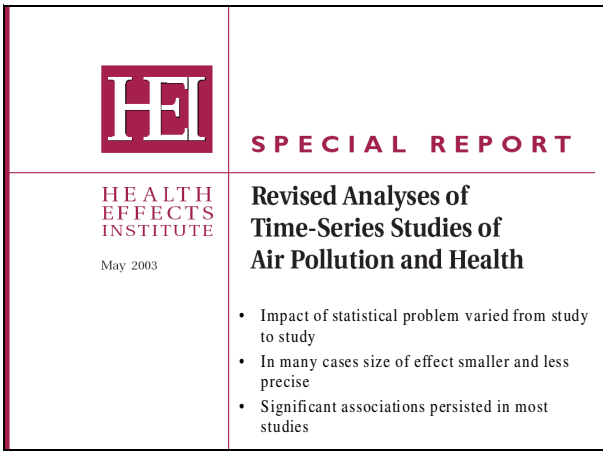


http://www.epa.gov/airnow//health-prof/EPA_poster-final_lo-res.pdf

These effects are now thought to represent the "tip of the iceberg" relative to other, milder effects, and effects have also been found at levels previously thought to be safe. A variety of biological mechanisms have been identified for these effects.

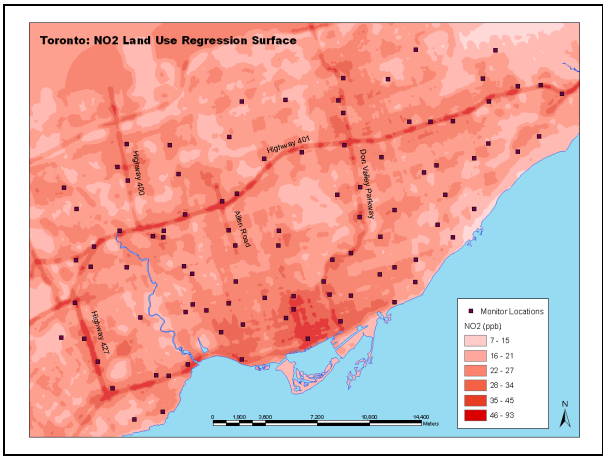
A recent study in Germany found that exposure to traffic could be a trigger for heart attack. In another study, people exposed to air collected in Toronto were found to experience narrowing of blood vessels sufficient to cause angina in someone with pre-existing coronary disease.

Methodological problems do arise: for example, three years ago a problem was found with the statistics package used for analyzing time-series studies.



Many studies were reanalyzed as a result and while the effect of the error varied between studies, the significant association of the health effects with AP remained. As well, it is recognized that findings have been replicated using widely varying study designs: from large scale population studies to controlled laboratory studies in humans/animals. Research continues into effects of specific sources, biological mechanisms, and long term effects.

While less in known about long-term effects of exposure to air pollution, evidence shows that people do not live as long in cities with high levels of air pollution, and traffic exposure has been of particular concern. A Dutch study indicated that people living near major roads were twice as likely to die from cardiopulmonary causes.



Other work found that exposure to $PM_{2.5}$ to be related to arthrosclerosis in the carotid artery, and a recent review of studies looking at air pollution and pregnancy outcomes found evidence was strong enough to support a causal link with low birth weight but weaker with other outcomes.

Related policy initiatives in Canada include low sulphur gasoline, the Canada-Wide standards (CWS) for PM, O_3, benzene, etc., the Canada-US air quality agreement, the Kyoto Protocol (reductions in greenhouse gases will also have air quality improvements), and a health risk-based air quality index.

An Irish example indicates that implemented controls can have an impact: banning of coal sales and distribution in Dublin in 1991 — a dramatic reduction in exposures — resulted in measurable decrease in death rates.

Monica Campbell, Toronto Public Health

Healthy public policy is fundamental for public health, especially for environmental health threats which require advocacy for policy shifts to be addressed. Local public health departments need to be able to provide good advice to medical officers and municipal representatives on a variety of air quality issues.

Areas of Activity in Influencing Policies Related to Air

- Exposure assessment and health risk
- Risk communication
- Broad determinants of health (e.g. social aspects)

Exposure analysis of both point sources and ambient air as well as evaluation of health risk is an important activity at Toronto Public Health (TPH). A new crematorium of concern to the community concern was evaluated using a combination of stack testing, monitoring, dispersion modeling, and emissions were found to be very low compared to both air quality standards and health benchmarks. Modeling of emissions from the Lakeview power plant indicated that an increase in power production using coal would increase NO_x and SO_2 emissions and enlarge the area of impact.

The Air Pollution Burden of Illness Report was able to estimate the impact of air quality in a cost-effective manner, provide health status information on which to base public health programs, communicate health risk, and influence decision makers.

Impact of 2000 BOI Study

- Gave rise to first *Smog Summit* in June 2000
- Catalyzed creation of *20/20 The Way to Clean Air*
- Initiated low-sulphur fuel purchases by City
- Gave rise to further research – *Condition Critical: Fixing our Smog Alert Warning System*
- Increased participation in policy discussions
- Facilitated NGOs in advocating for clean air

Risk communication is also an important activity at TPH. Mixed messages can easily arise using evidence and tools currently available: while the AQI indicates that air quality is "good" on most days in Toronto, the burden of illness study predicted 1,000 premature deaths and 5,500 hospitalizations each year from air pollution.

Broad determinants of health including social aspects must be considered when evaluating impacts of air quality. A study of the Ashbridges bay incinerator indicated the need to evaluate cumulative exposure from all sources and also to account for environmental justice concepts.

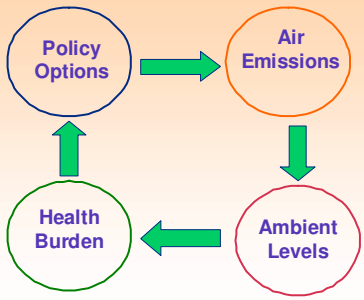
Environmental Justice Aspects

- Should consider integrating social dimensions such as environmental justice concepts when developing public policy
- Environmental justice concepts can lead to an examination of spatial distribution of pollution sources and correlations with community characteristics such as income levels, minority status or ethnicity.
- Can take into account that people of lower income are more likely to be exposed to air pollution and likely more susceptible to adverse effects from air pollution

Health Impact Assessment (HIA) may be a way to include a qualitative assessment of social aspects.

TPH would benefit from a "ready-made" integrated tool that incorporates policy options, health burden (from the perspective of the pyramid of health), air emissions and ambient levels.

Integration of Assessment Tools

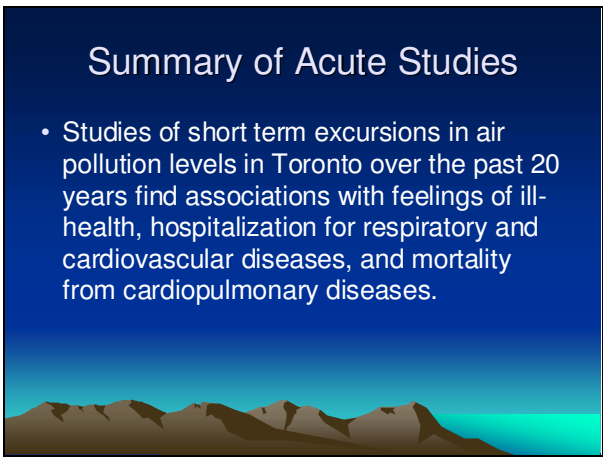


This would help to address policy questions of local significance such as: how does the burden of health shift with the introduction of designated transit lanes or road congestion pricing, creation of a bicycle network, required retirement of older vehicles, zoning changes to reduce urban sprawl, or replacement of coal-fired power plants.

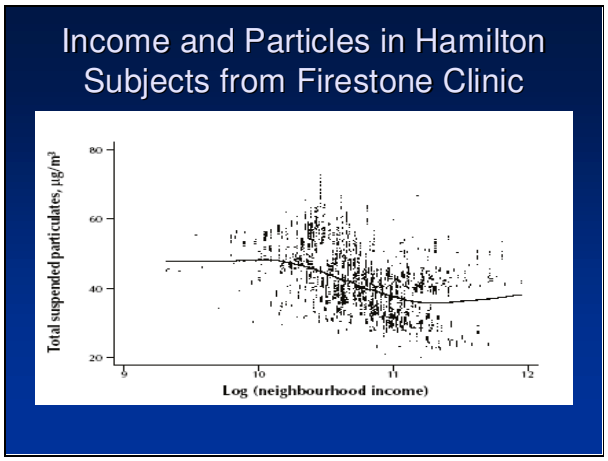
Murray Finkelstein, McMaster Institute of Environment and Health

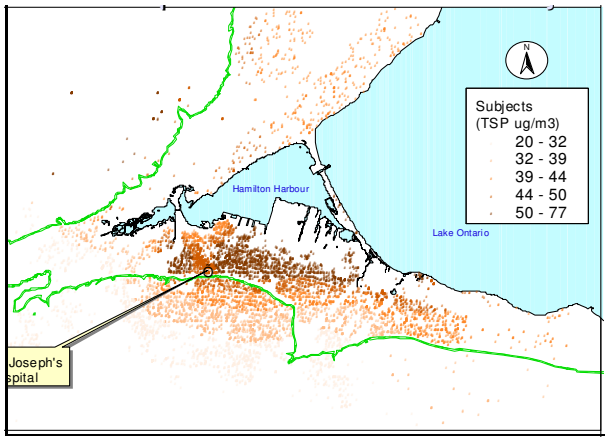
Historical evidence indicates that high levels of air pollution such as smog and SO_2 are linked to death. However, current research must address the lower levels that currently occur in Ontario.

A review of Ontario research into acute effects of air pollution suggest that a 0.2 ppm increase in CO and a 7 mg/m^3 increase in $PM_{2.5}$ are related to 30 per cent and 20 pre cent increases in disability days, that the five-day average of daily maximum ozone levels is related to a 35 per cent increase in the hospitalization of children under two years for respiratory problems, and that PM and CO were significantly associated with mortality in Toronto in the period 1980–1994.

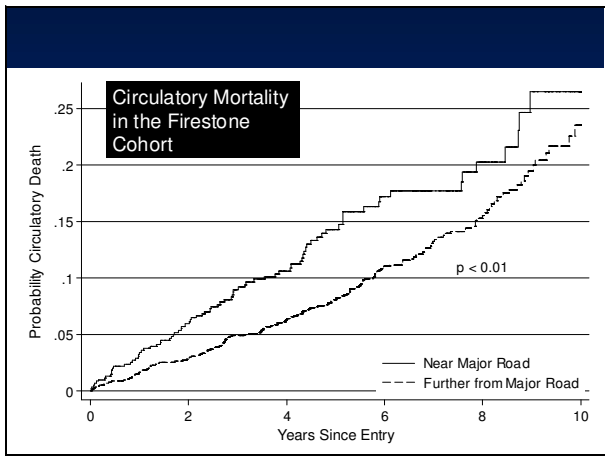


In order to investigate chronic effects of air pollution, the Hamilton/Toronto Cohort study follows 110,000 people assembled from respiratory and medical clinics in the two cities. Findings indicated that pollution affects different parts of the city differently, where people living in poorer neighborhoods appear to have higher exposures to $PM_{2.5}$, and a higher concentration of TSP occurs in downtown Hamilton.





Traffic exposure also affected health — residing within 50 metres of a major road or 100 metres of a highway increased the possibility of heart disease and death.

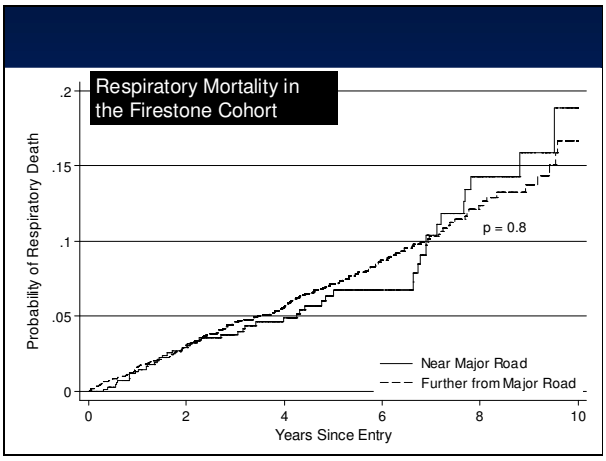


Among Toronto asthma clinic subjects, people living near major roads had a higher response rate for circulatory mortality and NO_2 exposure.

Mortality among Toronto Clinic Subjects

	Relative Risk of Circulatory Mortality	Relative Risk of Respiratory Mortality
Residence Near Major Road or Highway	1.55 (1.02 – 2.35)	1.04 (0.65 – 1.68)
NO_2 per ppb	1.05 (1.02 – 1.08)	1.00 (0.97 - 1.04)

However, there was no observed difference for respiratory outcomes in either study.



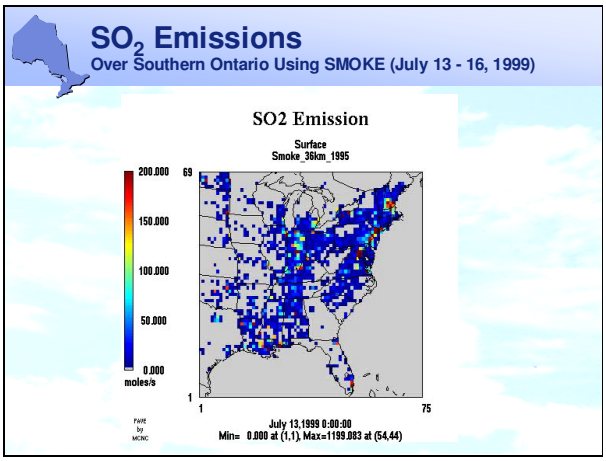
Analysis Examples and Issues

Anton Davies, RWDI

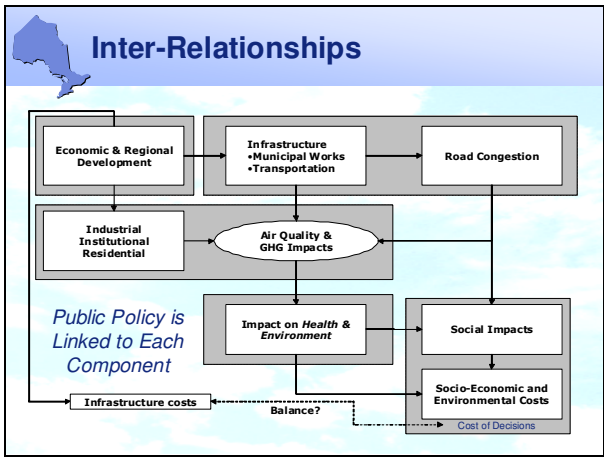
Recognizing that poor air quality which occurs in urban areas and near busy roads has impacts on both mortality and morbidity in southern Ontario today, it is clear that predictions of future impacts must consider the substantial population growth that is forecast to occur in coming years. Commute times will increase, with concomitant emissions increases.

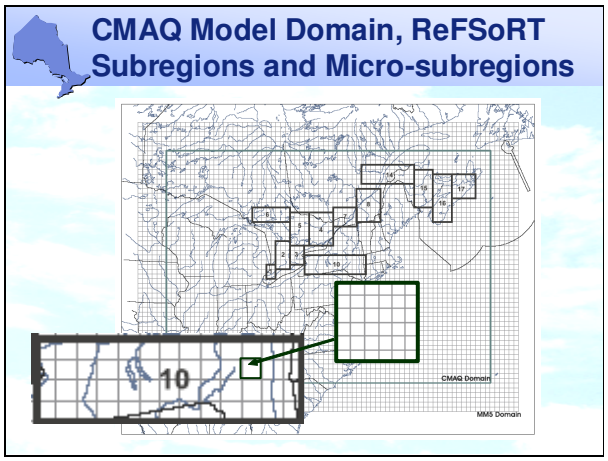
Despite the complexity of related planning issues there is a lack of a coordinated approach, and the region's current analytical tools have not integrated transportation, environment, health, economic, and social relationships in a comprehensive manner.

"SMOKE" is one model able to incorporate hour-by-hour emissions, merge with hour-by-hour meteorology, and incorporate chemistry to calculate ambient levels. High resolution is achieved and spatial distribution and gradients of air pollutants (such as the localized ozone deficit created by the Nanticoke plume) can be observed.



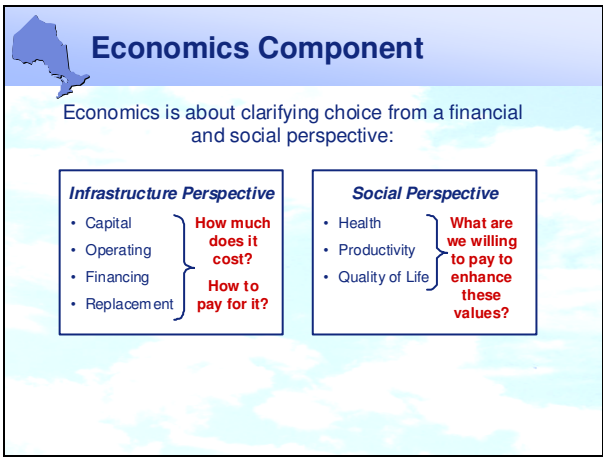
Public policy is linked to each component of many "inter-relationships", and these need to be considered together.

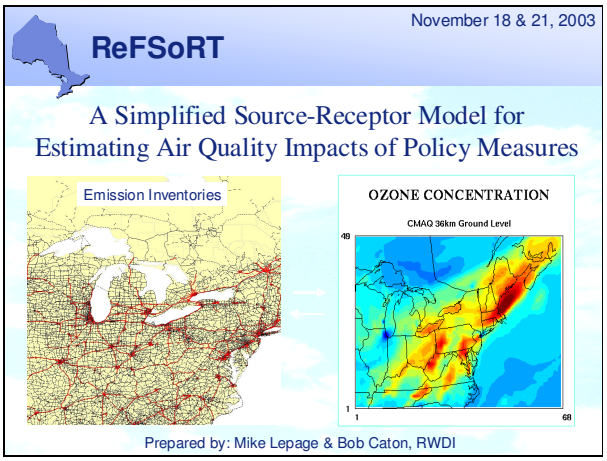




"ReFSoRT" is a simplified source-receptor model for estimating the air quality impacts of policy measures. It is able to account for some nonlinearities and for background. ReFSoRT numbers for ozone reduction are similar to predictions from other models such as CMAQ. However while ReFSoRT takes only seconds to run, the others take days. The parametric relationships used in ReFSoRT allow for significantly reduced cost to achieve high resolution information.

It is also important to be able to integrate effects on health and on the economy.





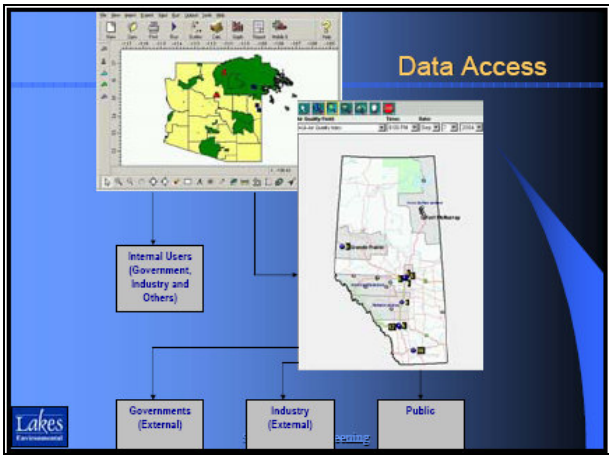
The next step will be to consider subregions such as what is happening within Toronto.

Jesse Thé, Lakes Environmental

Appropriate Risk assessment must include multi-pathway assessment of fate and transport, account for emissions from all relevant facilities and consider all sources, including traffic, which is an important source but has been neglected in previous large-scale studies developed for the US context.

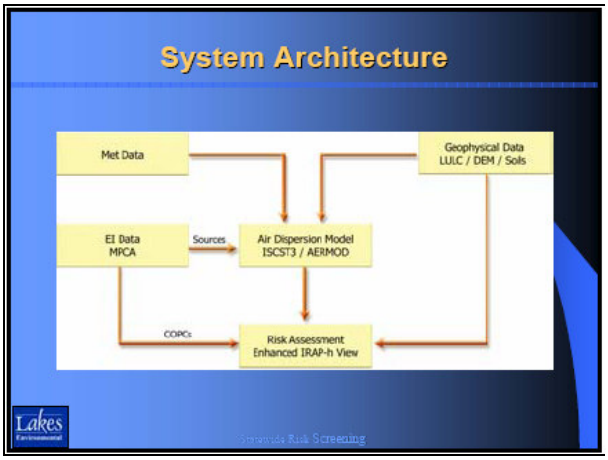
Lakes Environmental has developed the MPCA (Minnesota Pollution Control Agency) view, a sophisticated tool to comprehensively assess risks from emissions in the state of Minnesota. Minnesota is a state containing several large urban centres as well as rural areas, and ecosystem variations exist across the state as a result of the wet northeast regions and the dry southwest.

MPCA view integrates several modules including GIS, MOBILE6, calculators, non-road, and other functions which operate as a system on state-specific data acquired from a combination of internal and web-based systems.

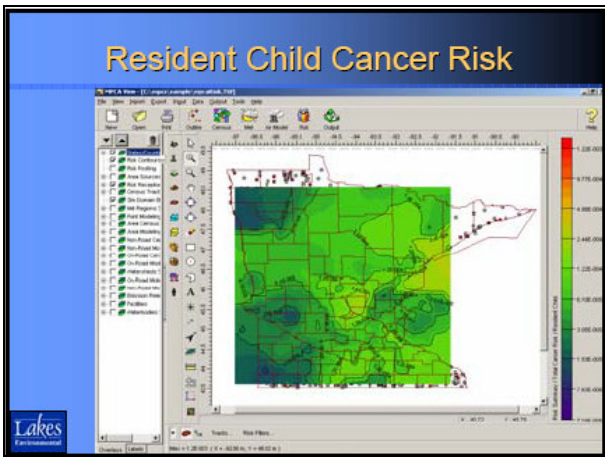


The GIS (geographic information Systems) component incorporates information such as land use, terrain and elevation, locations of water bodies, railways, facilities and other sources. The emissions inventory, which may be one of the most advanced inventories globally, accounts for source-specific parameter values, speciated emission rates, addresses issues of allowable vs. actual emissions and the sensitivity of emissions location. While the tool accounts for 9,000 point sources and 2,700 area sources including airports, roads and even fast-food restaurants, it is recognized that better spatial allocation and temporal resolution of data would improve the inventory.

As well, many sources are located outside the state, which increases the uncertainty of the inventory. The air dispersion modeling component uses hourly meteorological data, and site-specific vapour, particle, particle-bound, and mercury levels alongside ISCST3 technology to predict delivered concentrations across the state.



The risk modeling components allows for simultaneous calculation and tracking of risks from 205 substances from multiple sources and pathways. The tool incorporates common US default information to determine direct and indirect exposure, and toxicity data from a variety of sources including IRIS, HEAST, and MPCA. These methods allow for evaluation and visualization of risks (i.e., cancer) from specific substances or sources for various age groups within the population.



Using data from thousands of sources combined with sophisticated technology, this scalable tool is able to identify risks, focus resources through risk-based prioritization, track progress toward risk-reduction goals, and support monitoring activities. The methods are defensible, time and cost efficient, flexible, and solution-oriented. It is designed to be flexible for incorporation of new information, and generates reports and analysis for easy use.

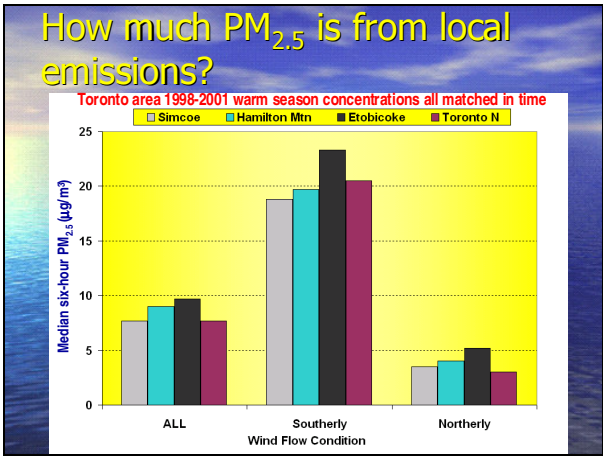
Jeff Brook, Environment Canada

The goals of air quality research include improving understanding of health effects (through identification of pollutants and sources of concern, and development of concentration response functions) and identifying main sources contributing to the problem through source apportionment methods and the development of predictive air quality models. Because many issues complicate the relationship between air quality and health problems, we want to develop predictive and integrative models which include cost-benefit analysis.

The air quality-health issue is complicated by uncertainties, incomplete information, and resistance to change.

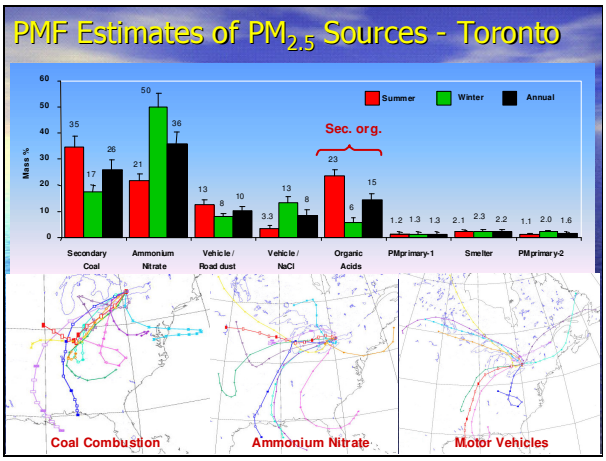
Although there are always new research questions, it is important to consider practical solutions for the near-term and the future. Detailed measurement data can provide insights: "receptor methods" bring these data together with models and knowledge of emissions to learn/inform policy analysis.

Examples of recent analysis of $PM_{2.5}$ data inform air quality management: an analysis of $PM_{2.5}$ concentrations in the Toronto region (Simcoe, Hamilton, Etobicoke, Toronto North) with different wind directions indicated the highest concentrations in Etobicoke for the southerly direction.



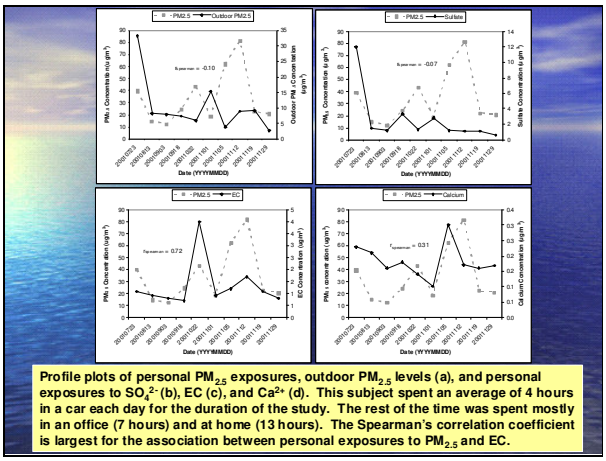
Transsects indicate that emissions from Toronto add about 4 mg/m^3 to the regional air mass as it moves northward. Trajectories indicate that many warm-season episodes in southern Ontario are linked to the Ohio valley.

Receptor models, which use fingerprints/ profiles to identify sources, indicate that the main sources of $PM_{2.5}$ in Toronto are secondary: transport of sulfate from coal combustion and ammonium nitrate.



Identifying source types and quantifying their contribution to PM is still a complex procedure.

Since policies to improve outdoor air quality should be trying to maximize health benefits it is important to think about exposure properties. Personal and ambient exposures may not be well-correlated, depending on how people spend their time.



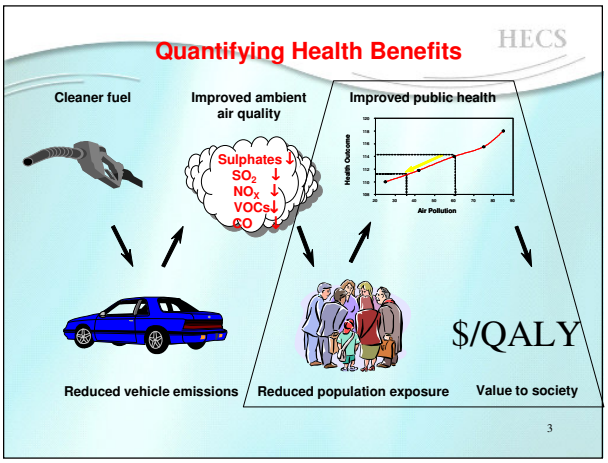
For example, traffic appears to play a larger role in influencing personal exposure than ambient $PM_{2.5}$ does, and the carbon component is more important for people who spend time commuting. Sixty per cent of personal exposure to $PM_{2.5}$ could not be linked to the three main source categories (haze and sulphate, combustion sources, and local dust) and is likely related to indoor exposures or specific individual activities.

Specific properties of PM may also be important: the organic carbon fraction (which comes from transportation) may be more acutely toxic. Ultrafine particle levels are variable and linked to traffic exposure.

Research is important in informing policy, but new policies to manage air quality often result from opportunity — we need to create an opportunity and then have the evidence — based information available.

Dave Stieb, Health Canada

Quantifying health benefits involves estimating the value to society of making some change that alters emissions and therefore exposure.

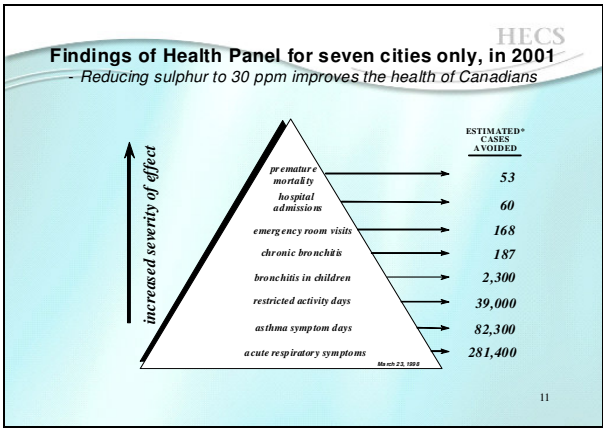


There is a large amount of information available to inform upon the relationships involved. Choosing specific parameter values could be done based on expert judgment, which is flexible and streamlined but can be viewed as arbitrary, or through systematic approaches, which are rigorous and comprehensive but also rigid and cumbersome. An alternative is to use a "structured consensus" approach.

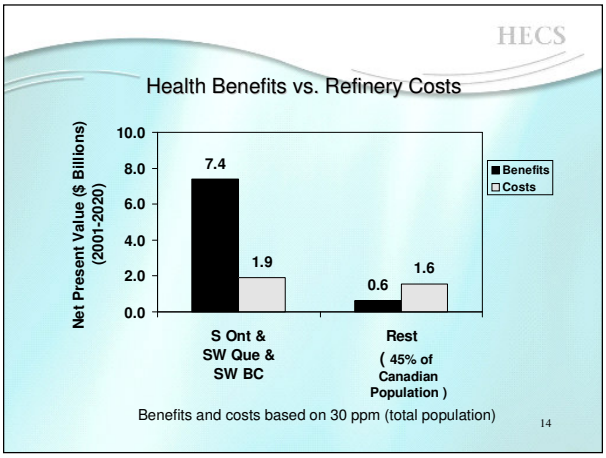
Chosen parameters are associated with uncertainty. The "what if" questions that arise from the possibility of various input values for a given parameter can be addressed through sensitivity analysis. Probabilistic analysis allows for multiple iterations of the model with inputs spanning specified distributions. This allows for output in the form of a distribution, which allows for the characterization of uncertainty associated with model predictions.

The Air Quality Valuation Model (AQVM) is a model which quantifies health benefits. Developed in 1996, it was peer-reviewed and has been applied in various contexts including analysis of Acidifying emissions, Air Quality Objectives, Sulphur in gas, Canada-Wide Standards, and Climate change co-benefits.

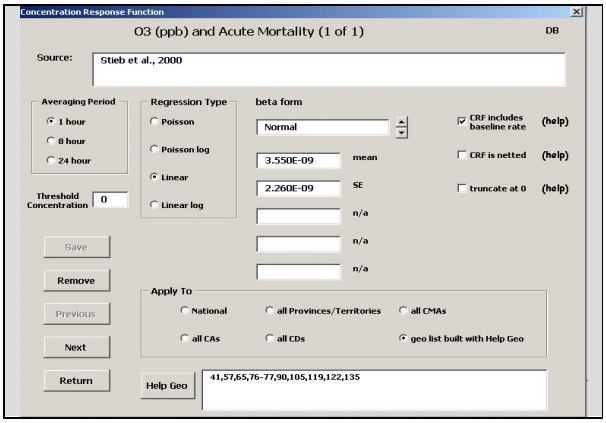
An example of a specific application is sulphur in gasoline: Canadian gasoline had levels ranging from < 10 to 1,000 ppm with a national average of 340 ppm. In 1999 a federal regulation was enacted to reduce average sulphur content of gasoline to 30 ppm by 2005. Analysis of the cost/benefit of reducing sulphur content indicated that although modest reductions in adverse health impacts were predicted, conservatively estimated health benefits outweighed compliance costs.



However, a regional difference was found in how benefits and costs compared.



There was a desire to update the capacity of the AQVM which included many objectives such as updating baseline air quality data and risk coefficients, allowing risk coefficients and baseline morbidity and mortality rates to differ by geographic area, including a more flexible approach to uncertainty analysis, and looking at alternatives to monetary valuation. As a result, the Air Quality Benefits Assessment Tool (AQBAT) is being developed with various capabilities. The functionality of the model allows different averaging periods, regression types, and probability distributions to be selected for the input by the user.



Other available models include the Ontario Medical Association's Illness Costs of Air Pollution (ICAP) model, which was released in Ontario in 2000 and has similar functionality to AQVM/AQBAT, and BenMAP, which is used by the USEPA.

Phil Blagden, Environment Canada

It is important to explore the concept of a "policy tool". Air Policy tools inform on many complex issues which have significant information requirements. Although data on individual pollutants is required to understand air quality issues, this alone cannot easily be used to guide decision-making.

The Air Quality Indicator (AQI) is a single number that applies to individual pollutants, and is not intended to characterize the health impacts of air quality. Neither can it help to determine causes for poor air quality.

The AQI is designed for short-term public health decisions. It is a communications tool for the short-term, providing a picture of air quality at a specific time. Examples of appropriate use of the AQI are to inform sensitive people about poor air quality or to indicate air pollution trends in a given community. Using the AQI, it is possible to indicate potential actions (such as staying indoors) or to demonstrate that air quality is an issue across the country.

It must be noted that air quality is more related to weather than to any reductions strategies used.

Limitations exist for time-series studies (such as correlation and multiple-pollutant) and other methods used to assess health impacts of air quality. Variation occurs with inputs and outcome selected. However, an overall idea of the relationship is obtainable, and individual pollutants such as PM can act as useful indicators.

The "old AQI", uses the pollutant whose concentration is highest relative to a standard to provide the indicator. It is a good basic system: often high levels of several pollutants occur together.

A "new AQI" is being formulated based on short and long-term health impacts using combined pollutants. This AQI will still be generated based on ambient monitoring information. Initially, the AQI formulation was to include CACs ($PM_{2.5}$, CO, NO_2, O_3), but CO was dropped since (a) it has no health effects and (b) issues with monitoring such as instrument sensitivity and spatial location relative to roadways was problematic. It is noted that NO_2 and CO are strongly correlated. Other pollutants were added based on risk factors based on mortality.

This "new" AQI relies on the pyramid of health effects and uses combined datasets of recent and long-term information. The formulation will be pilot tested this summer in British Columbia.

This AQI should also be viewed as a *communications tool.* Communication including appropriate community messages is critical. Messages much reach sensitive individuals without causing alarm to the community at large.

Within the public health context, air quality advice needs to recognize that there are various risk factors. Air pollution cannot be addressed on its own.

Poster Abstracts

(Summaries Only: Full posters are available at www.irr-neram.ca)

Change in Air Quality Around the Ashbridges Bay Treatment Plant

Anthony Ciccone[1,2], Dr. Angela Li-Muller[3], Mark Rupke[4], Jean Yves Urbain[5], Diane Michelangeli[6]

Local residents of South Riverdale and the Beaches have been concerned about effects of local industries on the local environment and their health. While many large industrial facilities have either closed or relocated by the end of the 1990s, the residents of these communities remain concerned about what they expressed as the "cumulative effects" of previous and current exposures to pollutants from these industries. Today the Ashbridges Bay Treatment Plant (ABTP) is one of the few large scale industrial plants remaining at the waterfront bordering these two communities.

The ABTP has undergone significant process changes since 1995 including the discontinuation of incineration, the addition of a pelletizer, and the addition of biofilters. These past changes as well as proposed changes alter the emission profile of the facility. Toronto Public Health (TPH) commissioned an evaluation of the ABTP impact on air quality in South Riverdale and the Beaches (the two (2) study areas). The modelling analysis evaluated the past, present and future potential concentrations of various chemicals in the two study areas resulting from the ABTP against the Ontario Point of Impingement (POI) standard, Ambient Air Quality Criteria (AAQCs) and various health benchmarks provided by TPH.

To evaluate the past, present and future emissions from the ABTP, four (4) emission scenarios were developed based on available emission testing data, literature information and engineering knowledge of the plant with the aid of the CALPUFF modelling system. A protocol to select 17 Chemicals of Concern (COC) from the 186 chemicals for air dispersion modelling was developed. This protocol took into account the quantity of emission, potential health impacts, persistence in the environment, accumulation in the biota, availability to humans and community's input.

[1] Golder Associates, [2] Principal Investigator, [3] Toronto Public Health, [4] City of Toronto, [5] Earth Tech (Canada) Inc., [6] York University

Environmental Benefits of Improved Air Quality

Michael Donohue[1]

Initiatives to improve human health by reducing air pollution will also result in significant environmental benefits. Reductions in PM & Ozone (smog) will have numerous environmental benefits, in addition to improving human health. Many of the same pollutants that are responsible for the creation of PM and ozone, also contribute to acid rain. Reducing these emissions will also reduce acid rain which will have a wide range of environmental benefits.

This poster will identify some of the environmental benefits of taking action to improve human health by reducing smog and/or reducing the emissions responsible for smog.

Benefits will be discussed qualitatively and wherever possible quantitatively. The quantitative assessment of the benefits will include both quantification of the physical impacts and the monetization of these impacts. That is, where possible, impacts on the environment, economy, and social well being will be expressed in dollar value equivalents. This poster will also discuss some of the tools and models used to quantify and monetize the environmental benefits of air quality improvements.

Some of the environmental benefits to be examined will include the following:

Smog

- Improved visibility
- Increased agricultural production
- Increased forest growth and health
- Reduced material soiling
- Improved environmental health

Acid Rain

- Increased tree growth
- Reduced building corrosion
- Commercial fishing industry benefits
- Recreational fishing benefits
- Improved wildlife and natural health

[1] Environmental Economics Branch, Environment Canada

Development of a Health Effects-based Priority Ranking System for Air Emissions Reductions from Oil Refineries in Canada

Stephanie Gower[1], John Hicks[2], John Shortreed[2], Lorraine Craig[2], and Stephen McColl[1,2]

In Canada, the CCME (Canadian Council of Ministers for the Environment) is currently engaged in a process to determine how best to reduce air emissions from oil refineries. The NFPRER (National Framework for Petroleum Refineries Emissions Reduction) is being developed with the input of stakeholders including NGOs, industry, and regulatory jurisdictions. One component of this framework is the development of a tool to prioritize emissions for reduction based on estimated health impacts. HEIDI II (Health Effects Indicators Decision Index II) is a spreadsheet-based model that prioritizes a series of carcinogenic and non-carcinogenic air toxics and criteria air contaminants commonly emitted from Canadian oil refineries. A generic meteorological dispersion model is applied to reported annual emissions data for each of Canada's 20 refineries. Photodegradation rates and ambient levels of each substance are accounted for, and air concentrations are calculated for 20 geographic zones around each refinery. These are coupled to toxicity data derived mainly from Health Canada and the USEPA, and applied to target populations of children, adults and seniors. HEIDI II predicts incidence of relevant disease endpoints from each substance emitted, except for BTEX and PAH, which are treated as chemical mixtures. Rankings are based on predicted case incidence or the application of a common health impact metric, Disability-Adjusted Life Years, (DALYs) to the predicted incidence. Using the DALY approach, priority rankings can be made within each of the chemical classes, or across all three classes together. HEIDI II incorporates several switches that allow the user to investigate alternate scenarios based on stack height, average daily sunlight hours (for calculating photodegradation), and the possibility of emissions below regulatory reporting thresholds.

[1] Dept. Health Studies and Gerontology, University of Waterloo, [2] Institute for Risk Research

A New Microscale Motor Vehicle Emission Model: Determination of Neighbourhood Air Pollution for Human Exposure Assessment

Rakesh Singh[1,2], James Sloan[1,2], and David Roewade[3]

The *MOBILE* emission model (developed by the US EPA) used in Canada to estimate vehicle emissions at national, provincial, and local level is not suitable to provide emission requirements of air quality models at micro scale. Waterloo Centre for Atmospheric Sciences has developed a new emission factor model for Canadian motor vehicle fleet to provide a high degree of temporal and spatial emissions information. This model development will support provincial/municipal planners to make accurate assessments of human exposure to determine the adverse health effects of motor vehicle traffic in urban areas and in understanding PM and ozone formation in Southern Ontario, Canada.

This poster presents a strategic partnership between WCAS and the local health unit. The project focus and purpose includes research considerations such as emissions from transport sector, *MOBILE* emission model, need for micro scale emission model and local exposure data, *MicroFac* model and it's performance for site-specific vehicle fleet and comparison with *MOBILE* results, demonstration of *MicroFac* and *CALINE4* roadway dispersion model in Waterloo Region, hospitalizations vs. locations of major roads, schools and daycare, per cent use of commute and hours spent in outdoor environment in Waterloo Region.

Finally, it is concluded that a site-specific real-time emissions are needed for modeling air transport/dispersion and human exposure in various roadway microenvironments. *MicroFac* models will provide emissions at fine resolution critical for the assessment and prediction of traffic related exposure conditions and potential health impacts.

[1] Waterloo Centre for Atmsopheric Sciences, [2] University of Waterloo, [3] Region of Waterloo — Environmental Health

Appendix A: Supporting Statements for Workshop Statement

1A. While consensus exists that poor air quality has an impact on human health, assessing the degree of its significance is complicated by uncertainties and requires knowledge about endpoints other than mortality.

Breakout group 1 (Bruce Walker, Chair)

- The health impacts of air pollution are relatively low; and may be confined to those with pre-existing medical conditions, the elderly, etc.
- While mortality may be higher with impacts such as car-accidents, the lost person-years is greater with air pollution

Breakout group 2 (Anton Davies, Chair)

- There is evidence to show effects on both morbidity and mortality, particularly for cardiorespiratory outcomes. Although the risks are relatively small, when examined on a population basis, large numbers are affected
- Need to be aware that focusing on end points for which we have evidence now may be limiting. Recent studies show impacts on birth outcomes (low birth weight, chromosomal damage), lung function deficits among teenagers (California study), lung cancer (ACS study) and childhood cancers (ACS study)
- Which particles sizes contribute most to health impacts? Studies indicate that the fine fraction is most harmful, however there is evidence to show that the coarse fraction is associated with triggering asthma episodes. It is not clear what the toxic component of the coarse fraction is. The evidence is unclear on the health significance of ultrafines. There is evidence of linkages with cardiopulmonary and respiratory symptoms but the biological mechanism is not clear. U of T is doing work in this area. The health impacts of ultrafines would be on a very local level

Breakout group 2 (Jay Barclay, Chair)

- At the broad level it is clear that there are health effects
- It is hard to get a sense of how significant air pollution is on a "small scale"/at a local level
- The pyramid of health effects can be useful for influencing decision-makers at the local level even when you don't have that many "bodies"
- There is a big lag on data availability i.e. for hospitalizations at the national level
- There is still a great deal we don't know (i.e., what about some of the constituents of vehicle exhaust including metals, ultrafine particles). Also what about various air toxics and their ability to "stick" to PM

Presentations

- Peggy Farnsworth: one in every three Canadians lived in areas with three-year averages above the $PM_{2.5}$ standard (2001–2003); one in every two Canadians lived in areas with three-year averages above the 0_3 standard (2001–2003)
- Steve Clarkson: "More people die and are admitted to hospital for heart and lung problems on days with elevated levels of air pollution"; "Effects found at levels previously thought to be safe"; "People do not live as long in cities with high air pollution"; "Air pollution may contribute to adverse pregnancy outcomes, atherosclerosis the development of lung cancer and chronic lung disease"

- Monica Campbell: Toronto's air pollution leads to 1,000 premature deaths and 5,500 hospitalizations each year; air pollution affects health year round
- Murray Finkelstein: Studies of short term excursions in air pollution levels in Toronto over the past 20 years find associations with feelings of ill-health, hospitalization for respiratory and cardiovascular diseases, and mortality from cardiopulmonary diseases; There is an association between traffic-related pollution in Hamilton and Toronto and increased rates of circulatory disease hospitalization and mortality
- Jeff Brook: Size of acute cardiovascular response is most-related to organic carbon
- Quentin Chiotti: [Evidence indicates] There could be 2300+ deaths attributable to air pollution in Ontario that is not caused by transboundary sources or from the province's coal-fired power plants

1B. Evaluation of the impact of air pollution on health must occur within the broad context of public health and consider social and interactive effects.

Breakout group 1 (Bruce Walker, Chair)

- There may be more potential benefits to spending money in other areas of public health
- Exposure (both chronic and acute) is involuntary
- There are also other issues to consider with air quality: those of aesthetics and non-mortality effects

Breakout group 2 (Anton Davies, Chair)

- Health impacts need to be considered within the broader context of public health. For example, what is the significance of air quality episodes on physical activity? Air quality needs to be viewed as a public health issue rather than a pollution control issue
- Traditional quantitative health impact assessment needs to be broadened to include social impacts (i.e. commuting time/road rage, quality of life)

Presentations

- Monica Campbell: Should consider integrating social dimensions such as environmental justice concepts when developing public policy
- Murray Finkelstein: Poorer neighbourhoods in Hamilton have higher levels of pollutants
- Anton Davies: Economics is about clarifying choice from a financial and social perspective

2A. There is agreement that tools and approaches are available which can inform policy at various levels; the most successful of these are broadly applicable.

Breakout group 1 (Bruce Walker, Chair)

- Inventories are improving over time with integration of tools such as GIS
- Models are reasonable for making use of monitoring data
- Need to target sources with multiple pollutants and sources with the greatest potential for reduction

Breakout group 2 (Anton Davies, Chair)

- Models are a useful policy informing tool, but need to take into consideration people's experience/other factors in making decisions. Their usefulness is situation-specific

Breakout group 3 (Jay Barclay, Chair)

- There are tools that relate emissions to ambient AQ (i.e., RWDI, Jesse Thé) … and tools that relate ambient AQ to health impacts (i.e., AQBAT, ICAP)
- Approach of linking sophisticated models with impacts is welcomed

- Yes — there has been a lot of work done by the city of Toronto, Jerrett etc.
- There are good "one-off" models — i.e., we have the capability to answer specific questions
- We are capable of doing environmental evaluation
- There are models to separately evaluate environmental and health effects (AQBAT an example for health effects)
- Most agencies are more comfortable implementing policies that affect a broad range of pollutants or actions — related to a need to implement actions at regional level

Presentations

- Anton Davies: descriptions of "SMOKE" and "ReFSOrt"
- Jesse Thé: description of MPCA view
- Dave Stieb: descriptions of AQVM, AQBAT, ICAP, mention of BenMAP

B. Barriers to meaningful use of available policy analysis approaches include

(i) complexity and inaccessibility — there is a need for guidance document
(ii) limitations inherent in data inputs, including emissions inventories and monitoring data
(iii) inability to address effects of air quality in a manner that reflects the various levels of policy and decision-making within and across the various jurisdictions that deal with air quality in Canada
(iv) limited capacity to identify cross-cutting benefits
(v) procedural limitations inherent in moving from output to application of policy including difficulties interpreting endpoints or outputs

2B(i) (complexity and inaccessibility)

Breakout group 1 (Bruce Walker, Chair)

- Criteria for applying (and not applying) modeling are not established
- Public health capacity with regard to AQ is lacking

Breakout group 2 (Anton Davies, Chair)

- Need to compare models in terms of approach and inputs. How do they do valuation, what are the exposure assumptions etc.?
- Policy makers/health planners at the local/municipal/regional level need greater capacity to use and interpret modeling tools including guidance on how to conduct an appropriate analysis and how much certainty is needed to implement a policy based on modeling results (NEED FOR A PRIMER). Need tools to assess the impacts of development on the airshed and human health to guide planning of schools, roads, trees in relation to residential neighbour-hoods. The public is asking serious questions on these issues and answers are not always readily available

Breakout group 3 (Jay Barclay, Chair)

- Want to have integrated models that can be used and manipulated by those who research policy and try to influence local decision-makers (i.e., local health units)
- Accessibility to tools to "make the case" is an issue at the local level
- A need to be able to create models/tools that can be used by non-experts. Also that are not too expensive/draining on resources
- Models are "arcane" — understood by only those who create them — need to be able to extract concepts to take them to decision-makers
- Models must be transparent; but not necessarily available for change by users (it is then not the same model)
- Local municiplaities have different specific questions that they are currently unable to answer:

- Small-scale S-R
- Urban design
- Residential sources — these can be important sources (i.e. biomass combustion in your backyard)
- Local/small-scale smog forecasting
- Impact of biodiesel
- Education as a policy tool (i.e. wrt residential emissions)

Presentations

- Monica Campbell: Mixed messages can arise when using currently available tools such as AQI

2B(ii) (limitations inherent in data inputs)

Breakout group 1 (Bruce Walker, Chair)

- More monitoring, ambient levels, especially within municipalities
- There is a gap between health department needs and monitoring information
- Routine monitoring cannot be done on a very fine resolution (is this important?)
- The cumulative impact is crucial
- Spot monitoring on an as-needed basis may be effective
- Local(community)-based ambient levels are based on Toronto average levels. Is this adequate?
- Modeling is dependent on emissions inventories. Do we have adequate modeling/inventory tools?
- Passive monitoring may be useful but is still not down to "block level
- Change in different methodologies, standards; comparing of different monitoring methods

Breakout group 2 (Anton Davies, Chair)

- There is a lot of focus on models and it is easy to be seduced by the graphic output. How useful they are depends on the quality of data inputs

Breakout group 3 (Jay Barclay, Chair)

- Previously, different agencies have come out with different estimates — there would be more confidence if there was a convergence of estimates; this is now starting to be observed

Presentations

- Monica Campbell: The cumulative impacts is: Total impact of all emission sources
- Jay Barclay: Areas of uncertainty include identification of key pollutants, source apportionment, trends (in emissions, policy impact, targets, and climate change impacts), health effects, vulnerable subgroups, the relative importance of indoor and outdoor air quality, and economic and environmental impacts
- Jesse Thé: Emissions inventories as source of uncertainty
- Jeff Brook: Capability to identify sources and characterize AQ could be out-stripping health knowledge
- Phil Blagden: The Air Quality Indicator (AQI) is not intended to characterize the health impacts of air quality

2B(iii) (multiple jurisdictions)

Breakout group 1 (Bruce Walker, Chair)

- Data is managed by various agencies/ ministries in various jurisdictions
- Question of municipal authority to manage urban pollution problem
- Important to have an integrated (multi-juristictional) approach to AQ management
- How can we influence action at pollution source outside of managerial jurisdiction (i.e., Ohio, PN)

Breakout group 2 (Anton Davies, Chair)

- GTA Clean Air Council has been working for two years on a joint GTA model across with all regions, City of Toronto, lower tier

municipalities. There are issues of who owns the data, how to get the data, how to develop models to suit various needs. There are issues of governance and authority and various sensitivities. Who has jurisdiction to develop rules and standards? Municipalities have information at a fine level of detail but it is difficult to undertake analyses on a local and regional basis to assist with decisions on new development applications. Jurisdictional and governance complexity adds to the complexity

Breakout group 3 (Jay Barclay, Chair)

- Many tools are created based on a need at the national level (i.e., international conventions)
- A diversity of approaches may be useful

Presentations

- Peggy Farnsworth: Federal government committed to pursue reductions in transboundary flow into Canada from the United States; Renewed federal/provincial cooperation
- Jay Barclay: pollution occurs on a variety of scales from local to international, and at any given location may be attributed to a variety of sources
- Jeff Brook: 30–37 per cent of fine particle concentrations in Toronto are locally produced

2B(v) (cross-cutting benefits)

Breakout group 2 (Anton Davies, Chair)

- The biggest gap is the inability to link climate change and air quality modeling. Need to identify win-win actions. Decisions on land use have impacts on air quality and climate change issue. Need to look at issues from an energy demand perspective. Work on modeling climate change impacts on air quality has primarily been through back of envelope calculations. There are many science gaps

Presentations

- Peggy Farnsworth: Federal government will focus on taking full advantages of linkages to climate change, acid rain, Project Green and other major initiatives

2B(v) (procedural limitations)

Breakout group 1 (Bruce Walker, Chair)

- Just because there is more information does not mean that gov't will be able to make changes to policy and management
- There may never be enough monitoring
- Mechanisms for linking air quality and health are improving to the point where the heal
- th interpretation is more than adequate for informing policy formulation
- Long lag time for new policies to be introduced
- Is our ability to interpret the model output adequate?

Breakout group 3 (Jay Barclay, Chair)

- Previously, different agencies have come out with different estimates — there would be more confidence if there was a convergence of estimates; this is now starting to be observed

Presentations

- Ed Cocchiarella: Re: approvals process in Ontario and other areas — it is complicated — it is hard to know whether you have met all the requirements/done everything before even proposing new projects or new industry

3. Models and analyses should be able to identify good policy options that are effective and cost-efficient. Interest was expressed in approaches that (i) are comprehensive (ii) are integrated, especially multi-government (iii) identify barriers to existing options (iv) are subject to continuous improvement, and (v) result from stakeholder dialogue

(i) Development of comprehensive approaches

Breakout group 1 (Bruce Walker, Chair)

- Not sure of the effects of currently implemented policies — how can we model effects of potential policies?
- Inventories do not account for residential, transportation sectors, etc.
- Models must communicate the predicted/ simulated impacts of choices over the long-term
- "low hanging fruit" are often the cheapest options
- We have been working on these issues for some time — low-hanging fruit may not be the issue
- Need to consider policy objectives and the appropriate policy response — can use multiple options simultaneously
- Option of limiting two-stoke engines
- Suggested approach: take the approaches for the top 10 cities in SW Ontario and lump all solutions together for the SW corridor; see what happens to AQ

Breakout group 2 (Anton Davies, Chair)

- We need policy decision criteria to guide the choice of health metrics. Should premature mortality be the endpoint for valuation? If we move to Quality Adjusted Life Years the emphasis shifts from older people to youth. The metric will influence the outcome and this has societal implications. Should the emphasis be placed on poor health among the elderly?

Breakout group 3 (Jay Barclay, Chair)

- The EC is currently trying to develop tools that look at the benefits to Canadians in more than just a fiscal sense
- Uncertainty is still a big issue; conclusions being drawn may not be robust enough
- Some models (i.e., AQBAT) have used statistical approached to incorporate uncertainty
- While the application of hard science has been useful, modelers need to look at the "softer side"
- Quantifying social benefits of air quality
- Benefits of improving AQ should be defined in terms of more than just financial/"competitiveness"
- There is a need to bring together all factors — economic and social

Presentations

- Monica Campbell: TPH would benefit from a 'ready-made' tool that incorporates policy options, health burden (from the perspective of the pyramid of health), air emissions and ambient levels
- Jay Barclay: Broadly, we may need to consider how economic activity ultimately affects human welfare. There are a variety of relationships that can affect each other.
- Jeff Brook: Traffic played a larger relative role in influencing personal exposures compared to ambient $PM_{2.5}$
- Dave Stieb: Quantifying health benefits includes estimating value to society, not just predicted incidence
- Phil Blagden: Within the public health context, air quality advice needs to recognize that there are various risk factors. Air pollution cannot be addressed on its own.
- John Shortreed: We need to design models that address the "weakest link" in the long list of links
- Quentin Chiotti: how do we address land use, behaviour, etc?

(ii) Development of multi-government (integrated) approaches

Breakout group 1 (Bruce Walker, Chair)

- Different jurisdictions have diverse capacity and resources. Need increased information-sharing and analysis of easy steps to take
- Need political commitment on a long-term basis
- Need management on an airshed basis, not a source basis. Can then look at more flexible tools such as ET Modeling can help in this regard. Using airshed models would require involvement of multiple jurisdictional governments

Breakout group 2 (Anton Davies, Chair)

- This is like "arranging deck chairs on the titanic". We are really trying to work within the existing paradigm and are not tackling fundamental issues such as can we continue with business as usual, continued growth, subdivisions with thousnads of homes in GTA. Who is looking at these issues? Ultimately these issues have to be addressed within the climate change file
- It is difficult to divorce other aspects of environment from air. How can we responsibility plan new development (new urbanism), high density residential areas around transportation corridors in walkable quadrants? Should roads be paved or use trees as buffers? We don't have the integrative regional scale models and tools to compare the various options? Who pays for these analyses, the developer, the region? There is the expectation that municipalities are key actors in the solution but that's the piece that is missing
- Need to think about scale for policy making. In the case of new power plants would we require plant to be built as co-generation facility? In thinking about strategies for siting and considering tradeoffs should we tie policies in to urban strategies rather than focusing on the provincial level?

Breakout group 3 (Jay Barclay, Chair)

- Should there be a national consensus about the pollutants of interest? Although experts rarely agree, if an expert panel or subgroup was formed, there is possibility of reaching an agreement
- There is a disconnect between planners and builders
- Want to have integrated models that can be used and manipulated by those who research policy and try to influence local decision-makers (i.e., local health units)

Presentations

- Anton Davies: The regions' current analytical tools have not integrated transportation, environment, health, economic, and social relationships in a comprehensive manner; Public policy is linked to each component of many "inter-relationships", and these need to be considered together.
- Quentin Chiotti: Will emissions trading lead to hotspots i.e., in Ontario or elsewhere?

(iii) Identification of barriers to existing options

Breakout group 1 (Bruce Walker, Chair)

- Do our models indicate which policy strategies offer the most effective options?
- Policies are not necessarily enforced, i.e., anti-idling is not always easy — think of drive-thrus, exempted vehicles; hard to make people comply

Breakout group 2 (Anton Davies, Chair)

- Economic barrier — citizens must bear the cost, and therefore public must be convinced that there is a benefit (*Education, especially children)

(iv) Continuous improvement of modeling methods including incorporation of new technologies, improved exposure assessment, and characterization of uncertainty

Breakout group 1 (Bruce Walker, Chair)

- Unclear how accurate modeling outputs are; depends on inputs!
- To understand health impacts, need to know real exposure, beyond ambient levels — allows targeting of emissions reductions in the most impactful way

Breakout group 3 (Jay Barclay, Chair)

- Exposure assessments are still very inaccurate
- Want to be able to zero in on policies that affect receptors (related to Brook's info that 60 per cent of personal exposure cannot be linked to ambient)
- In many places the monitoring is not appropriate, i.e. monitors high above the breathing level; not enough urban monitors

Presentations

- Jeff Brook: 60 per cent of personal exposure to PM2.5 could not be linked to the three source categories
- Dave Stieb; can incorporate sensitivity analysis and probabilistic analysis
- Dave Stieb: AQBAT as an improvement on AQVM; both AQVM and ICAP underwent/ undergo periodic reviews and updates
- Phil Blagden: A "new AQI" is being formulated based on short and long-term health impacts using combined pollutants.
- Greg Evans: The relationship between individual exposure and ambient exposure is not close

(v) Continued stakeholder dialogue

Breakout group 1 (Bruce Walker, Chair)

- What are the implications of considering ambient and acute pollution versus the POI method?

Breakout group 2 (Anton Davies, Chair)

- There is a need for continued interaction between policy makers and scientists. So policy people can clarify there decision needs and scientists can explain the model limitations and assumptions. This is important to ensure that the model results are not misused

Breakout group 3 (Jay Barclay, Chair)

- Perhaps the biggest gap identified was a gap of communication between stakeholders. Information about the relevant questions and the availability of models or of methods to address those questions is not being transferred effectively. Information about what models are available does not appear to be reaching people involved in policy-making at the local level in an efficient way. This workshop was seen as a good start to this process; however there needs to be continued fostering of communication between these stakeholder groups

Presentations

- Phil Blagden: Communication including appropriate community messages is critical
- Ed Cocchiarella: Stakeholder dialogue should be ongoing — it creates an atmosphere of mistrust when it occurs only for specific issues.
- John Shortreed: Stakeholder buy-in: we want to "get on with" most cost-effective options

Appendix B: Comments on Draft Statement and Actions Taken

A process was followed to seek comments and feedback from workshop participants. Although some editorial changes were suggested, no comments altering the substance of the workshop summary were received.

Appendix C: Background Materials

(This list is not intended to be exhaustive, but rather provides a starting point for further research)

Environment Canada (Last update 2002). The Corporate Smog Action Plan: Smog Alert. A Federal Response Guide for Federal Facilities in Ontario. Retrieved June 15, 2005 from www.on.ec.gc.ca/pollution/fpd/csap/7000-e.html

FAQs on the Health Effects of Air Pollution: A Resource for Health Professionals. Canadian Public Health Association. Retrieved June 15, 2005 from www.cpha.ca/cleanair/FAQ.pdf

The Illness Cost of Air Pollution: Ontario Medical Association 2005–2026 Health and Economic Damage Estimate.s June 2005. Retrieved June 15, 2005 from www.oma.org/phealth/smogmain.htm

NERAM III CONFERENCE STATEMENT Strategies for Clean Air and Health. Rome, Italy 2003. Retrieved June 15, 2005 from www.irr-neram.ca/rome/Rome%20Statement.pdf

NERAM IV Colloquium Framework Document. International Perspectives on Air Quality: Risk Management Principles for Policy Development — Global perspective on the development and implementation of air quality management policies at the international, national, regional, state, and local levels. Retrieved June 15, 2005 from www.irr-neram.ca/about/Colloquium%20Framework.pdf

NERAM IV COLLOQUIUM STATEMENT. International Perspectives on Air Quality: Risk Management Principles for Policy Development. National Institute for Public Health — Cuernavaca, Mexico. January 31–February 1, 2005. Retrieved June 15, 2005 from www.irr-neram.ca/pdf_files/Mexico_Statement.pdf

Ontario Ministry Programs and Initiatives Publications. Various. Available for download from www.ene.gov.on.ca/programs/index.htm#AIR

Pollution Probe. Smog Primer. Retrieved June 15, 2005 from www.pollutionprobe.org/Reports/smogprimer.pdf

Provincial Health Officer's Annual Report 2003. Air Quality in British Columbia, a Public Health Perspective. Retrieved June 15, 2005 from www.healthservices.gov.bc.ca/pho/pdf/phoannual2003.pdf

Toronto Public Health. Curbing Transboundary Air Pollution: Protecting Health through Legal Action. A report from Dr. David McKeown, Medical Officer of Health. Toronto, Ontario: 2005. Retrieved June 15, 2005 from www.city.toronto.on.ca/health/hphe/pdf/boh_curbing_transboundary_air_pollution_full.pdf