The State of Edmonton's Ambient Air Quality

By Matthew Dance

Abstract

Air quality (AQ) is a relative measure of our ambient air that is a reflection of how much pollution is emitted into the atmosphere versus how quickly the atmosphere can absorb and disperse those emissions. Edmonton has 4 Ambient Air Quality monitoring stations. These data indicate that Edmonton's AQ is considered good over 90% of the time and that poor AQ is often a result of forest fires or temperature inversions. Fine particulates and ground level ozone (PM&O3) are two common urban pollutants that are components of smog and have a negative impact on human and ecosystem health. Following the 'keeping clean areas clean' principal, PM&O3 management frameworks are being developed to manage these emissions, and Edmonton has a key role to play.

Within this context, the City of Edmonton is implementing an ambitious strategic plan that integrates municipal development and transportation master plans in a bid to create a modal shift from cars to transit. Supporting this work are several policy initiatives and projects such as an anti-idling by-law and the LRT expansion. Recommendations include the development of an enhanced citizen based monitoring network, coupled with continued work on currently active policy initiatives, strategic plans and projects.

Biography

Matthew Dance, a Director with the Tomorrow Foundation, is currently completing a Masters of Arts at the University of Alberta. His thesis is focused on how people understand location and express that understanding with emerging web-based tools. As part of his research, he is building an application that combines mapping, social networks and collaboration elements that will enable the citizens of Edmonton to discuss on-line their use of Edmonton's River Valley trail network. Prior to starting graduate school he worked as an independent consultant primarily with Alberta Environment helping to develop environmental policy. He filled project management, facilitation, research and strategic advice roles on several policy projects. In addition, he worked as a Senior Project Manager developing air quality policy for Edmonton's Clean Air Strategic Alliance.

Discussion Paper

What is Air Quality?

Air quality (AQ) is a relative measure of our ambient (that which surrounds us) air and is a reflection of how much pollution is emitted into the air versus how quickly the atmosphere can absorb and disperse those emissions. Air quality is also ephemeral and subject to climate and natural variations; we can experience good air quality in the morning and, as a result of - for example - a temperature inversion or a forest fire, poor air quality in the afternoon. People expect that the quality of the air that they breathe be good and that the air not subject them to any harmful effects or exacerbate any current health conditions such as asthma, which implies an effective, efficient and appropriate ambient air quality management process.

This discussion paper will review the current state of air quality in the city of Edmonton; describe the main sources of emissions and the current regulatory framework that seeks to control those emissions within a broader Edmonton region. In an effort to focus this paper, specific attention will be paid to those primary and secondary emissions that contribute to smog. Primary emissions are those emissions like oxides of nitrogen and particulate matter that are emitted during combustions. Secondary emissions, such as ground level ozone (O3), occur when primary emissions undergo photochemical transformations.

I will also provide a brief AQ policy overview of two initiatives undertaken by the City of London that provides some insight into the innovative ways that air quality can be understood and managed in Urban Areas. Within this context, emerging innovative technologies will also be discussed.

Overview

Regional Context

The question of Edmonton's ambient air quality is complex. Edmonton's air does not exist in isolation; our air (and air quality) is part of a broader system of air that is influenced by industrial point source emissions originating to the west and east of the City. We are also subject to area and transportation emissions, the non-point source emissions that we generate in our everyday lives doing things like heating our homes and driving to work. Edmonton's air quality is also influenced by hourly, daily and annual variations in temperature and sunlight. To try to understand these complexities, it is important to provide an overview of the emissions in the Edmonton region and how those emissions are regulated and monitored.

Emissions

Edmonton's air quality is influenced by several emissions sources. **Point source emissions** within the broader Edmonton region include Thermal Electric (Coal) Power Generation located west of the city in addition to Oil and Gas (Upgraders and other processes such as Chemical Manufacturing) east of the city. These facilities operate under Alberta Environment approvals[i] or Alberta Energy Resources Conservation Board[ii] permits. **Area Sources** are stationary sources that do not need to obtain a license to operate. Area sources include residential emissions (home heating, wood burning), associated with the operation of commercial buildings, and light industrial emissions. When compared to industrial point source emissions, each individual area source is small but as a whole area emissions are significant. Finally, **Transportation Sources** comprise on-road (i.e. personal vehicles for commuting, commercial traffic, etc.) and off-road vehicles such as railways, aircraft, and small recreational or yard maintenance / farming engines. The emissions from transportation sources are managed by federal regulation associated with vehicle (or small engine) emissions standards, and fuel standards.

Municipalities have a leadership role to play in terms of behavior management. Programs such as anti-idling by-laws, vehicle emissions clinics, and specific taxes such as British Columbia's carbon tax, all encourage people to think about how they use their cars, as well as the emissions associated with vehicle use.

Policy / Regulations

Several provincial and federal policy pieces exist that provide a framework for the management of emissions in the Edmonton area[iii], including the emissions from the Coal Fired Power Plants to the West and Upgrading Facilities to the East.

There are over 15 pieces of Federal Environmental Legislation and Regulation[iv] that pertain, directly or indirectly, to ambient air quality. In general, Federal Regulation is designed to be broad in scope and to address issues of national significance. For instance, it is the Federal Government, as previously mentioned, that regulates vehicle (on- and off-road) emissions and fuel standards as well as the Canadian Clean Air Act[v].

The Government of Alberta is concerned with legislation and regulation at the provincial level. The cornerstone piece of provincial environmental legislation is the Alberta Environmental Protection and Enhancement Act (AEPEA[vi]) that enables other provincial legislation, regulation and policy related to air quality. Some specific pieces include a management framework for the electricity sector[vii] (those power plants to the west of Edmonton) and several regulations that manage emissions from the oil and gas sector including Facility Approvals [viii]and Ambient Air Quality Objectives[ix]. Alberta's Clean Air Strategy [x]outlines the Ambient Air Quality monitoring goals and objectives – it is the basis for all of the monitoring that occurs in the province.

Federal and provincial governments are in a position to legally control the emissions from industrial sources by setting binding standards as well as exacting consequences to those

who exceed those standards. The same is true for the manufacture of vehicles (including small engines) and fuels. Municipalities are limited in comparison and must rely on municipal level legal instruments and policy to inform urban form and transportation options. The instruments that a municipality can use to influence air quality outcomes, includes: by-laws, City policy and strategic plans such as Municipal Development Plans, Transportation Master Plans and By-laws In addition, the City of Edmonton is in the process of developing an environmental sustainability plan, The Way We Green[xi].

Edmonton's current Municipal Development Plan, The Way We Grow[xii], was amended as a bylaw in January 2010 (expected approval date is June 2010). The Transportation Master Plan, the Way We Move[xiii], was made a bylaw in September 2009. Both of these policy pieces mark a significant change in thinking about the City of Edmonton in that The Way We Grow and Move were developed concurrently "...as an acknowledgement that land use and transportation are inherently linked" and collectively represent a policy foundation for managing the City of Edmonton's environment, including air quality.

Monitoring

There are two general types of monitoring conducted within the Edmonton region; emissions monitoring addresses industrial settings in addition to Ambient Air Quality (AAQ) monitoring, which is conducted as a means of understanding the integrated exposure that a population may be subjected to as a result of all emissions.

Within the greater Edmonton region there are 10 AAQ monitoring stations; three of which allow public access to their real time data feeds[xiv] and provide a public assessment of the air quality relative to an Air Quality Index[xv]. At these locations, Alberta Environment reports that Edmonton's air, as measured by this Air Quality Index, is considered 'good' over 90% of the time. Those times when the air quality is not good usually occur as result of weather conditions that inhibit pollution dispersion into the atmosphere. The Air

Quality Index is based on outdoor concentrations of carbon monoxide, fine particulate matter, nitrogen dioxide, ozone and sulphur dioxide.

Current Air Quality

Although Edmonton has 'good' air quality over 90% of the time, we do have an issue with two specific pollutants - Particulate Matter (PM) and Ozone (O3) – that are components of urban smog. PM and ozone are described by the United States Environmental Protection Agency as being concerning due to their potential human health impacts, including reduce airway function and may cause permanent lung damage after repeated exposure. While there is no immediate urgency with this issue as Edmonton is not over the health thresholds as set by the Canadian Council of Ministers of the Environment, it is important to understand where the PM and Ozone are coming from, and how we can keep Edmonton's air clean given a growing economy and population. Currently, we do not have a good understanding of PM and ozone distribution in Edmonton.

PM is emitted by combustion from a number of sources including vehicles and wood burning (it is also a component of road dust and can be formed by atmospheric photochemical processes). Ground Level Ozone is not emitted by a source, but occurs as a result of a photochemical reaction between vehicle emissions (including oxides of nitrogen), sunlight and heat. As such, we are more likely to see smog in the summer time when temperatures are warm enough to drive a photochemical reaction. Alberta Environment's PM and Ozone Assessment[xvi] (2006 – 2008) indicates that the Edmonton Region has an increasing intensity of ground level ozone that requires the development of an ozone management plan. This collaborative process is occurring through the ACAA, in which the City of Edmonton plays a key role.

Outstanding Questions

In recap, Edmonton is surrounded by many industrial emissions sources that are regulated and monitored by federal and provincial authorities. All regulated emissions are reported to the National Pollution Release Inventory (NPRI) and are publicly available on-line from the NPRI[xvii]. The City of Edmonton, on the other hand, has a combination of regulated and unregulated emissions sources that are poorly understood and only monitored via the four ambient air quality monitoring stations. This situation raises many questions:

1. What impact do industrial emissions have on local (Edmonton's) air quality?
2. What is the air quality in Edmonton in all of the places where monitoring does not occur? For instance, the AAQ monitor in downtown Edmonton is located away from major arteries and on the top of a building. Does this adequately reflect the air that we breathe at street level?
3. What is the impact of older vehicles and single occupancy vehicles on air quality adjacent to the major roadways in Edmonton?

The most important thing that can be done in managing Edmonton air quality is to understand in greater detail where the problems are and what their cause is. I think that new technologies have a key role to play in creating a better understanding.

Technology as a Monitoring Tool

Background

The Social Internet defines a means of interaction between people that is characterized by a rich user experience including an exchange of multimedia information[xviii]. Within this context, new technologies are enabling citizens to collaborate in a geo-located online environment where each person can be considered as a sensor in that they may see or respond to poor air quality, and report their response on-line. Eye on Earth[xix], a web-based mapping tool developed in a partnership between Microsoft and the European

Environment Agency, plots air quality stations and their associated data on a map, and supports citizen observations and experiences where citizens can rank the quality of the air in a specific location. There is the potential with collaborative mapping to also gain insight into specific experiences of people with health conditions, such as asthma, that are exacerbated by poor air quality. For instance, someone may report that the air in downtown Edmonton is poor at the corner of 109 Street and Jasper Avenue, and that they have had tightening of the chest or some other symptom as a result

Distributed Sensor Networks

Purchasing and installing a standard AAQ monitoring station like those used by Alberta Environment with the ACAA can be prohibitively expensive. A typical monitoring station can cost tens of thousands of dollars; distributed sensor networks may offer a cost and space effective solution. A distributed sensor network uses small commercially available sensors to establish a network of interconnection that can provide, in this example, a tapestry of AAQ data readings for a large area. For instance, Edmonton's busiest roadways can be monitored for carbon monoxide and oxides of nitrogen; the resulting data can help us make decisions on how to manage vehicle traffic, and what populations of people may have adverse health outcomes due to an increase in traffic flow.

Cambridge University's CamMobSens project[xx] is in the process of developing this type of distributed network. They are currently testing a suite of GPS enabled sensors that will monitor NO and CO, where the output from these sensors can be displayed in Google Earth. Some of these sensors are built small enough that a pedestrian can carry it while walking though the city.

Mobile Sensor Networks

A mobile sensor network is simply a distributed sensor network that moves. There are some advantages to this in that a broader geographic area can covered, and citizens can

become engaged by actively monitoring the locations where that have some concern. An example of this is the MIT Senseable City Lab[xxi] Copenhagen Wheel. A Copenhagen Wheel combines GPS and smog sensors with a regular 26" or 700c bicycle wheel that can fit onto many standard road and mountain bikes. The Copenhagen Wheel will be commercially available for around $500.00 in 2011[xxii]. In effect, a person riding a bike equipped with a Copenhagen Wheel will record AQ data every few meters of the route that they have ridden.

Issues with new Technology

Privacy and reliability

Location and data privacy is a major concern often cited in reference to on-line mapping or reporting tools. Location privacy relates to sensitive personal location information becoming available to a broader public. For instance, a person may not want their home or work place inadvertently included on a route recorded with a personal GPS. There are two specific issues; an individual having data control so that they can modify or mask personal location information, in addition to understanding who can or will be able to see their personal data. The AQ data readings from several people can be automatically aggregated to mask individual identity and specific location.

Of course, there is also a concern that individuals may not always report details accurately. In that case it is possible to create a ranking tool within the application that rates the validity of the report based on the number of observations. In addition, certain reliable individuals can have a 'moderator' status that is granted once their reliability has been confirmed. Individual personal reports can also be validated with a distributed sensor-monitoring network.

Best Practices

The City of London offers two examples of best practices:

1. The London Air Quality Network[xxiii] provides an interactive map of London, England that allows the user to explore air quality trends on a parameter-by-parameter basis. For example, when you access the map you can select the area of London that you would like to see, the parameter that would like data for (e.g. particulate matter, oxides of nitrogen) and the map will display those ambient concentrations. It is a powerful visualization tool as it highlights the areas of most concentration (often roadways) and offers a 3D view for certain sections of the city. This type of map interface can also be linked to sensor networks, allowing for real time AQ visualization.

2. London is also home to a Congestion Charge Zone[xxiv] (CCZ). The CCZ was introduced to London in 2003, and expanded to include a larger geographic area in 2007. Its purpose is to reduce congestion and raise funds for London's transportation network by charging drivers a toll to drive into the central part of London. In essence, it is a levy for drivers to access central London, and act as a control on the number of vehicles in central London, and the number of occupants per vehicle (more people per car implies less cost per person, thus supporting car pools).

While there are congestion benefits to the CCZ, it is hard to conclude where the air quality benefits come from – less traffic in central London or better vehicle emissions control technology.

A Proposed Way Forward

Industrial Emissions

The City of Edmonton is not in a position to directly influence industrial emissions in the broader Edmonton region; these emissions are regulated at the provincial and federal levels. Indirectly, though, the City has a leadership role to play. Currently there are three

airshed zones that cover or abut the city of Edmonton boundaries[xxv]. These zones are multi-stakeholder organizations that work in a collaborative manner to monitor and, in some cases, manage emissions through the development of local policy. The City of Edmonton should continue its participation at the board level of the Alberta Capital Airshed Alliance (ACAA). Through the ACAA's partnership with the Capital Air Partnership, which is made up of all three airsheds in the Edmonton region, it has the ability to influence air quality management decisions in the region.

The Strathcona Industrial Association (SIA) operates 4 ambient air quality-monitoring stations east of Edmonton within the Strathcona Industrial Complex. The City of Edmonton should work with other municipalities and Alberta Environment to encourage all organizations, including the SIA, to collect and provide ambient air quality data in an open and transparent manner in keeping with the City of Edmonton's Open Data policy.

Area Source Emissions

There is a very poor understanding of the extent and impact of area source emissions on ambient air quality. One obvious outcome from this is to document, at a community or neighbourhood level, general emissions sources – residential, light industrial, transportation (i.e. rail yards), and then deploy a distributed ambient AQ monitoring network to document the AQ impacts from those emissions sources.

Building standards define the minimum requirements that a building must obtain to be used. The current Alberta building code does not explicitly state minimum energy efficiency. In contrast, British Columbia is undergoing a Greening the Building Code[xxvi] process that will see the following improvements:
- Code changes to improve the energy performance of housing to the equivalent of EnerGuide 80 in 2011

- Participation in a national process to establish an improved energy code for larger, more complex buildings
- Solar hot water ready homes (where practical) in 2010
- Code requirement for high-efficiency toilets (including dual-flush) and urinals in new construction in 2010
- Code requirements to support increased use of non-potable water for toilet flushing, irrigation and cold-water clothes washing in 2011

The City of Edmonton can work with the Government of Alberta to amend Albert's building code to reflect a greater interest in energy efficiency and pollution management. Furthermore, the City of Edmonton can initiate a program to train builders in new energy efficiency building techniques.

City of Edmonton Programs

The City of Edmonton has taken an integrated approach to Urban and Transportation planning that is very powerful. This approach acknowledges the relationship between urban form and modes of transportation and seeks to better manage both. For instance, The Way We Move emphasizes the use of roads for the transportation of goods, and the LRT / Transit / Active Transportation Network as the primary means of moving people. Performance measures have been established by the City that seek to document citizen access to transit, and alternative moves of transportation (i.e. a cycling network) The combined outcomes of these initiatives can be improved air quality as well as healthier communities.

Anti-idling is a behavior modification approach to managing emissions from personal and commercial vehicles that is topical within the city of Edmonton. Implementation of this policy is difficult in that people may not voluntarily change their behavior. In fact, there is evidence in the research literature calling into question the effectiveness of broad based

voluntary measures[xxvii]. Within this context, there are a couple of approaches that can be explored:

- City of Edmonton fleet vehicles should not idle unless it is vital to the work that they are accomplishing. The idling of City of Edmonton vehicles could potentially be managed through the creation of a job performance measure for employees who drive a City vehicle as part of their day-to-day job.
- Children are vulnerable to the smog associated with vehicle emissions. As such, school zones should be the focus of an anti-idling policy. In my experience, involving children in an environmental campaign is an indirect way to put pressure on the parents who are responsible for its implementation.

Vehicle Inspection clinics can also be effective if implemented appropriately (these could be a joint program between the City of Edmonton and the Government of Alberta). Ontario and British Columbia both operate vehicle inspection programs where, on an annual basis, all personal vehicles are inspected to assess their tail pipe emissions. Data from the Clean Air Strategic Alliance ROVER II Project[xxviii] indicates that this may not be an efficient approach to vehicle emissions management. Specifically, this survey identified 5% of vehicles as being gross emitters, and those vehicles can be characterized as older (model years older that 1996), or fueled by propane. As such, it may be more appropriate to develop a targeted policy that addresses older, high emitting, vehicles rather that a broad based policy that encompasses all vehicles.

These are significant steps that acknowledge the relationship between transportation modes and air quality. Additional steps can include:

1. An analysis of a Congestion Charge Zone,
2. Limiting the number of parking stalls in Edmonton's downtown core,
3. Evaluating the benefits of increasing the cost to park in downtown Edmonton, and;
4. Implementing a pedestrian mall pilot project on Jasper or Whyte Avenue where the avenue would be closed for a brief period of time.

Conclusion

While the Air Quality in Edmonton is good most of the time, economic and population growth may increase the ambient levels of particulate matter and ground level ozone. To better understand the current distribution and occurrence of PM&O3, additional AAQ monitoring should be implement in key Edmonton locations, such as along major transportation and pedestrian arteries. Within this context, the City of Edmonton should develop an air quality strategy that could include citizen engagement coupled with a goal of understanding current air quality and future trends. Emerging novel technologies, such as distributed monitoring networks and crowdsourcing, can help engage citizens with this goal in mind.

Furthermore, the City of Edmonton should continue with the implementation of an expanded LRT system coupled with their numerous strategic and policy directions aimed at managing vehicles and vehicle emissions coupled with a transit and pedestrian friendly urban form. Novel approaches should also be explored, such as:

- A modified building code that would increase the minimum efficiency of new and renovated homes, including a streamlined process to approve PV and solar water heaters
- The potential of pedestrian malls should be explored. While the AQ benefits may be time sensitive, a pedestrian mall may challenge citizens to think outside the 'big' box and to shop locally

[i] More information regarding Alberta Environment facility approvals can be accessed at: http://environment.alberta.ca/01529.html

[ii] Please see the following for more details: http://www.ercb.ca/portal/server.pt/gateway/PTARGS_0_0_299_260_0_43/http;/ercbContent/publishedcontent/publish/ercb_home/about_the_ercb/what_we_do/

[iii] Dance, Matthew (2008). A review of Existing Ambient Air Quality Policy Potentially Affecting Emissions of PM and Ozone Precursors with Alberta Airshed Zone. This bibliography is available through the Alberta Central Airshed Alliance.

[iv] Dance, Matthew (2008). A review of Existing Ambient Air Quality Policy Potentially Affecting Emissions of PM and Ozone Precursors with Alberta Airshed Zone. This bibliography is available through the Alberta Central Airshed Alliance.

[v] More information regarding Canada's Clean Air Act can be found at: http://www.ec.gc.ca/cleanair-airpur/clean_air_act-ws1ca709c8-1_en.htm

[vi] Alberta's Environmental Enhancement and Protection Act can be accessed through Alberta's Queens Printer at: http://www.qp.alberta.ca/

[vii] The Emissions Management Framework for Alberta's electricity sector can be found at: http://www.environment.alberta.ca/0959.html

[viii] More information regarding Alberta Environment facility approvals can be accessed at: http://environment.alberta.ca/01527.html

[ix] Existing Ambient Air Quality Objectives, as well as a description of the policy can be found at: http://www.environment.alberta.ca/01005.html

[x] Alberta's Clean Air Strategy was developed through a multi-stakeholder consensus based process at the Clean Air Strategic Alliance (CASA). The Clean Air Strategy can be found on CASA's website at: http://www.casahome.org/?page_id=3194

[xi] Details pertaining to the City of Edmonton environmental strategic plan,The Way We Green, can be found at: http://www.edmonton.ca/city_government/city_wide_initiatives/the-way-we-green.aspx

[xii] Information pertaining to the City of Edmonton's Municipal Development Plan, The Way We Grow, can be found at:

http://www.edmonton.ca/city_government/city_wide_initiatives/municipal-development-plan.aspx

xiii Information pertaining to the City of Edmonton's Transportation Master Plan, The Way We Move, can be found at: http://www.edmonton.ca/city_government/city_wide_initiatives/draft-transportation-master-plan.aspx

xiv Alberta Environment's Current Air Quality Website integrates a map of Alberta with live AQ data feeds and can be found at: http://www.envinfo.gov.ab.ca/AirQuality/

xv Alberta's Air Quality Index produces a qualitative measure of outdoor air. Details of the Index can be found at: http://www.envinfo.gov.ab.ca/AirQuality/

xvi A complete list of Alberta Environment's PM and Ozone Assessments and Fact Sheets can be found at: http://environment.alberta.ca/0895.html

xvii Information on the National Pollution Release Inventory, including a Google Earth Map of facility locations and emissions, can be found at: http://www.ec.gc.ca/inrp-npri/default.asp?lang=en

xviii Parameswaran, M., & Whinston, A. B. (2007). Social computing: An overview. *Communications of the Association for Information Systems, 19*, 762-780.

xix Eye on Earth is a European Environmental Commission map of water and air quality monitoring for Europe. This map may be adapted for Edmonton or Alberta. Please check out: http://Eyeonearth.cloudapp.net

xx Cambridge University's CamMobSens project can be found at: http://www.escience.cam.ac.uk/mobiledata/

xxi The Senseable City Lab does some very innovative work around enabling sensors within cities. I suggest that you have a close look at the WikiCity Rome Project and the Firefly Project in addition to the Copenhagen Wheel. The Lab can be accessed at: http://senseable.mit.edu/

xxii Personal communication (2010). You can find our more about the Copenhagen Wheel and receive regular updates by joining their Facebook site at: http://www.facebook.com/#!/pages/The-Copenhagen-Wheel/227258447591?ref=ts

xxiii The London Air Quality Map can be found at:
http://www.londonair.org.uk/london/asp/virtualmaps.asp?view=maps

xxiv The London Congestion Charge Zone can be found at:
http://www.tfl.gov.uk/roadusers/congestioncharging/

xxv A map of the airsheds the cover and abut Edmonton can be found on the Alberta Capital
Airshed Alliance website at:
http://www.capitalairshed.ca/AboutUs/tabid/56/Default.aspx

xxvi Please see the British Columbia House and Construction Standards web site at:
http://www.housing.gov.bc.ca/building/green/

xxvii For a complete discussion on policy instruments, please see *Chapter 2, Policy
Instruments and Implementation Styles: The Evolution of Instrument Choice in Canadian
Environmental Policy* by Michael Howlett found in Canadian Environmental Policy, Context
and Cases (2002) edited by Debora L VanNijnatten and Robert Boardman.

xxviii The Clean Air Strategic Alliance ROVER II Project can be found at:
http://www.casahome.org/?page_id=119