Coal • Health • Carbon • Wildfires • Climate Change

Electricity was recognized by the UK Department of Health as the 'most vital of all infrastructure services' because 'without it most other services will not function.' – *Power Outages, Extreme Events and Health: A Systematic Review of the Literature from 2011-2012*

Burning Questions

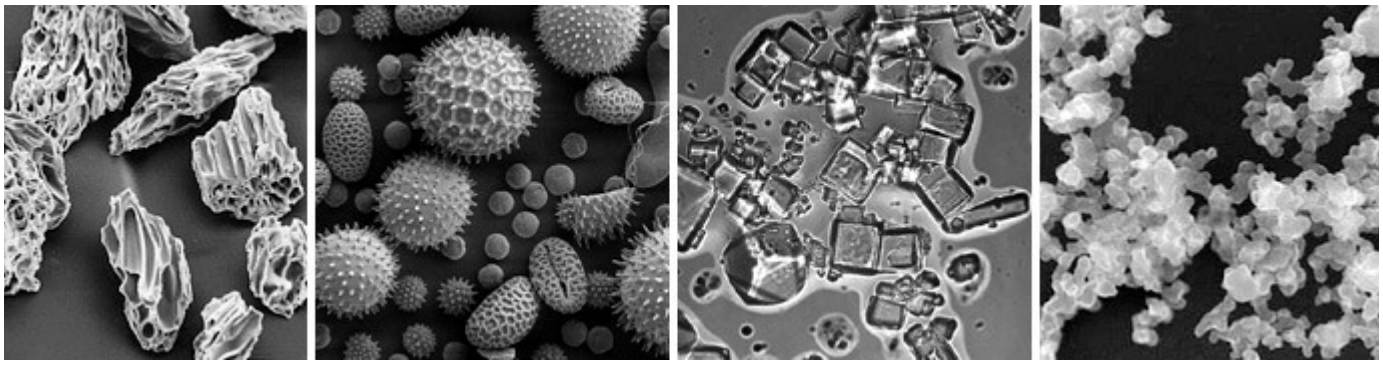
An Evidence-based Review of the Alberta "Phase-out Coal" Campaign

FRIENDS OF SCIENCE
Providing Insight into Climate Science

January 2015

Examples of particulate matter smaller than 2.5 or 10 microns.

These images show particulate matter from natural sources and human activity (i.e soot/black carbon stems from burning biomass such as residential fireplaces or wildfires and also from fossil fuel use). Natural and industrial PM2.5 emissions affect human health in many ways.



These scanning electron microscope images (not at the same scale) show the wide variety of aerosol shapes. From left to right: volcanic ash, pollen, sea salt, and soot. [Micrographs courtesy USGS, UMBC (Chere Petty), and Arizona State University (Peter Buseck).]
http://earthobservatory.nasa.gov/Features/Aerosols/

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Burning Questions

An Evidence-based Review of the Alberta "Phase-out Coal" Campaign

Executive Summary

This report was prepared in response to the recent 'Alberta Phase-out Coal' campaign that is based on the Pembina Institute's report "A Costly Diagnosis: Subsidizing Coal Power with Albertans' Health". The Pembina Institute report is based on a health-illness computer model, not actual patient records and misrepresents the facts about coal-fired power plant emissions, exaggerating them by 15 fold.

In 2004, Dr. Ross McKitrick, economist at the University of Guelph, tested the Illness Cost of Air Pollution (ICAP) and found that it predicted more people died of air pollution than died in total.

In 2011, coal-fired power plants emitted ~1,800 tonnes of particulate matter smaller than 2.5 microns (PM2.5) while wildfires emitted 1,715,000 tonnes of PM2.5 – almost one thousand times that of coal-fired power plants. Recent research from the National Smoke Conference confirm acute and chronic health impacts from wildfires. Asthma and other health issues are exacerbated by particulate matter that is smaller than 2.5 microns – known as PM2.5.

Tonnes PM2.5	2011	2012	% Change
Coal-fired plants	1,782	1,628	-8.6%
Human-caused-including coal	400,571	510,937	+27.71
Coal/all human	0.44%	0.32%	

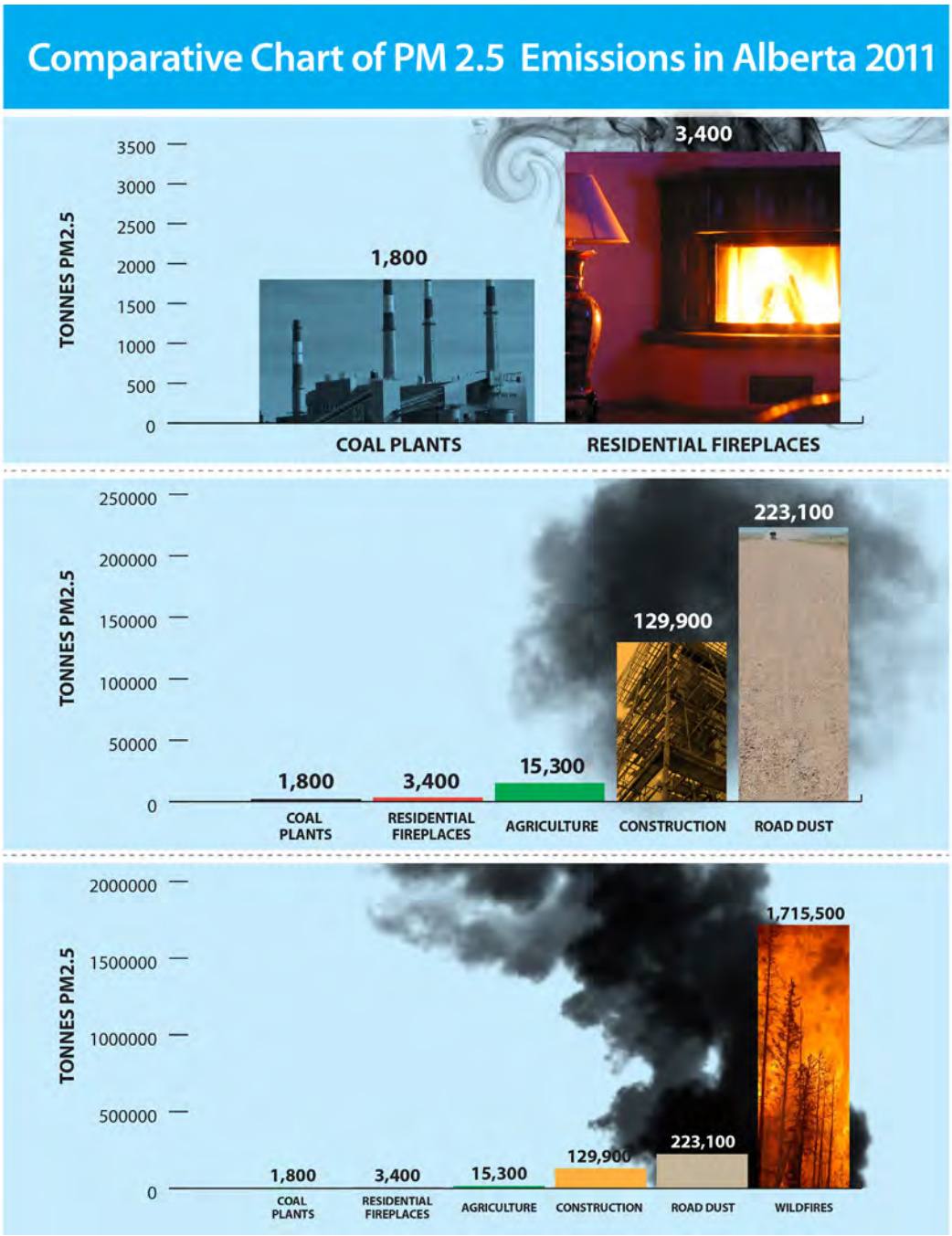
According to Environment Canada, coal-fired power plants in Alberta in 2011 emitted only 0.4% of PM2.5 of human-made emissions (excluding wildfires); Pembina Institute claimed coal-fired power plants emitted 6% of human-made PM2.5 emissions and that carbon emissions from coal-fired power plants cause climate change and wildfires. Environment Canada 2012 statistics show a reduction by 8.6% in PM2.5 emissions to 1,628 from coal-fired power plants.[i]

All Alberta coal-fired power plants use pulverized coal technology that ensures complete burning. Alberta's carbon dioxide emissions barely register on NASA's recent satellite observations of earth. Human-made carbon dioxide emissions are only 5% of 0.039% of the atmosphere.

In short, Albertans' health is not at risk from coal-fired power plants; if anything the high quality of available health care and advanced treatments and surgeries (i.e. cancer

diagnostics, complex surgeries, transplants, ICU, etc.) all rely heavily on stable, affordable power.

The Pembina Institute and the health charities supporting its report frequently refer to Ontario's phase-out of coal-fired power plants as a success without mentioning that Ontario hospitals are now facing a 27% rise in power prices and will be cutting services in order to manage. Moving from coal-fired power plants in Alberta in 10 years, as Pembina demands, would cost >$11 billion, plus billions in compensation to the coal industry, for no measurable benefit.



Data Source: Environment Canada 2011 (excepting natural sources)
Wildfire source: Data Cdn Integrated Forest Fire Services for hectares (ha) burned; USDA FOFEM (20% consumption rate) analysis; ~50-80% of all wild land fires are human-caused.

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1.Overview

This report is an independent initiative by Friends of Science Society in response to the 2013 publication "A Costly Diagnosis: Subsidizing Coal Power with Albertans' Health" and the 2014 "Alberta Phase-out Coal" campaign.

Recently there have been calls for the early shut-down of coal-fired power plants in Alberta. Coal-fired power plants already have a federal decommissioning schedule in place (over the next 50 years) as older plants reach the end of their useful lives. The proponents of an early phase-out of coal-fired power plants, claim that this would measurably benefit health, reduce medical costs, and reduce global warming. They claim that renewables (wind and solar) can replace coal to reduce health costs and save lives. Their health claims rest on the Illness Cost of Air Pollution (ICAP) computer model which uses PM2.5 emissions (particulate matter smaller than 2.5 microns) and ozone as health impact markers.

PM2.5 emissions are far too small to be seen with the naked eye, but when present in the air in quantity, from a source of combustion, these black carbon (BC) particles are visible as soot or smog, as in the image below in China. PM2.5 is visibly evident in Canada during the summer wildfire season. PM2.5 emissions are also generated by other human activities like industry, construction, road dust and from ammonia fertilizer used in agriculture which can morph into a barely visible mist carrying PM2.5 particles. Natural sources of PM2.5 emissions include pollen, spores and moulds that appear seasonally and are more prevalent in farming areas. In China, as in many developing nations, the residential use of coal and wood/biomass burning for heating and cooking exacerbate indoor and outdoor pollution. [ii]

The Pembina report relies on a health effects model that uses PM2.5 and ozone as health markers. Thus the focus on PM2.5 in this report, though it is not the only asthma factor from industrial facilities, vehicles or wildfires – or nature – as noted above.

China coal boom
http://www.jbrussellimages.com/#/reportage / china coal-boom/China0511-038

PM2.5 Visualization
Source: US EPA, from S. Henderson National Smoke Forum 2014
http://firesmoke.ca/national-forum/2014/04-Henderson-HealthEvidence.pdf

A July 31, 2014 Calgary Herald editorial by two doctors claims "it is past time to ban coal." These doctors cite a 2013 Pembina Institute report entitled "A Costly Diagnosis" in which the Pembina Institute inaccurately claimed coal-fired power plants were responsible for 6% of human-made emissions of particulate matter PM2.5.[1] This is a 15 fold exaggeration of the actual emissions.

1" airborne particulate matter with a mass median diameter less than 2.5 µm"

According to Environment Canada (Appendix B), in Canada in 2006 only 0.5% PM2.5 came from coal-fired power plants. Environment Canada 2011 statistics show that Alberta's coal-fired plants emitted only 0.4% of the total human-caused PM2.5 and only 1,628 tonnes or 0.32% in 2012.

In fact, in a national context, Environment Canada 2011 statistics show that Canada's coal-fired plants emitted only 0.23% of the total human-caused PM2.5. This difference in 2006 Environment Canada data versus 2001 and 2012 data may be attributed to four key factors – the generation decommissions of older plants since 1998 in Alberta of 4 coal, 4 natural gas, and 1 biomass plant, a transition to cleaner-burning natural gas-fired plants and improved emissions management overall, plus the addition of supercritical, high-efficiency coal-fired power plant technology like Genesee3 that features emissions filtration of 99.8%.[2] The 2012 data shows consistent reduction in emissions.

For decades, Alberta has taken power generation air quality seriously.

Since 1945, Alberta's Public Health Act incorporated air quality considerations;[iii] air pollution controls began in 1961. In 1971, Alberta established Canada's first environment ministry and subsequently the Clean Air Act.

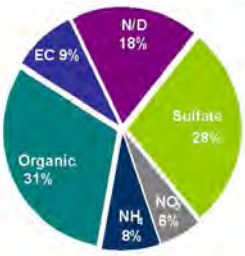
By 1986, Alberta power plant owners were taking proactive measures to reduce emissions. By 2000, scrubbers were introduced on new boiler plants to reduce sulfur oxides (SOx).

By 1990, the Alberta government introduced the Best Available Technology Economically Achievable (BATEA) regulations, mandating that new industrial facilities be built with high efficiency and low emissions to meet or better air quality standards.

The Alberta government continues to invest millions in technological R&D to reduce air pollution, improve emissions management and maintain cost-efficiency in power generation. Some 48 continuous air monitors report hourly air quality levels across Alberta, [iv] reporting on both industrial and natural source emissions to the on-line Air Health Quality Index. [v] Extensive provincial, national and international efforts have been made by forest fire, environment and meteorological services in conjunction with NASA and the Canada Space Agency to create a forecast system of air quality and PM2.5 emissions, through the GEM-MACH[3] model. [vi]

2 Fabric filters that stop 99.8% of particulate matter from reaching the atmosphere. A flue gas desulphurization unit that brings sulphur dioxide (SO2) emissions well below the provincial emission standard, and less than half the emissions produced by vintage facilities. Low nitrous oxide (NOx) burners reduce NOx emissions by 70%

3 GEM-MACH (Global Environmental Multi-scale - Modelling Air quality and CHemistry) http://weather.gc.ca/aqfm/index_e.html#pm25 GEM-MACH is run twice a day over North America and is used to provide guidance for the production of air quality forecasts for Canadians



Typical Chemical Composition of Fine Aerosol (<1μm) in an Urban Area [Heintzenberg, 1989]

www.nist.gov/iaao/upload/1-7-GSmallwood-NRCC.pdf

EC - Elemental carbon particles (9%):
• produced during combustion (cars, trucks, trains, planes, coal or natural gas-fired power plants, fireplaces)
[Coal-fired plants in Alberta = 0.4% of total - See Appendix B for Environment Canada 2006 breakdown]
Organic particles (31%):
• primary organic particles
– emitted directly to the atmosphere
• secondary organic particles
– formed in the atmosphere by oxidation and condensation of volatile organic carbon
– often requires photochemistry
Sulfates(28%)
• ammonium sulfate particles
• mixed ammonium sulfate-organic particles
Nitrates (NH4-8%/NO3-6%)
N/D- Not Determined (18%)

Organic Particles make up 31% of urban fine aerosols-including spores, molds and pollens.

Human-caused PM2.5 emissions in Alberta 2011:

• Coal-fired power plants:	~1,800 tonnes
• Residential fireplaces:	3,400 tonnes
• Agriculture:	15,300 tonnes
• Construction:	129,900 tonnes
• Road Dust:	223,100 tonnes
• Wildfires (2011)	1,715,000 tonnes

Even residential fireplaces are responsible for twice the PM2.5 of coal-fired power plants and, like wildfires, emit carcinogenic[vii] compounds due to an incomplete burn. Data Note [ix]

The 2011 figure of 1.7 million tonnes of toxic wildfire smoke from forest/wild fires alone (20% FOFEM)[viii] is almost one thousand times* the ~1,800 tonnes of PM2.5 emissions from Alberta-based coal-fired power plants. Some 80% of the wildfires in 2011 are attributed to human causes.[ix] (See Appendix D-1/D-2)[4]

A 2010 study on asthma incidence at Emergency Departments (ED) in Alberta between 1999 and March 2005, published in the Canadian Journal of Emergency Medicine[x] reveals that 93,146 patients made 199,991 ED visits for asthma.

Crude rates in 2004/05 were:	
Edmonton	7.9/1000
Calgary	6.5/1000
Non Major Urban	15.4/1000

The Edmonton and Calgary regions had consistently lower ED visit rates for asthma than the Non Major Urban (NMU) regions. This suggests that other factors such as road particulate matter, agricultural dust and PM2.5 from biogenic sources like spores, moulds, and pollens, agricultural fertilizer, ambient forest fire smoke, more outdoor exposure due to lifestyles are the more crucial factors. See 2011 spore and pollen weekly counts for Edmonton in Appendix E.

Residential factors like smoking and cooking play a role. There is a higher ratio of smokers in rural areas in Alberta (Feng Xiao Li et al (2009).[xi]

*(~950 times) Alberta area burned in total hectares from Cdn National Forestry Database official report: 806,054 hecatres http://nfdp.ccfm.org/data/compendium/html/comp_31e.html

4 According to a 2014 email from the Provincial Forest Fire Centre (PFCC), Environment and Sustainable Resource Development, Government of Alberta: "Almost 80% of fires that year (2011) are considered human caused." Human caused fires include causes like trees blowing down on power lines, and railway starts and industrial causes, amongst others. Not all human caused fires are caused by careless individuals at the scene, but any fire that is not lightning caused is categorized as human caused and is, in some measure, likely preventable.

A Swedish study by Koistinen KJ et al (2004) published in the Swedish Journal of Work, Environment and Health confirmed that indoor pollution is underestimated. It cites an earlier US finding by the EPA that people spend most of their time at home, and that people face higher indoor PM2.5 exposure for longer durations than most outdoor exposures,[xii] with another study citing smoking and cooking as highest indoor emitters.[5] This is relevant as Alberta experiences similar cold weather to Sweden and many Albertans spend more time inside in winter months.

A number of coal-fired power plants are located in the Edmonton area (See map Appendix A), but the results of the studies mentioned above suggest that asthma rates are related to other factors. There are no coal-fired power plants near Calgary, nor are there coal-fired plants evenly distributed in rural areas where the asthma ED rate is double that of urban centres. Dr. Ross McKitrick assessed the Illness Cost of Air Pollution (ICAP) model used in "A Costly Diagnosis" in 2011 and found "…it attributed over 100 percent of all deaths to air pollution. It just doesn't make sense."

2. "A Costly Diagnosis…" vs. the Evidence

1. "A Costly Diagnosis" by the Pembina Institute states that coal-fired power plant PM2.5 emissions are 6% of human-made emissions in Alberta. In fact coal-fired power plant emissions are only 0.4% of total human-made emissions, according to Environment Canada 2011 data (excluding prescribed and wildfire emissions).
2. The evidence shows that there is a large volume of other sources of PM2.5 emissions; the volume of wildfire emissions are never mentioned as asthma triggers despite co-sponsors of the report, the Canadian Lung Association and the Asthma Society, providing publications like the Canadian Smoke Newsletter on the health risks of wildfire smoke to their supporters. Alberta Health Services and Environment Canada frequently issue wildfire smoke health alerts that the doctors and report researchers should have been aware of. [xiv]
3. The the evidence shows that industrial and wildfire emissions, atmospheric chemicals and relevant meteorological factors (i.e. humidity) are extensively monitored by international satellite systems, ground monitors (hourly readings), provincial, federal and international meteorological, fire and industrial monitoring bodies, independently and through the GEM-MACH (Global Environmental Multi-scale - Modelling Air quality and CHemistry) http://www.weather.gc.ca/aqfm/index_e.html#pm25 GEM-MACH[xiii] satellite scan is run twice a day over North America and is used to provide guidance for the production of air

5 The results of two other large-scale exposure studies (more than 150 homes), the Harvard six-city study and the New York State ERDA study, showed that the two most important indoor sources of PM2.5 were smoking and cooking.

quality forecasts for Canadians. These form part of the reports through the on-line provincial Air Quality Health Index. This massive air quality monitoring effort began as early as 1983 with the Canadian Air and Precipitation Monitoring Network (CAPMoN) of Environment Canada. These efforts are founded in international, national and provincial environment laws and air quality objectives. Alberta industries are subject to compulsory monitoring of many environmental factors, consistent with the 'polluter pays' principle.[xv]

4. The evidence shows that renewable energy projects are of little interest to investors, according to a 2012 Morrison Park Advisors Inc. market report [6] commissioned by the Market Surveillance Administrator of Alberta.[xvi]

5. The Illness Cost of Air Pollution (ICAP) model used to estimate health costs and persons injured is far from reality, based on a review of relevant actual statistics, by Dr. Ross McKitrick of the University of Guelph. As early as 2010 Dr. McKitrick and two Scottish researchers[xvii] had demonstrated that this model was inherently flawed.[xviii] [xix]

6. An earlier 1996 Alberta Health study [7] (Waters & Gabos) of actual case statistics in a time (1950-1992) of greater air pollution (due to less advanced emissions management and the use of older, now retired, coal-fired power plants) did not find a higher incidence of mortality in the northern region due to asthma, and cited seasonal factors as likely causes of asthma and respiratory conditions.[xx]

7. The evidence shows that recent revelations by the Intergovernmental Panel on Climate Change (IPCC) of the Physical Sciences Working Group 1 report (Sept 2013) stated that global warming had 'paused' for 15 years [as of their press date – now it is an 18 year 'hiatus'] despite a significant rise in carbon dioxide. According to the Flat Top Complex Wildfire Review Committee report of 2012 that studied the Slave Lake area fires, Alberta's "aging coniferous forests dominate more of the landscape, which means Alberta's forest are likely more flammable than they were even 50 years ago." Thus wildfires are not consequence of climate change due to alleged global warming. In fact, in a Garnett & Khandekar (2010) report on prairie weather published in the Canadian Meteorological and Oceanographic Society Bulletin of 2012, a evidence shows prairie conditions are wetter. Wetter climate trends are more representative of global cooling periods, which correlate to previous precipitation trends that occurred during times of low sunspot activity..[xxi]

6 "Even with the historically low interest rate environment of the last few years, the full cost of new wind projects, with a reasonable return on equity capital included, is higher than the average price of electricity in the Alberta market… At the time of writing of this report, there are more than 1,000 MW (Megawatt) of wind projects that have received all required regulatory approvals and permits, but are not currently proceeding to construction."

7 "This report provides the findings of a descriptive epidemiologic study of asthma, bronchitis and emphysema in Strathcona County. Comparisons of rates of these selected respiratory diseases are made for Ft. Saskatchewan, Edmonton, Ft. McMurray and the province. The study was undertaken at the request of Strathcona County Council, due to a concern that respiratory diseases, especially asthma, may be higher in their community."

8. Alberta's carbon dioxide emissions barely register in NASA's recent satellite observations of earth (Appendix F). Natural sources of carbon dioxide (CO_2) make up 95% of the carbon dioxide on earth (Appendix G). Human contribution to the 0.039% carbon dioxide in the atmosphere is just 5%. Alberta's industrial contribution is virtually insignificant in the global context.

Surgery assistant nurse working with artificial cardiac valve

3. What of the Benefits of Coal-fired Power Plants?

The phase-out coal campaign does not address the public health or socio-economic benefits of coal-fired power plants, which far outweigh the claimed negative impacts.

Perhaps the simplest test of the 'dangers' of coal-fired power plant emissions lies in the measure of life expectancy. Thanks in part to modern electrification from coal-fired power plants, and the ensuing ability to offer advanced medical care, life expectancy at birth has gone from about 58.8 years in 1921[xxii] to 82.5 years today.

4. New Coal-fired Power Plants will be built

Federal legislation calls for a phase-out of older coal-fired power generation plants over the next 50 years – but future coal plants will be built and operated if they meet higher emissions standards. This will likely require a method of capturing carbon dioxide.[xxiii] The new Boundary Dam coal-fired power plant using such technology began operation Oct. 1, 2014 in Saskatchewan.[xxiv]

5. "Phasing out Coal" – A Partisan Forum

A workshop event at the University of Calgary on Sept. 30, 2014 featured Prof. Alan Lockwood, Emeritus Professor of Neurology at the University at Buffalo, describing the negative health impacts of coal. Prof. Lockwood's book "The Silent Epidemic"[xxv] originally written in the 1970's (reissued in 2012), was undoubtedly important research at the time in educating authorities and the public about the dangers of unmanaged coal-fired power plant emissions.

Since the 1970's, coal-fired power plant technology and emissions standards have dramatically improved, thanks to the work of Prof. Lockwood and others like him.

However, a Friends of Science representative who participated in this workshop reported that Prof. Lockwood did not explain many other sources of PM2.5 than coal-fired power plants. When the Friends of Science representative asked about the impact of the 1.7 million tonnes of forest fire PM2.5 emissions in Alberta in 2011 that were almost 1,000 times that of the ~1,800 tonnes of PM2.5 from coal-fired power plants, Professor Lockwood admitted that forest fire emissions were problematic. [8] [9] Prof. Lockwood appeared to be unaware of the scope of these emissions in Alberta and region. He noted that sources of PM2.5 varied from place to place and there were many other sources that impact the environment and air quality.

Unfortunately there were no coal-fired power industry representatives at this forum, no emissions or compliance experts, no power engineers to discuss base load power or the challenges of integrating renewables, no economists to discuss the cost-benefits of affordable power, no health experts to discuss diverse exposure paths of PM2.5 emissions and no wildfire experts. Consequently the information presented by the forum was skewed. Friends of Science saw an urgent need for this comprehensive, critical review of the "Alberta Phase-out Coal" campaign.

6. Alberta's Stringent Emissions Standards - Monitored 24/7

A July 21, 2014 Calgary Herald article written by two doctors who are in favor of early phase out of coal-fired power plants, referred to a number of studies (1980's Dublin study by Luke Clancy et al (2002),[xxvi] a 1991 Utah study by C. Arden Pope, a Paul J. Villeneuve et al, (2007)[xxvii] study set in Edmonton, Alberta) to support their view that coal-fired power plants have adverse health effects. These are inappropriate references.

8 B.C. Centre for Disease Control "Evidence Review: Wildfire smoke and public health risk" 2014 http://www.bccdc.ca/NR/rdonlyres/6505C3A4-A610-4F09-9819-41933C87522B/0/WFSG_EvidenceReview_WildfireSmoke_FINAL_v3_edstrs.pdf

9 Institut Nationale Sante Publique du Quebec "Health Impacts of Particles from Forest Fires" 2014 http://www.inspq.qc.ca/pdf/publications/1793_Health_Impacts_Forest_Fires.pdf "Particles from forest fires have a measurable impact on public health", pollutants from the July 2002 forest fires in northern Quebec were linked to a major increase in the amount of fine particles in Baltimore, an American city over 1000 km from the fire site (Sapkota et al., 2005). Smoke from these fires also affected other cities, including Montreal, where average daily concentrations three times higher than normal were noted, exceeding 35 µg/m3 with hourly maxima above 100 µg/m3."

The US and Dublin do not have the environmental and emissions standards required of Alberta power plant owners. Research about Dubliners in the 1980's who were burning coal in unfiltered, unprotected residential fireplaces/stoves has no relevant empirical merit in the context of a large, environmentally managed power plant in 2014 in Alberta.

Alberta's coal-fired power plants use pulverized coal for more complete burn and reduced emissions. Alberta has two advanced supercritical coal-fired plants, which filter 99.8% of PM2.5 emissions. All earlier model coal-fired power plants are equipped with emissions scrubbers. They all have mandatory 24/7 air quality monitoring[xxviii] and reporting on an hourly basis. Hourly reporting ensures there is no long-term duration of exposure in the event of an exceedance; any rise in emissions will trigger one of four stages of compliance response as per the Capital Region Air Quality Management Framework – or relevant air shed framework.

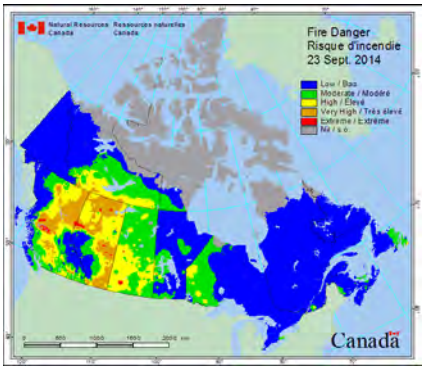
Air pollution equipment for coal-fired power plants has been commercially available and used for the last 25 years; thereby up to 99% of SOx, NOx, and PM can be and have been collected and prevented from entering the air.

Alberta's Environment and Sustainable Resource Development (ESRD – formerly Alberta Environment) conducts unannounced air quality monitoring throughout the province using the Mobile Air Monitoring Laboratory (MAML). [xxix] [xxx] There is a comprehensive network of some 160 [10] air quality monitors across Alberta. [xxxi]

Plant owners can be fined or shut down for non-compliance under Alberta's stringent emissions standards.

By contrast, Alberta is surrounded with a perennial air quality problem from wildfires.

This is a health concern as wildfire smoke produces a far more dangerous health hazard than PM2.5 carbon particulate matter – these being the Polycyclic Aromatic Hydrocarbons (PAH), free radicals and Volatile Organic Compounds (VOCs) which are invisible components of smoke that results from burning complex carbon-based fuels such as wood. PAH are the components of cigarette smoke that causes heart and lung disease and is linked to cancer. These PAH components represent the most serious pollution from smoke regardless of source whether from cigarettes or forest fires. Burning low-energy dense material such as wood and charcoal generally emits more particulates and hydrocarbons than burning of energy-dense materials (gas, mineral oil, black/brown coal). [xxxii] The US-Environmental Agency estimates that the cancer risk from wood smoke is twelve times greater than that from equal amounts of tobacco smoke. [xxxiii]

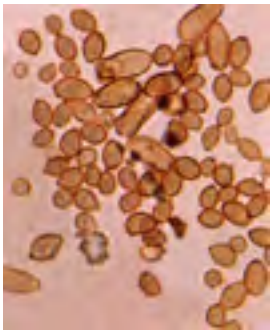


Wildfire risk status in Alberta and region Sept. 23, 2014 - high to extreme.

10 Alberta Environment and Sustainable Resource Development, Airshed zones, Environment Canada, and industry operate a comprehensive network of about 160 air quality monitoring stations across Alberta that measure the ambient air quality. These consist of:

- five stations operated by Alberta Environment and Sustainable Resource Development
- 56 stations operated by air quality management zones
- one station operated by Environment Canada
- almost 100 stations operated by industry as an Approval requirement

Industry is required to monitor air quality on a permanent and temporary basis. Permanent stations are operated year round while temporary stations are operated from two to six months per year. Industries are also required to monitor air parameters on an intermittent, passive and static basis. With this type of non-continuous monitoring samples are collected and sent to a lab for analysis.



Cladosporium sp

Wood smoke contains over 200 chemicals and compound groups. The emissions are almost entirely in the inhalable size range. (Cooper 1980) [xxxiv]

The Villeneuve study in Edmonton, cited in the doctors' op-ed in the Calgary Herald, was conducted between April 1992 and November 2002, and does not even mention forest fire emissions.

Aerobiology Research data from 2011 in Edmonton (Appendix E) shows that ratios of asthma/allergy triggering pollens and spores can be significant. June had an average of ~35,500 particles per cubic meter of air (P/m^3) of spores (4 weeks in June, two weeks ~25k, two weeks ~45k). September had an average of ~11,300 P/m^3. The first week of October, however, shows a huge spike of ~75,000 P/m^3 as plants die and start to rot. About half these spores are Cladosporium sp, a well-known asthma trigger mould and most of the rest were miscellaneous Basidiomycota, a form of fungi.

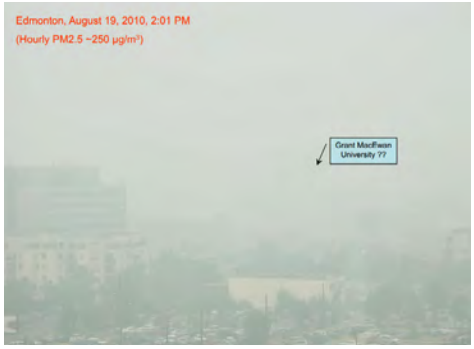
7. Air Quality Health Index – Sophisticated Air Monitoring

The images below are from an Environment Canada presentation for the 2012 EPA Emissions Inventory Conference, evaluating the GEM-MACH air quality forecasting system, using the 2010 Cariboo Fire in British Columbia as an example. The images show the rapidity and influence on the city of Edmonton of wildfire smoke drifting from B.C.

Wildfire smoke like this is omnipresent and may stay for days. By contrast, according to the Capital Region Air Quality Management Framework, industrial emissions of PM2.5 at only 15 µg/m3 are a level 1 trigger with a level 4 trigger of 30 µg/m3 requiring mandatory reductions. (pg. 7)
http://environment.gov.ab.ca/info/library/8593.pdf

Edmonton without smog –
Grant McEwan University as visual marker

Edmonton, August 19, 2010 11:35 AM
Hourly PM2.5 ~80 µg/m3



Edmonton, August 19, 2010 2:01 PM
(Hourly PM2.5 ~250 µg/m3)

2011 Data Shows Very Few Exceedances

As seen in the wildfire smoke images of downtown Edmonton, smoke alone can reach levels of more than 250 µg/m3 of PM2.5 in a short time, having serious chronic health implications – and not just on an acute level, as new research reveals.

Data monitoring records reveal very few exceedances in 2011. Environment Canada (See Appendix B) attributes high PM2.5 emissions density " along the Edmonton–Calgary corridor...(as)...likely the result of emissions from the transportation sector."

The following excerpt from the 2012 Spring-Summer Canadian Smoke Newsletter gives an example from British Columbia during the same 2010 Cariboo fire as referred to in the previous images of Edmonton, showing the ratio of respiratory reliever medication dispensation counts (gray bars), vis a vis the magnitude of PM2.5 volumes (red line).

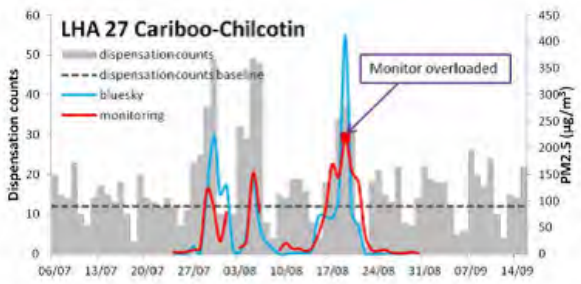


Figure 5. Gray bars indicate the daily counts of dispensations for respiratory reliever medications (low days are weekends and holidays). The broken black line indicates the average daily counts in July, August and September from 2003 through 2010. The blue and red lines indicate the PM2.5 concentrations predicted by BlueSky and measured by the monitoring stations, respectively. On August 19th, the monitoring instrument was overloaded by the intense smoke, resulting in unreliable records.

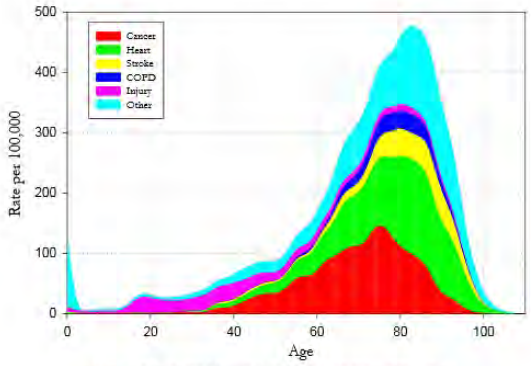
As shown in the Alberta Health Services graph below, the distribution of deaths due to serious illnesses related to respiratory conditions is small compared to other causes like cancer, and appears in later years of a patient's life – suggesting earlier behavioral or more confined or direct exposures (smoking tobacco or job-site exposure to agricultural or construction particulate matter) may be key factors. [xxxv]

Number of Times Alberta Ambient Air Quality Objectives were exceeded in 2011

Source: CASA Data Warehouse Jan. 1 - Dec. 31, 2011 Parameter and averaging period	PM2.5 over 24 hour period
Objective	30 µ/M3
Monitoring Station	
Calgary Central 2	3
Calgary East	0
Calgary Northeast	1
Edmonton Central	7
Edmonton East	3
Edmonton McIntyre	4
Edmonton South	5
Genesee	1
Red Deer - Riverside	14

Figure 62 illustrates the distribution of deaths in Alberta by major cause (note that COPD is an abbreviation for chronic obstructive pulmonary disease) and by age group. As can be expected, the vast majority of deaths occur in the 50-and-over age categories; however deaths due to injury begin at a much earlier age.

Figure 62: Distribution of Deaths in Alberta, 2005



Source: Alberta Vital Statistics, Death File, October 2006 release

As noted in the introduction, the rural incidence of smoking is higher than urban in Alberta, and the incidence of Non Major Urban asthma visits to Emergency Departments is double that of major urban centres. While Edmonton is about an hour's drive from the nearest coal-fired power plants, Calgary has no coal-fired power plants nearby. Calgary air quality also benefits from strong Chinook winds blowing east and limited agricultural cultivation west of the city. Ranching is more prevalent west of Calgary than crop growing which requires cultivating the land and the related use of ammonia based fertilizers; farming kicks up dust and spores while ammonia based fertilizers can form into bodies of pervasive PM2.5. By contrast, Edmonton is surrounded by farm-land and set in boreal and parkland forests, closer to diverse pollens, and wildfire smoke. Calgary is on a high open plain 1,000 m above sea level.

The following US EPA guide shows levels at which humans experience health impacts to the parts per million of particulate matter.

EPA United States Environmental Protection Agency

AQI AIR QUALITY INDEX

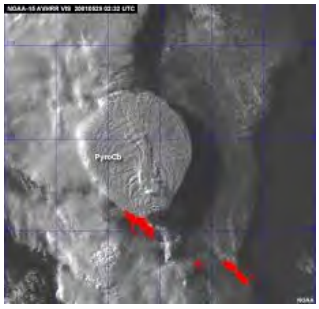
Air Quality Guide for Particle Pollution		
Good	0-50	None
Moderate	51-100	Unusually sensitive people should consider reducing prolonged or heavy exertion
Unhealthy for Sensitive Groups	101-150	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
Unhealthy	151 to 200	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion
Very Unhealthy Alert	201 to 300	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.

US EPA Air Quality Standards

Wildfires Can Spread Particulates Far and Wide

The 2001 Chisholm, Alberta, wildfire formed a pyroCb (pyro cumulonimbus) cloud on May 28, 2001 in which the "Chisholm smoke reached an altitude at least as high as 18 km, 9.5 km above the tropopause. Temperatures reached 458K (184.5 degrees C)."
By June 11, 2001, 2 weeks after the pyroCb event, the Chisholm plume …"leading edge at that time was over far eastern Asia and the northern Pacific Ocean." (Fromm et al, 2008)[xxxvi]

Chisholm, Alberta Wildfire 2001



Chisholm fire as observed by NOAA-AVHRR Satellite Advanced Vary High Resolution Radiometer
Photo credit: COMET/UCAR

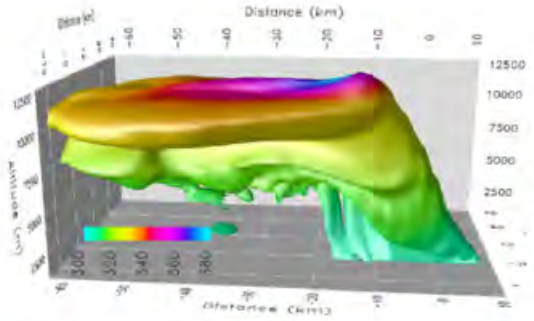


Figure 3. *Reconstruction of the Chisholm Fire's plume (Trentmann et al. 2006: Atmos. Chem. Phys. Discuss., 6, 6041-6080)*

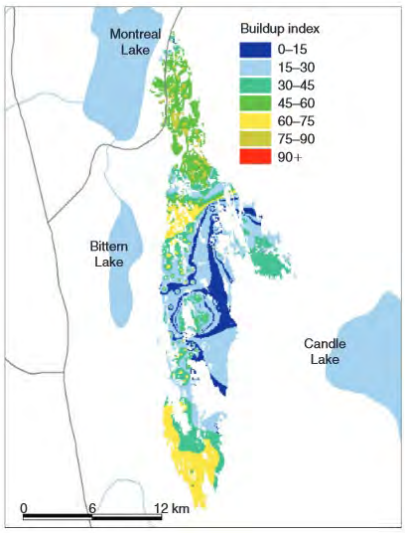


Fig. 5. Spatial map of carbon emissions from the 2003 Montreal Lake fire, Saskatchewan, as determined by the Fire Behavior Prediction System. This map was constructed using fuel-type and spatial weather data. A similar map based on the Boreal Fire Effects Model also requires fuel load data, which were not available in a spatially explicit form for the study area.

The volumes of carbon emissions and toxins are surprising.

"The 2002 fire season in central Quebec accounted for ~30, 60 and 80% of the annual primary greenhouse gases, carbon monoxide and black carbon emissions respectively for that province. In 2003, fires represented 60 and 20% of greenhouse gas emissions in Manitoba and British Columbia respectively. During the 2004 fire season in north-western Canada, when area burned was above average, fires were responsible for almost all greenhouse gas emissions occurring in the sparsely populated Yukon Territory and Northwest Territories. On average, between 2000 and 2004, fires contributed 10, 30 and 40% of Canadian annual greenhouse gases, CO and black carbon emissions respectively." [xxxvii]

A study by de Groot et al (2007)[xxxviii] includes this graphic map showing the range of carbon emissions in a pilot project in Saskatchewan. Variations in emissions are due to factors such as type of burn (smouldering or flaming), type of vegetation/ forest, peat, etc.

8. Health Impact of Wildfire Smoke is Significant

The recent National Smoke Forum held in Halifax, Nova Scotia on October 10, 2014 brought to light the increasing awareness of the health impact of wildfire smoke, locally and regionally. [xxxix] Topics ranged from human health impacts by Sarah Henderson of the B.C. Center for Disease Control, to the huge international BORtas study on the contribution of wildfire smoke to surface PM2.5.

In March of 2014, the B.C. Center for Disease Control issued a detailed report on the need for clean air shelters in the home and community during wildfire smoke events. [xl]

The Province of Quebec has undertaken a study of the impact of wildfire particulate matter on health "Health Impacts of Particles from Forest Fires" (2014) reviewing 110 epidemiological studies on the topic. [x]

"Particles from forest fires have a measurable impact on public health not only locally, but also in areas hundreds of kilometres away from the combustion source. For example, pollutants from the July 2002 forest fires in northern Quebec were linked to a major increase in the amount of fine particles in Baltimore, an American city over 1000 km from the fire site (Sapkota et al., 2005). Smoke from these fires also affected other cities, including Montreal, where average daily concentrations three times higher than normal were noted, exceeding 35 μg/m3 with hourly maxima above 100 μg/m3. Plumes from combustion sites also affect concentrations of pollutants other than the particles found near fire sites, such as carbon monoxide and atmospheric ozone (Wotawa and Trainer 2000). Concentrations of pollutants (e.g.: ozone) that contribute to urban smog can also increase downwind of and at a great distance from these sites.

A better understanding of the health impacts of forest fire smoke, particularly in relation to particles, that can occur even at extended distances from fire sites (e.g.: in cities where these pollutants already exist because of other emission sources [e.g.: industrial]) is therefore essential."

Clearly this is a significant factor in the Alberta context, affected by wildfires almost every year.

9. The Slave Lake Fire Complex

To give readers a sense of equivalencies in terms of release of energy and emissions, the following comparison was drawn up, based on the USDA First Order Fire Effects model using a 20% consumption rate of consumption rate of the human-caused Slave Lake Fire Complex of 2011.

Alberta

	Slave Lake - 2011		2011	Notes
Total 2011				
Fires *	1		1150	
Cost *				
Ha *	4,700		946,688	
$/ ha				
Silviculture Requirement				
ha	2,350		473,344	THFLB
Seedlings	2,820,000		568,012,800	
Cost	$ 3,384,000	$	681,615,360	
Timber Values Lost				
Volume destroyed	1,410,000		284,006,400	m³
Stumpage loss	$ 705,000	$	142,003,200	
Biomass Consumption				
Gross	967,824		194,941,993	BDT
Net	193,565		38,988,399	BDT
Energy Release				
Heat - Gross	2,903,472		584,825,979	GJ
Heat - Net	2,467,951		497,102,082	GJ
Heat - value	$ 27,147,463	$	5,468,122,903	
Homes heated	22,436		4,519,110	Home heating needs per year
Electric - Gross	807,165,216		162,581,622,129	kWhr
Electric - Net	201,791,304		40,645,405,532	kWhr
Electric - value	$ 14,125,391	$	2,845,178,387	
Homes electrical	11,057		2,227,146	Home electrical needs per year
Explosion equivalence	0.59		118.81	Mt TNT
Emissions - Greenhouse Gas				
CO2	518,754		104,488,908	tonnes CO2e
CO	180,209		36,298,199	tonnes CO2e
CH4	1,112,998		224,183,292	tonnes CO2e
NOx	84,007		16,920,985	tonnes CO2e
Total GHG	1,895,967		381,891,364	tonnes CO2e
BC Carbon Tax	$ 28,439,508	$	5,728,370,463	
Personal GHG	611,602		123,190,763	People
Car Equivalent	379,193		76,378,273	Passenger Car - gas
Truck Equivalent	43,090		8,679,349	Truck - diesel
Emmisions - Human Health				
PM 2.5	8,517		1,715,490	tonnes
SO4	387		77,977	tonnes
PM 10	77,977		272,919	tonnes
Diesel Truck Emmision Comparison				
PM 2.5	2,224,187		448,002,318	Diesel trucks
SO4	151,128		30,440,645	Diesel trucks
PM 10	326,542		65,773,104	Diesel trucks

10. "Gateway to the North" - Air Quality Factors

Returning to the literature review of the 2014 "Alberta Phase-out Coal" campaign which relies on the Pembina Institute's report "A Costly Diagnosis…" anti-coal activists point to the several coal-fired power plants in the Edmonton region as the principle cause of air quality issues. These claims appear to have been accepted at face value and met with public outcry, in part because of lack of awareness over new coal technologies and emissions management. While Edmonton does have a higher rate of asthma than Calgary, there are many contributing factors.

The impact of PM2.5 on long-term health has been typically founded on exposure by dose and duration. Until very recently, the long-term health effects of wildfire smoke had not been considered; wildfire smoke had been seen as intermittent and causing only acute episodes. The most recent "National Smoke Forum" included three presentations on impact, range [xlii] and long-term health effects. [xliii] [xliv]

The anti-coal focus on coal-fired power plants ignores the multitude of exacerbating air pollution sources and factors in the Edmonton region. The City of Edmonton is a transportation hub and "Gateway to the North." Canada's fifth busiest airport (and physically the largest) is Edmonton International, just south and west of the city. [xlv]

Edmonton is also a ground transportation hub for two major rail lines that distribute goods to and from Prince Rupert and Vancouver ports in B.C. to destinations across North America. This, and the number of heavy equipment and truck fleets operating in and around the Edmonton area contribute to large quantities of road dust and diesel fuel emissions. Diesel emits PM2.5 and related emissions exacerbate asthma; [11] these are known as Diesel Exhaust Particles (DEP). [xlvi]

The sun affects photochemical reactions of some emissions and can enhance ozone conditions, an asthma trigger, depending on various factors.

On the east side of Edmonton in Strathcona County, "Refinery Row" contributes both monitored industrial emissions, and more importantly, volumes of steam, which aggravate smog during inversions. According to a NavCanada prairie weather publication, (pg. 72) [xlvii] there are two typical weather phenomena that appear to affect northern Alberta somewhat more than the south. The first is a low-level temperature inversion in summer months that is created by radiative cooling with little wind at ground level, despite very gusty winds far above. The cold layer may reach 305 meters (1000 feet) during the night, trapping emissions in stagnant cold air that is released by the sun during the day.

The North Saskatchewan River and the many lakes and sloughs in the northern region, combined with the steam from Refinery Row on the east, can contribute to humid conditions leading to emissions-trapping fog, especially when temperatures drop to -30˚C in winter.

11 "DEPs appear to have greater immunologic effects in the presence of environmental allergens than they do alone. This immunologic evidence may help explain the epidemiologic studies indicating that children living along major trucking thoroughfares are at increased risk for asthmatic and allergic symptoms and are more likely to have objective evidence of respiratory dysfunction."

Likewise Edmonton experiences a great number of powerful thunderstorms in summer. According to DLR – the German Aerospace Center, thunderstorms significantly affect the formation of ozone – a trigger in asthma and respiratory difficulties. Ground pollution can be sucked up at speeds of 100 km/h or more to altitudes of 10 km where the combination of intense solar radiation, low temperatures and humidity changes mean "nitrogen oxide can produce up to 10 times as much ozone as on the ground." [xlviii]

Another weather phenomenon, which appears to affect the Edmonton region the most, is the so-called 'dirty ridge' (pg. 73 NavCanada). A combination of weather factors in B.C. lead to warm, moist Maritime air, overflowing an Arctic cold front and pouring into Alberta over the mountains. This results in freezing rain.

None-the-less in 2011 the air quality in Canadian cities was judged to be the best in the world by the World Health Organization. [xlix] [l]

11. Particulate Matter PM2.5 – From Many Sources

According to Environment Canada, coal-fired power plants are not a primary source of particulate matter in Canada (excludes natural sources). Nationally, electricity generation is cited as 0.5% - while agriculture represents 5.1%, residential wood combustion (RWC) at 9.7%, construction at 19% and road dust at 48%. (Appendix B) [Note: these statistics vary somewhat by province, however according to Environment Canada statistics, Alberta's coal-fired plant emissions were only 0.4% in 2011 despite Alberta having the largest number of coal-fired generation plants in Canada.]

Based on the Environment Canada PM2.5 emissions map (see Appendix A) Alberta appears to have a higher distribution of PM2.5 than other provinces overall. Possible causes include a larger geographic area under cultivation than in other provinces, more enhanced monitoring due to the fact that some ~40 [li] of the 186 National Air Pollution Surveillance network (NAPS) monitors [lii] are located across the province and therefore more accurate reporting is available.

A seasonal factor is certainly related to spores and pollen from natural and agriculture land use and disturbance. A further factor is that of outdoor moulds, according to allergy expert Dr. Stuart Carr,[liii] who reports that regional agriculture contributes to this factor in asthma and allergies in Edmonton during springtime after snow-melt and through late summer to early fall. Numerous pollens affect Edmonton air quality. [liv](See Appendix E)

Another key factor is also Alberta's agricultural land use, which uses substantial ammonia fertilizer (NH_3) – a component that creates PM2.5 in the form of ammonium salts. [lv]

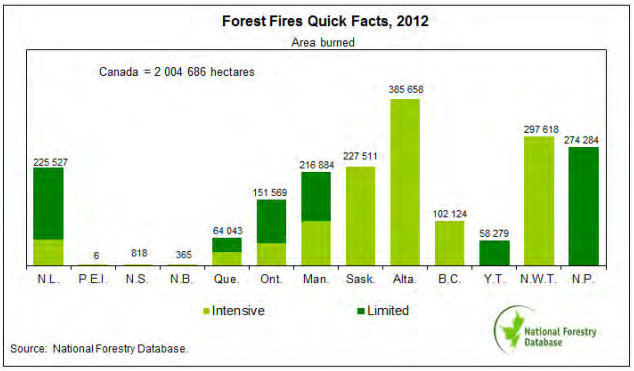
This Alberta Environment report of 2004 describes the special characteristics of fine particulate deposition and how ammonium sulfates can travel for long distances, airborne. [lvi]

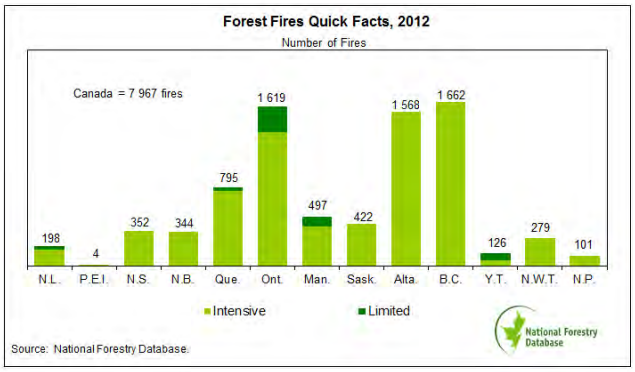
> *In the atmosphere, laws of gravity do not readily influence fine particle deposition on to surfaces. They are transferred on to surfaces by Brownian motion and thus ammonium sulfate [(NH4)2SO4] and ammonium nitrate [NH4NO3] have low deposition velocities and prolonged atmospheric residence times. Assuming an atmospheric residence time of 6 days and a wind velocity of 5 m s-1, the transport distance of (NH4)2SO4 and NH4NO3 may be as large as 2,500 km (Irwin and Williams, 1988).*

Alberta, Saskatchewan and Manitoba have highly developed agricultural sectors and have cultivated much cropland using NH3 as fertilizer; likewise, large feedlots have ammonia concentrations related to animal urine.

NAPS monitors in Alberta outnumber those of most other provinces. (See Map – Appendix C) Alberta Environment air quality is reported to be 'good' 97% of the time (pg. 13, Alberta Environment and Sustainable Resources Development 2012-2013 report)[lvii]

However, compared to the rest of Canada, wildfires are a continuing annual challenge for Alberta in terms of area burned, intensity and number of fires. Certainly from April to November, this is a significant factor in PM2.5 emissions in Alberta, more so than other provinces – and Alberta experiences more cross border drift from wildfires in British Columbia, the Northwest Territories and Siberia as well.





Typical seasonal prevailing wind patterns and directions gathered over a 30 year period by Alberta Agriculture [lviii] do not support the theory that coal-fired plant emissions represent persistent exposure.

As noted earlier, a 2010 study on asthma [lix] reveals that Emergency Department (ED) visits for asthma by crude rates in 2004/05 were:

Edmonton	7.9/1000
Calgary	6.5/1000
Non Major Urban	15.4/1000

The Edmonton and Calgary regions had consistently lower ED visit rates for asthma than the Non Major Urban (NMU) regions. This suggests that other factors such as natural pollens, spores and moulds, road particulate matter, agricultural dust and PM2.5 from agricultural fertilizer, ambient forest fire smoke, more outdoor exposure due to lifestyles or higher residential exposure to smoking are the more crucial factors. As mentioned there is a higher ratio of smokers in rural areas in Alberta (Feng Xiao Li et al (2009).

Dose and Duration of Indoor PM2.5 Pollution

Alberta Health Services also indicate that Edmonton has a higher smoking rate than Calgary with Stats Canada (2011/2012) reporting Edmonton's asthma rate at 9.4% and Calgary's at 6.9% which means it is far more likely that individuals will encounter recurrent cigarette smoke exposure in confined spaces – exacerbating factors in respiratory conditions. Dose and duration are key factors in exposure effects of PM2.5 emissions.

Empirical Data Refutes the ICAP - Illness Cost of Air Pollution Model Results

According to the Waters & Gabos (1996) comprehensive Alberta Health study of Respiratory Diseases related to Strathcona County (which contains 'Refinery Row' of Fort Saskatchewan on the east side of Edmonton) and which compared to province-wide statistics at the time the estimates were:

"In 1991, there were about 200,000 physician visits for asthma in Alberta, 127,000 physician visits for bronchitis, and 15,100 physician visits for emphysema. There were 6,900 hospital admissions for asthma, 1,400 for bronchitis and 450 for emphysema. For asthma alone, the Alberta Lung Association estimates the cost of treatment at $24 million (1996)."

By contrast, the Pembina Institute report "A Costly Diagnosis…" uses the ICAP model, not actual medical records and claims the following:

"The study shows that in Alberta each year this pollution contributes to over 4,000 asthma episodes, over 700 emergency visits for respiratory and cardiovascular illnesses, and around 80 hospital admissions, with chronic exposures resulting in nearly 100 premature deaths."

Note that the Pembina Institute's claim of 100 premature deaths is based on the ICAP model, not the actual cases. The ICAP model does not appear to jive with the empirical data of the Waters & Gabos (1996) study. The top ten causes of death in Alberta according to vital statistics do not reference asthma as a cause of death. The vast difference between the empirical data and the Pembina Institute's ICAP model indicate that asthma and related disorders appear to have dramatically reduced in the past 23 years in Alberta.

In fact, according to a StatsCanada 2011 report [lxi], residents of Edmonton and Calgary have a higher life expectancy than people in other parts of Canada.

12. Ten-year Phase-out - Multi-Billion Dollar Price Tag

According to a spokesman for the Independent Power Producers Society of Alberta, the proposed 10-year phase-out of coal-fired power plants in Alberta, based on the "Ontario did it" model – blithely claimed by anti-coal activists, fails to appreciate the substantial differences between the Ontario and Alberta power markets, the capacity needs, and the cost.

Pembina Institute's report claims that closing coal-fired power plants would save $300 million in health care costs; power generation experts state it would cost >$11 billion to replace existing coal-fired power generation capacity, with natural gas. [lxii] In terms of actual capacity in Alberta, it would not be possible to make such a transition in 10 years. There would certainly be no savings – not in costs and not in health care (as is shown in this research).

As well, a forced transition to natural gas would immediately double the costs of power – or more. Natural gas is a market commodity, and has been subject to wild fluctuations in the past, unlike coal, which historically has stable prices.

If 'renewables" like wind and solar were added to the mix as the phase-out coal advocates propose, there would be additional billions of dollars in costs of building new transmission lines to the remote locations of the wind and solar power plants; these are borne by consumers.

Ontario did it – a Faulty Argument

Ontario was able to go off coal-fired power generation in the space of a decade due to unique features of its market. First of all, Ontario has no coal reserves. Secondly, Ontario is blessed with substantial hydro electric power(i.e. Niagara Falls, access to interties with Quebec's vast hydro electric power supply) and several of its own nuclear power plants. Both of these forms of power generation are ideal base load. Once built, their 'input costs' are already set or nominal.

However, adding wind and solar to the grid creates instability due to the fact that wind power changes every minute, and can be near zero for lengthy periods of

time, then suddenly surge up. Solar power also varies due to clouds, and the sun does not shine at night. In the winter, sunlight hours are short, but electrical power demands are very high in the evenings as people turn on lights, cook, do laundry, watch TV, use space heaters and electronic devices.

This means a balancing mechanism must also be added, to deal with the surging variable nature of wind and solar – and that means additional expense.

For hydro-electric power, output can be ramped up or down by opening or closing the flow, unlike that of coal or natural gas-fired power plants. [12] Hydro-electric base load systems can better accommodate the addition of large industrial wind or solar farms. To manage the sudden surges of power from renewables, Ontario was forced to add natural gas-fired peaking power plants – and power prices skyrocketed. From May 2008 to November 2014, off peak electricity prices in Ontario increased by 85%, while peak pricing increased by 51%.

While 'phase-out coal activists' are claiming a successful transition to wind and solar in Ontario, a recent study by Dr. Ross McKitrick and Tom Adams shows that wind and solar are responsible for the spike in power prices in Ontario. [lxiii]

By contrast, Alberta is one of the four Canadian provinces blessed with coal – but very little hydro, no nuclear power plants and limited natural gas-fired power plants. While some hydro-electric power can theoretically be imported from British Columbia, replacing all 52% of Alberta's current base load with imported hydro, or new capacity in natural gas-fired power plants, would cost billions of dollars. Renewables like wind and solar cannot replace base load – instead they require extended base load to manage the extreme variability of power from wind and solar.

A further geopolitical consideration of being reliant on importing large volumes of hydropower from British Columbia relates to the strong resistance from B.C. toward oil sands pipeline development. If Alberta were more dependent on B.C. for power, this could also be a significant issue if price or supply were to become 'negotiating tools.'

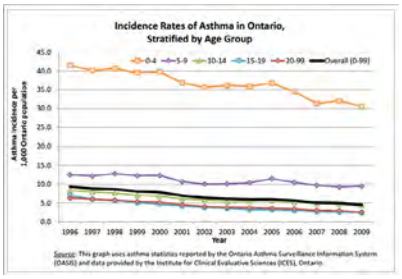
Did closing coal-fired power plants reduce asthma in Ontario?

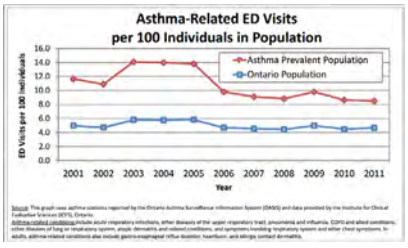
Ontario's asthma related Emergency Department visits did drop since 2003 – however it is not clear how much of that is due to changing weather patterns, closure of coal-fired plants in Ontario, reduction of emissions from the US and Ontario industry due to the recession and some transference of power-generation in the US to natural gas. (US coal-fired plant emissions standards are lower than Alberta's.)

According to an Ontario Durham Health Region Asthma report of May 2012, asthma is most correlated with socio-economic conditions, smoking and poverty. The Durham Region is considered to be representative of asthma across the province. [lxv]

What of the smoggy foggy days of years ago in 2005 and 2007? The Durham report references the Ontario Ministry of Environment reports for those years and states the smog was due to extended periods of hot humid weather and an influx of airborne pollution from the United States. [lxvi]

In Ontario it seems the incidence rate of asthma had already been in a steady decline.





12 By contrast, coal-fired power plants cannot ramp up and down easily to compensate for the variable nature of wind/solar power. "Peaking" power generators are typically based on natural-gas technology; but this requires sudden volumes of the more expensive fuel inputs to ramp up and down or 'peak' to match variable power surges or dips. However, while technologically sound, natural gas is less efficient and has more emissions when used for ramping up and down to match wind and solar power variations.

Coal-fired power plants appear not to have been the asthma problem in Ontario.

13. Hospitals Require Quality Power, Stable and Reliable

> *Essential services that are critical to Albertans, such as hospitals, rely on large amounts of power. On average, hospitals use 1,875,000 kilowatt hours (kWh) of electricity a month. That's enough to power more than 3,000 typical homes for a month…*
>
> (Source: AltaLink http://www.altalink.ca/valueoftransmission/projectsvot/did-you-know.cfm)

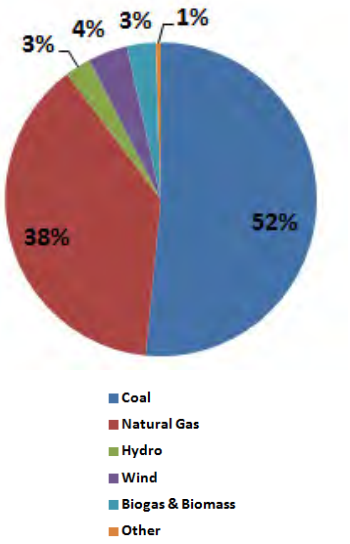
As of September 2014, about 43 percent of Alberta's installed electricity generation capacity is from coal and almost 40 percent of the installed capacity from natural gas. Alberta also uses water, wind, biomass and waste heat as forms of electricity generation.[lxvii] [Note: Coal provides 52% of Alberta's deregulated electricity market.]

"Base load" is the permanent, minimum level of power required for a modern power grid to operate. This base load must be provided 24/7 by the most reliable, most cost-efficient source – typically coal-fired power plants, nuclear or hydro. Base load coal and nuclear power plants are not designed to ramp up power output to meet sudden capacity demands; they are instead the foundation of the power grid's reliability.

Coal-fired power plants presently provide more than half of Alberta's power requirements, including that of Alberta's hospitals. In the context of modern medicine, with modern emissions management, cost-efficient coal drives the "power to heal" – ensuring affordable, reliable, abundant electricity to power the many electronic diagnostic, therapeutic, sterilization and patient care systems of today's modern medical environment. There is no easy, more affordable, reliable replacement for coal, which is an abundant resource in Alberta.

To get a sense of operating costs of coal versus natural gas or wind turbine, the table below shows excerpts of an the Alberta 10 Year Generation Forecast, prepared in 2006 for the Alberta Electric System Operator (AESO). Clearly coal-fired power plants have the lowest generation costs and best capacity ratio-to-cost of the three options. Wind is the most expensive form of generation and the least reliable, even though its apparent fuel cost is zero if the wind is blowing. A power grid cannot operate without reliable, high capacity, low-cost base load power. A comprehensive explanation of the Alberta grid can be found in the 2013 AESO Annual Market Statistics Report.[lxviii]

Alberta's Electricity Generation 2013



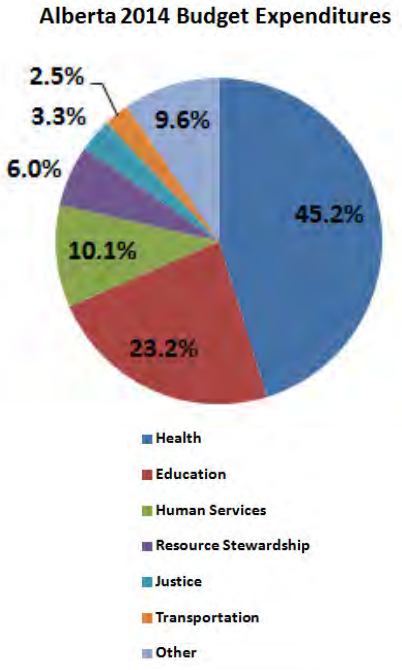
Comparison of Unit Power Costs (excerpt from pg. 20 of 10 year forecast)

Cost Analysis	Coal (pulverized coal)	Gas (combined cycle)	Wind
Cost of Fuel ($/GJ) Per Gigajoule	1.0	7	0
Fuel Cost ($/MWh) Per MegaWatt hr	10	50	0
Capacity factor %	90	95	35
Generation Cost ($M/Wh)	45	67	78
Total generation costs inc. CO2 ($/MWh)	50	67	74
Please see the full report for comprehensive details.			

Reliable Power is Vital to Health Care and Hospital Operations

Excerpt of UK report "Power Outages, Extreme Events and Health: a Systematic Review of the Literature from 2011-2012"

"Electricity was recognized by the UK Department of Health as the 'most vital of all infrastructure services' because 'without it most other services will not function'. A survey conducted in Japan found that 65% of disaster base hospitals (i.e. hospitals which are responsible for supporting other hospitals during a disaster) considered electricity to be the most vital lifeline for the functioning their hospital. This survey also revealed that 60% of these hospitals felt that key services such as emergency surgery and hemodialysis would have to be stopped if generator power was unavailable. Key equipment related services such as laboratory services, imaging and sterilization would also be stopped if generators failed. Most hospitals have generator backup for only eight hours. However, in longer term power outages, hospitals can be faced with limited fuel and difficulties in sourcing fuel for generators, due to transportation and communication difficulties." [lxix]



Alberta Health Services already Consumes 45% of the Annual Provincial Budget. [lxx]

In addition to the cost of Alberta's health care system to the Alberta provincial budget, health related jobs are one of the largest categories in Alberta. This 2010 chart [lxxi] of employment by industry in the Calgary Region, shows health services as the third largest group, topped only by retail and professional/scientific/technical services. A spike in electrical power costs would lead to a drop in hospital services or jobs…or both. Experience in the UK and EU reveal that wide-spread social misery, like 'heat-or-eat' poverty, more health problems and deaths would follow.

Employment by Industry – Calgary Region					
	2006	2007	2008	2009	2010
All Industries (Thousands) - Total	738.7	756.5	771.2	760.1	765.9
Goods-Producing Sector	189.0	194.6	199.3	177.8	187.1
Forestry, Fishing, Mining, Oil & Gas	56.6	59.8	55.9	50.4	51.0
Construction	66.1	69.6	75.2	70.2	75.1
Manufacturing	52.4	50.4	53.4	44.7	49.2
Services-Producing Sector	549.7	561.9	571.8	582.4	578.8
Wholesale Trade	24.9	32.5	30.1	25.7	26.7
Retail Trade	79.5	73.2	81.5	80.0	87.6
Transportation & Warehousing	42.2	44.8	37.8	43.5	41.4
Finance, Insurance, Real Estate & Leasing	43.2	45.7	51.2	47.7	47.6
Professional, Scientific & Technical Services	84.0	80.9	89.9	83.7	79.2
Educational Services	27.5	32.5	27.8	30.5	28.5
Health Care & Social Assistance	65.9	68.3	67.4	72.4	76.2
Information, Culture & Recreation	34.3	36.2	33.8	37.7	37.5
Accommodation & Food Services	50.9	46.5	52.0	53.7	49.6
Other Services	27.5	33.3	32.6	36.1	33.2
Public Administration	20.0	25.1	27.7	27.2	26.2

Source: Statistics Canada, Labour Force Survey
N/A= data suppressed, insufficient sample size
Statistics Canada cautions the reader that the regional Labour Force Survey estimates may be subject to large year-to-year fluctuations, especially for the smaller industries, due to sample size problems.

14. Heat-or-Eat Poverty a Consequence of Renewables

Since the advent of the 'rush-to-renewables' like wind and solar, the problem of fuel poverty has skyrocketed in the UK and EU, as have power rates. This is known as 'heat-or-eat poverty' as people are forced to compromise on either their home heating/power use, or their food budget.

In the UK and much of Europe, the emphasis on stringent climate change targets, using 'renewables' (and related costs/subsidies and coal-fired plant closures to reach the targets) has led to devastating consequences for people of all ages. Many of these tragedies were recounted by Dr. Benny Peiser during his presentation in Calgary (May 2013) at the Friends of Science 10th Annual Luncheon - "To Heat or Eat: Europe's Climate Policy Fiasco."

Professor John Hills of the Centre for Analysis of Social Exclusion within the London School of Economics and Political Science prepared a report titled "Fuel Poverty: The Problem and its Measurement" that documents the tragic outcomes. The report was commissioned by the UK Department for Energy and Climate Change. [lxxii]

In the UK, thousands of pensioners and others with weaker health have died due to being forced into heat-or-eat poverty because of climate change reduction policies.[lxxiii]

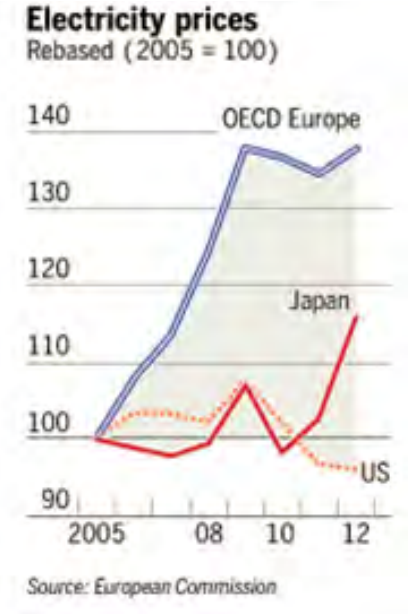
Millions of consumers have been forced into 'heat-or-eat' poverty; hundreds of thousands of Germans are unable to pay their electricity bills. [lxxiv]

In the EU, carbon prices have fallen from 34.90 euro per tonne in 2008 to 2.90 euro in the spring of 2013 as the carbon market collapsed.

Germany, like Alberta, is rich in coal and it presently has supercritical coal-fired power plants. Consequently, Germany is returning to the reliable, affordable, and local power generation option of coal, using modern supercritical technology like that of Alberta's Genesee3 and Keephills3[lxxv] said to be one of the most advanced coal-fired power plants in the world.

This Alstom video describes supercritical clean coal-fired plant technology.
http://youtu.be/fJVhwg5o0vA

As Johns Hopkins epidemiological expert M. Harvey Brenner found in his 2005 study [xxvi] related to coal-plant closures - on the linkage of health and low-cost energy in the US: *"… the adverse impact on household income and unemployment (of coal plant closures) could result in 195,000 additional premature deaths annually. That figure is on the low end of a range between 171,000 and 369,000 deaths."*



This chart shows how power prices skyrocketed in the EU due to the implementation of renewable technologies, carbon taxes and stringent climate change GHG reduction targets.

15. Ontario Hospitals Face 27% Spike in Power Prices

The outcome of the Ontario experiment with wind is that Ontario hospitals are now facing exorbitant, unexpected and unbudgeted power costs, as reported in the April 24, 2014 edition of the Windsor Star. [lxxvii]

> *"Patient care could ultimately suffer because of rising electricity costs that Windsor Regional Hospital predicts will add an extra $1 million to its budget this fiscal year, a 27 per cent increase from 2012-13….. And hospitals are just one place under pressure from rising electric costs, which have jumped about 30 per cent since 2010 and promise to rise another 33 per cent over the next three years."*

The question must be asked – if the problem is asthma and respiratory conditions that require medical interventions and power-driven HEPA filters as part of the treatment, and Alberta clearly has chronic issues with wildfire and agricultural dust and other emissions, why do advocates pursue an early phase-out of coal-fired power plants?

Coal-fired power plants are part of the solution, particularly as 58.6% of the Alberta Health Services budget allocation is dedicated to power intensive treatments like acute, long-term and continuing patient care, cancer treatment, transplants, cardiac treatment and renal dialysis. [lxxviii]

Likewise, world-class facilities like the ITOR – Interventional Trauma Operating Room at the Foothills Hospital, the first of its kind in the North America, rely on substantial electrical power to save lives. We have invested so much to create first class facilities that can save lives – we must not put these advances and lives at risk.

16. Powering Prosperity

Despite Alberta's relatively small 3 million+ population, there is an industrial manufacturing boom in progress, in part related to the oil sands; in part related to Alberta's own entrepreneurial sector finding new markets. Low cost and abundant coal energy leads to higher GDP growth in jurisdictions that use coal - leading to more jobs and higher affluence among the citizenry.

Coal use is increasing worldwide (3-5% per year over the last several years) and is expected to be the number one fuel used worldwide by 2021.

Manufacturing growth relies on affordable, reliable power.

According to AlbertaCanada.com:

> *"With approximately $14.5 billion per year of existing activity, Alberta is one of Canada's major metal manufacturing centres, behind only Ontario. Thanks to a strong demand from Alberta's energy sector, there are a number of opportunities for the province's metal manufacturing companies. Tens of billions of dollars are being spent in*

both the oil sands and conventional oil and gas sectors each year.

Demand in Alberta will require nearly $200 billion of new construction and maintenance spending over the next twenty-five years, much of it for fabricated metal products." [xlxxix]

To power this prosperity, Alberta needs reliable, conventional, affordable power. Alberta's industrial sector can learn from the head-aches and financial losses that Germany experienced in their 'rush-to-renewables.'

Germany's drive to almost double power output from renewables by 2035 has seen one operator reporting five times as many potential disruptions as four years ago, raising the risk of blackouts in Europe's biggest electricity market. [lxxx]

Alberta Manufacturing by Major Sub-Sectors

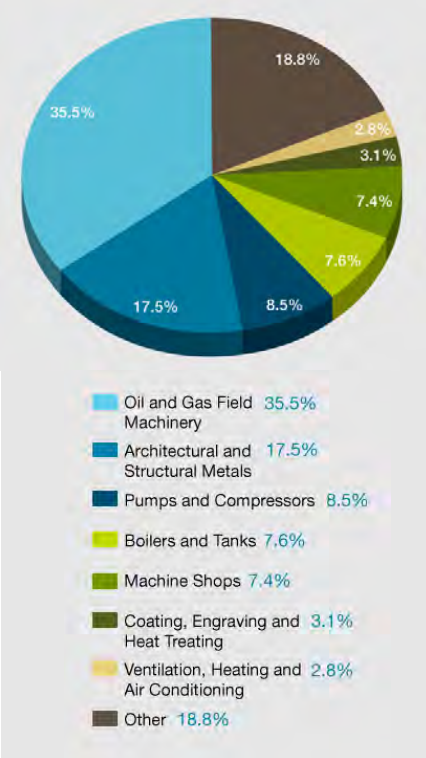
Clearly, additional renewables like wind or solar are unsuited to a rapidly expanding industrial base. Again, we can learn from the UK and Germany. [lxxxi]

Der Spiegel online reported in August 2012 that:

"Sudden fluctuations in Germany's power grid are causing major damage to a number of industrial companies. While many of them have responded by getting their own power generators and regulators to help minimize the risks, they warn that companies might be forced to leave [the country] if the government doesn't deal with the issues fast." [lxxxii]

The need to have a conventional power source backing up renewables can also result in further market extremes that have a negative impact on consumers and industry in terms of power prices.

[In Germany]…Utilities that sign up to the 800 million-euro ($1.1 billion) balancing market can be paid as much as 400 times wholesale electricity prices, the data show.



Revenue Shares in 2012 for Major Sub-Sectors

17. Affordable, Reliable, Cost-efficient Power is a Necessity

Winters in Alberta are cold; temperatures sometimes plunge below -40 °C. By contrast, winter temperatures in Germany are about -5 °C. Alberta has a growing industrialized sector and a modern health care system. An interruption of electrical power can be both costly and dangerous, especially in the winter. Alberta consumers, industry and our health care system require affordable, reliable electrical power. This report has demonstrated that coal-fired power plants in Alberta, which have had increasingly stringent emissions management for over 30 years, are the most cost-efficient, least polluting energy option, with unmatched benefits to human health and provincial prosperity, on balance, with only positive societal benefits. Coal-fired power plants offer cheap, safe, reliable power.

18. Firesmart [lxxiii] - an investment in health and safety

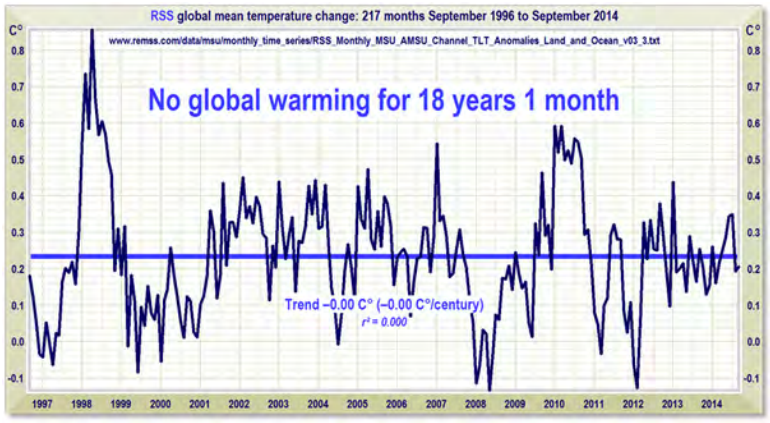
Since the release of the Firesmart manual in 1999, provincial and federal governments have been making a concerted effort to unite the public and all levels of government in wildfire mitigation efforts. The Firesmart program now extends that work.

Despite widespread publicity about fire safety, wildfires are still commonly started by human activity and many homes in high risk areas of the province, typically surrounded by boreal forests, are considered by their owners to only face low to moderate risk, even though provincial fire agencies consider them to be a high risk. [lxxxiv]

In light of the observed impacts on valuable forestry stocks, wildlife and natural habitat, regional climate, the local and regional health impacts and the potential for catastrophic property loss, surely enhanced investment and publicity of the Firesmart program would have far reaching benefits.

19. Climate is Changing…all the time

The Intergovernmental Panel on Climate Change AR 5 report quietly announced that there had been a 15 year 'hiatus' in global warming since 1998 to 2012. It is now 18 years since global warming stopped naturally - despite a rise in carbon dioxide.

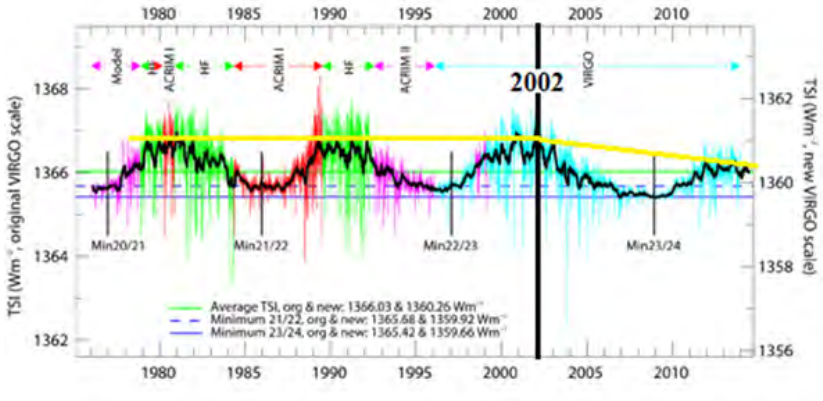


After over a decade of climate science review, Friends of Science, a growing group of earth, atmospheric, astrophysical scientists and engineers who volunteer their time and resources to educate the public, are of the view that the sun is the main direct and indirect driver of climate change – and that it is the influence of various solar and atmospheric cycles along with other natural factors that account for the changes in global climate patterns at this time.

January 16, 2014 atmospheric scientist Dr. Judith Curry of Georgia Tech [lxxxv] testified to the US Senate committee on Environment and Public Works that the case for human-caused global warming had been weakened by the evidence, that the IPCC (Intergovernmental panel on Climate Change) was unable to explain why their theory of Anthropogenic Global Warming was not proving out, and that carbon dioxide (CO2) is likely not the 'control knob' of climate variability.

Dr. Curry has called for the IPCC to be shut down, [lxxxvi] saying: "the IPCC still has not provided a convincing argument for how much warming in the 20th century has been caused by humans."

Indeed, a number of physicists like William Happer of Princeton [lxxxvii] , Nir Shaviv of Hebrew University in Jerusalem [lxxxviii] and Friends of Science resident science advisor, geophysicist Norm Kalmanovitch [lxxxix] question the effect of carbon dioxide on warming. Well-respected German industrialist and IPCC expert reviewer Fritz Vahrenholt and Sebastian Lunning have published a book entitled "The Neglected Sun: How the Sun Precludes Climate Catastrophe." Few of these scientists' views are represented in the media or IPCC reports.



Source: World Radiation Center, Davos, Switzerland

Total Solar Irradiance – note added trend line in yellow showing a drop in solar irradiance, visible on the graph since 2002, coinciding with the stagnation in global warming.

This perspective is supported by the evidence from the World Radiation Center in Davos, Switzerland, which shows a clear drop off in solar irradiance as of 2002.

Whether you agree with the Friends of Science perspective on climate change science or not is irrelevant to the foregoing discussion. We believe we have clearly demonstrated that Alberta's coal-fired plants offer cascading benefits from inexpensive, reliable, environmentally managed power. By contrast to claims that coal-fired plant emissions are the sole or major cause of respiratory ailments, Alberta has a persistent, perennial PM2.5 issue from a complex set of factors – wildfires, agricultural dust and fertilizer, road dust and construction and residential fireplaces together with intermittent weather conditions like inversions.

Closing coal-fired power plants will not solve any of these much larger issues; it will not stop asthma or respiratory incidents and it certainly will not save the Alberta government a penny on health care. Expect power prices to jump, grid reliability to fail and power quality to fall if coal-fired plants are phased out early and renewables added to the grid.

If anything, a more significant investment in the nation-wide and provincial FIRESMART program will help improve air quality, preserve forests and property, and reduce wildfire black carbon and toxic aerosol pollution, which this literature review has shown results in long-term health impacts.

Likewise, reducing wildfires will reduce the turbulent energy of massive wildfires that can exacerbate ozone, spread brown and black carbon soot and PM2.5 emissions far and wide. To get an idea of the energy released, one forestry expert has suggested the human-caused Slave Lake Fire Complex of 2011 released the equivalent of about 28 megatons (MT) TNT.
Hiroshima was 13 kilotons (kT) TNT. [13]

13 TNT equivalent is a method of quantifying the energy released in explosions. The "ton of TNT" is a unit of energy equal to 4.184 gigajoules (1 gigacalorie), which is approximately the amount of energy released in the detonation of a ton of TNT. The "megaton of TNT" is a unit of energy equal to 4.184 petajoules.[1] Source: Wikipedia commons http://commons.wikimedia-.org/wiki/File:Nukecloud.png

20. The Power of Natural Forces

The "Alberta phase-out coal" campaign proponents say their proposal would save Alberta $300 million in medical costs and save hundreds of lives, but the claims are based on a faulty computer model, not factual evidence. They have focussed emissions claims on coal-fired power plants which in 2011 generated only 1/1,000th the PM2.5 emissions of wildfires – omitting a myriad of other PM2.5 sources, natural and human-caused.

According to the Flat Top Complex Wildfire Review Committee report of 2012 that studied the Slave Lake area fires, Alberta's "aging coniferous forests dominate more of the landscape, which means Alberta's forest are likely more flammable than they were even 50 years ago." This health risk will continue to be a problem far greater than coal-fired power plants.

This evidence-based review does not support the claims of the 'Alberta phase-out coal campaign.' Albertans are being misled.

Slave Lake Fire aftermath photo credit: unknown.

Jet flies by PyroCb mushroom cloud of explosive pyroCb power as it rises up from the Oregon Gulch Fire above tropopause July 31, 2014 – Photo: by James Haseltine, Oregon Air National Guard [xc]

US Naval Research Laboratory sees climate effects of wildfires - see the work of Mike Fromm.

In Closing

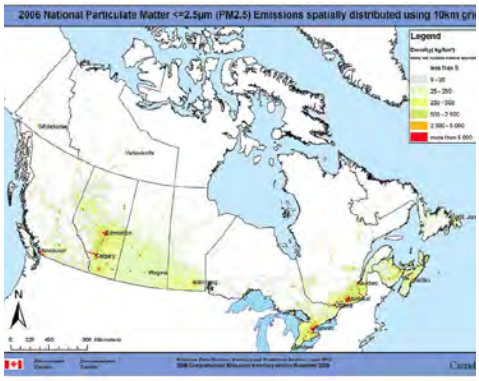
In closing, we ask readers to consider the following in terms of growing demand for health care and power in the province of Alberta.

- The PM2.5 emissions from wildfires can be 1000 times that from coal-fired power plants in Alberta. Numerous other PM2.5 sources affect Alberta in general and the Edmonton region in particular, though Albertans still have the best quality of life of major cities in Canada; Canada is deemed to have excellent air quality by the WHO.
- Wildfires can become pyro convective, causing wide-spread distribution of PM2.5 and other airborne toxins.
- The PM2.5 emissions from coal-fired power plants in Alberta represent only 0.4% of all human-caused, non-wildfire sources.
- Proposed replacements like wind and solar are the least reliable, most expensive forms of power generation, and require wasteful 24/7 back-up by conventional thermal or hydro power.
- Electricity from coal-fired power plants is inexpensive and reliable; Alberta's coal-fired power plants meet stringent environmental regulations while providing safe, affordable power - a requirement for comfortable living, productive learning in schools and universities, competitive industry and quality health care, especially in a climate that reaches -40°C/F and below in winter.
- The IPCC claims about carbon dioxide as the most significant factor in causing global warming/climate change is increasingly challenged by evidence of 18 years of no global warming despite a global rise in carbon dioxide emissions, compounded by the evidence of a significant drop in solar radiation.
- Public policy decisions about Alberta's energy future must be based on facts and evidence.

Appendices

APPENDIX A

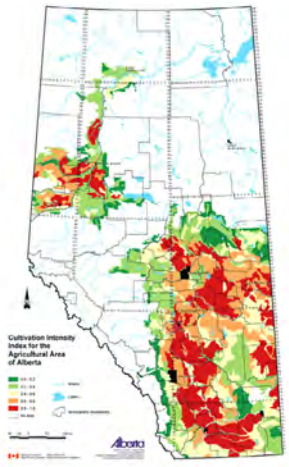
The map of Canada below shows the distribution of PM2.5 concentrations by density. The Alberta map top right shows coal-fired power plant locations. The lower maps of Alberta show (left) agricultural Cultivation Intensity and (right) the Fertilizer Expense index, suggesting better correlation between PM2.5 density with agricultural activity, than with the location of coal plants (Note: There are no coal plants in the Calgary region but asthma incidence and visits are on a par with Edmonton. Edmontonians report a higher smoking rate than Calgary).



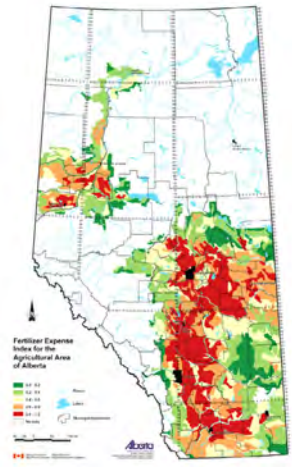
Below: Map of Alberta Coal Plant Locations from Pembina's "Costly Diagnosis"

Figure 1. Coal-fired electricity generating units in Alberta (coloured bars denote unit size in MW)

Data source: Milner Power, TransAlta, Atco Power; map adapted from Natural Resources Canada[1]



Agricultural Cultivation Intensity



Fertilizer Use Intensity

APPENDIX B – Environment Canada does not see coal plants as a major source of PM2.5

Primary Particulate Matter (PM)

The largest sources of primary (directly emitted) fine particulate matter (PM2.5) are road dust and construction/demolition activity, both characterized as open sources, amounting to approximately 67% of the national total. Other important anthropogenic sources are residential wood combustion, transportation and some industrial activities such as wood processing and pulp and paper plants (Figure 10). One area of high PM2.5 emissions density is the Windsor–Quebec City corridor resulting mainly from industrial activities and from the transportation, and residential wood combustion sectors (Figure 11). Major urban centres in western Canada and along the Edmonton–Calgary corridor are also shown as areas of high PM2.5 emissions density, again likely the result of emissions from the transportation sector. Figure 11 includes the emissions from open anthropogenic sources, illustrating the impact of these sectors such as in the interior of British Columbia. In this area, primary PM2.5 is a major issue of concern associated with residential woodstoves, agricultural and controlled burning, and road dust.

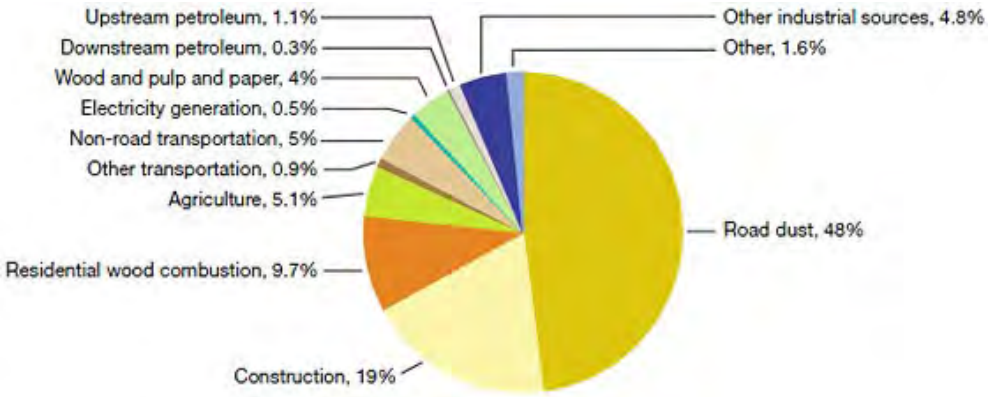


Figure 10 Key sectors contributing to the 2006 PM2.5emissions inventory

Figure 11 Density map of PM2.5 emissions (kg km-2) including open sources, in Canada for 2006

Total anthropogenic PM2.5 emissions have remained fairly stable from 1985–2006 (Figure 9). Excluding open sources, PM2.5emissions have decreased by approximately 50% over that period due to reductions in emissions from the wood, pulp and paper and electricity generation sectors. Overall, anthropogenic PM2.5 emissions (including open sources) are projected to slightly increase to 2015 due to the high proportion of road and construction dust and residential wood combustion.

Natural sources are also important contributors to primary PM2.5emissions. They include forest fires, windblown soil, sea salt spray, and volcanic dust. Forest fires can contribute to primary PM2.5emissions in the boreal forest and sea salt is an important influence along the coast.

Source: Environment Canada - Canadian Smog Science Assessment Highlights and Key Messages

APPENDIX C – Map of NAPS monitor distribution

http://www.ec.gc.ca/rnspa-naps/default.asp?lang=En&n=B420EEC0-1

APPENDIX D-1

Human- vs. Lightning-Caused Wildfires

Number of Wildfires							Hectares Burned				
Year	Human Caused	% Human	Lightning Caused	% Lightning	Total		Human Caused	% Human	Lightning Caused	% Lightning	Total
2002	579	40%	868	60%	1,447	2002	247,935.45	50%	248,579.43	50%	496,514.88
2003	661	56%	527	44%	1,188	2003	23,501.55	31%	51,372.72	69%	74,874.27
2004	880	55%	732	45%	1,612	2004	4,185.17	2%	231,905.13	98%	236,090.30
2005	1,016	70%	432	30%	1,448	2005	12,122.82	20%	48,640.27	80%	60,763.09
2006	1,208	62%	746	38%	1,954	2006	21,184.96	18%	97,576.91	82%	118,761.87
2007	836	62%	513	38%	1,349	2007	910.87	1%	102,757.68	99%	103,668.55
2008	933	54%	779	46%	1,712	2008	2,264.05	11%	18,522.77	89%	20,786.91
2009	1,144	67%	566	33%	1,710	2009	3,695.94	6%	63,249.30	94%	66,945.24
2010	1,099	60%	741	40%	1,840	2010	2,392.90	3%	81,263.64	97%	83,656.54
2011	936	81%	214	19%	1,150	2011	870,523.45	92%	76,164.05	8%	946,687.50

5 year Average											
	Number of Wildfires						Hectares Burned				
Year Span	Human Caused	% Human Caused	Lightning Caused	% Lightning Caused	Number of Wildfires		Human Caused	% Human Caused	Lightning Caused	% Lightning Caused	Hectares Burned
2007-2011	990	64%	563	36%	1,552		175,957.44	72%	68,391.49	28%	244,348.95

10 year Average											
	Number of Wildfires						Hectares Burned				
Year Span	Human Caused	% Human Caused	Lightning Caused	% Lightning Caused	Number of Wildfires		Human Caused	% Human Caused	Lightning Caused	% Lightning Caused	Hectares Burned
2002-2011	929	60%	612	40%	1,541		118,871.72	54%	102,003.19	46%	220,874.92

APPENDIX D-2 2011 Alberta wildfires versus 10 Yr. Avg. (*FOFEM)

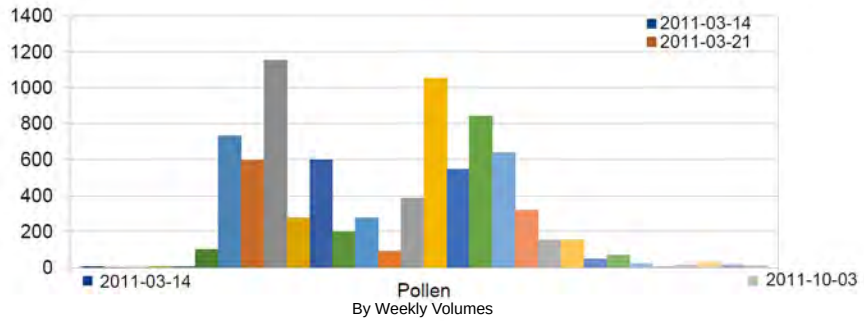
Source: Wildfire Data Archives ESRD
Assessment Based on USDA First Order Fire Effects Modelling* at 20% consumption rate.

Alberta

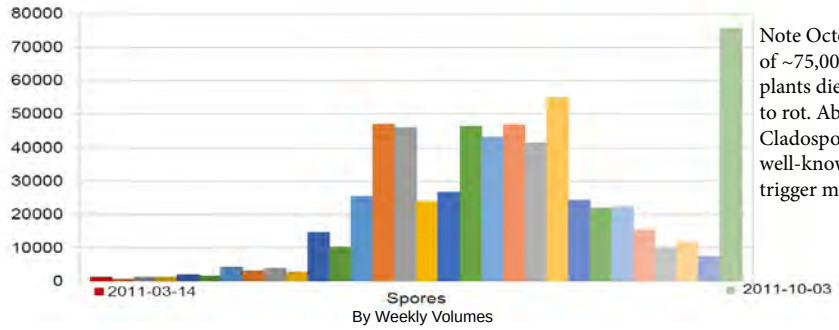
	2011	10-Yr Average	Notes
Total 2011			
Fires *	1150	1541	
Cost *			
Ha *	946,688	220,875	
$/ ha			
Emmisions - Human Health			
PM 2.5	1,715,489	400,247	tonnes
SO4	77,977	18,193	tonnes
PM 10	18,193	63,676	tonnes
Diesel Truck Emmision Comparison			
PM 2.5	448,002,081	104,524,908	Diesel trucks
SO4	30,440,629	7,102,208	Diesel trucks
PM 10	65,773,069	15,345,741	Diesel trucks

APPENDIX E

Comparing Villeneuve et al (2007) with 2011 Edmonton Pollen/Spore counts from Aerobiology

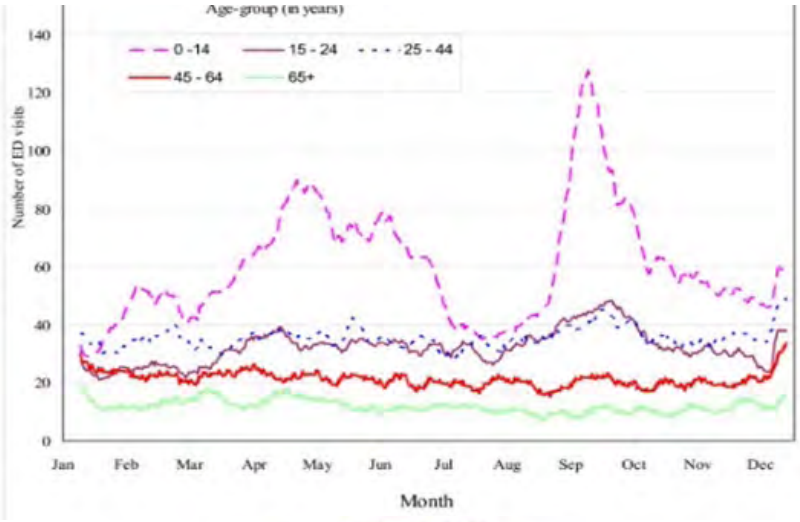


Particles per Cubic Meter of Air, per Week



Note October spike of ~75,000 P/m^3 as plants die and start to rot. About half are Cladosporium sp, a well-known asthma trigger mould.

Particles per Cubic Meter of Air, per Week



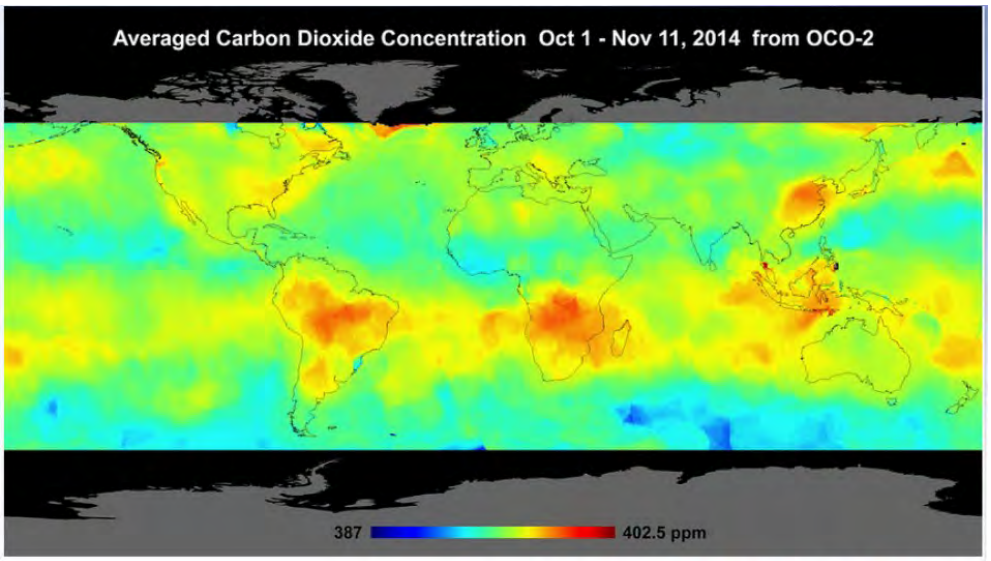
Villeneuve et al (2007)

Source:
Environ Health. 2007; 6:40.
Published Online Dec 24, 2007.
doi: 10.1186/1476-069x-6-40

Source:
Canadian Interagency Forest Fire Centre.
Note: This represents Canadian Fires not just Alberta fires. This demonstrates seasonal trends.

APPENDIX F

Alberta's carbon dioxide emissions barely register in NASA's recent satellite observations of earth. NASA's imagery confirms that the largest concentrations of carbon dioxide are in areas of the world where forests are being burned off or in highly industrialized areas, most prevalent where there are poor environmental standards.



Text Size 0 25

Global Atmospheric Carbon Dioxide

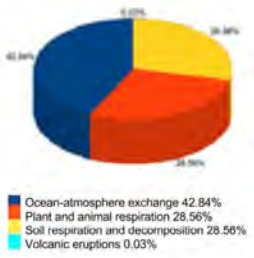
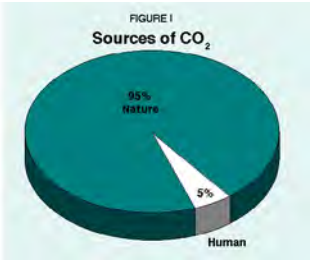
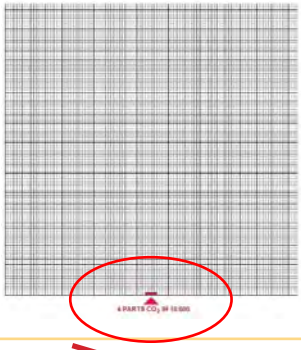
Global atmospheric carbon dioxide concentrations from Oct. 1 through Nov. 11, as recorded by NASA's Orbiting Carbon Observatory-2. Carbon dioxide concentrations are highest above northern Australia, southern Africa and eastern Brazil. Preliminary analysis of the African data shows the high levels there are largely driven by the burning of savannas and forests. Elevated carbon dioxide can also be seen above industrialized Northern Hemisphere regions in China, Europe and North America.

Image credit: NASA/JPL-Caltech

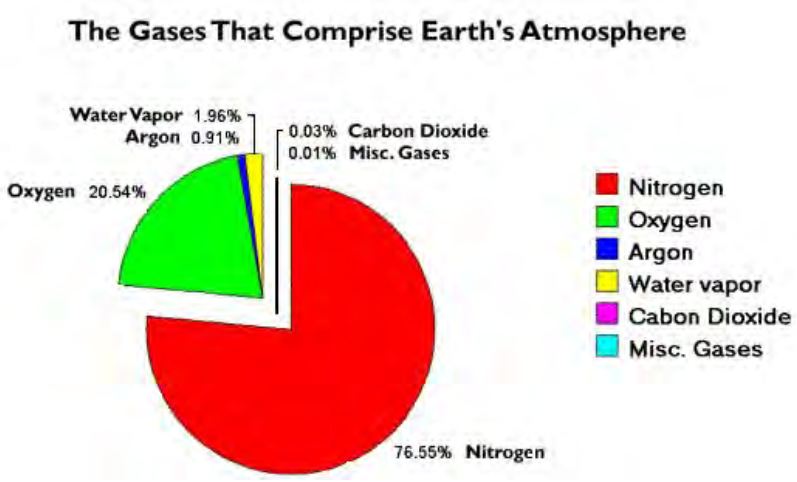
http://www.nasa.gov/jpl/oco2/pia18934/#.VJ2kY14AKA

APPENDIX G

Natural sources of carbon dioxide (CO2) make up 95% of the carbon dioxide on earth – and carbon dioxide is just a tiny portion of trace gases.

Natural Sources of Carbon Dioxide	Natural Sources of CO2 make up 95% of all CO2	Human contribution is 5% of 4 parts per ten thousand or (400 parts per million)
		

Only 5% of this 0.039% of carbon dioxide are from human emissions.



(Original Source: J. M. Wallace and P. V. Hobbs, Atmospheric Science, An Introductory Survey, Academic Press, 1977, page 5). CO2 updated from latest DOE statistics.

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viii. http://www.fs.usda.gov/ccrc/tools/fofem NOTES: Wildfire statistics reports earlier on in this presentation reflect an analysis of wildfire statistics posted on Alberta's Environment and Sustainable Resource Development site, assessed via USDA FOFEM (First Order Fire Effects Model) with the following inputs: Emissions - burned area x fuel loads x combustion completeness. [Another model "CONSUME" is often used; this article describes the range of emissions depending on type of forest in British Columbia 2011: http://www.bcairquality.ca/reports/pdfs/wildfire-emissions-2011.pdf]

ix. http://wildfire.alberta.ca/wildfire-maps/historical-wildfire-information/historical-wildfire-database.aspx
Data note: Canadian Interagency Forest Fire Centre Inc. 2011 archive shows the full extent of forest fires to Aug. 30, 2011 while Environment Canada stats that were used in the Pembina Institute report do not include wildfire data; 2011 was the Slave Lake wildfire in Alberta (human-caused) – the largest fire in Alberta's history – however any year selected reveals wildfire emissions that exponentially exceed those of coal-fired plants. Wildfire emissions reporting is handled in various ways by federal and provincial departments and is not clearly reported by Environment Canada (which reports on managed emissions) but confusingly is variously reported in differing terms by National Resources Canada, Canadian Forest Service, Canadian Wildland Fire Information Service, National Pollutant Release Inventory, Alberta Environment and Sustainable Resources, Alberta Office of Statistics and Information, and also tracked by the Canada Space Agency

x. http://cjem-online.ca/v12/n4/p339

xi. journal.cpha.ca/index.php/cjph/article/download/2100/2043 "Smoking Frequency, Prevalence and Trends, and Their Socio-demographic Associations in Alberta, Canada"

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xiii. http://www.atmos-chem-phys.net/12/8237/2012/acp-12-8237-2012.html A global air quality modeling system GEM-AQ/EC was developed by implementing tropospheric chemistry and aerosol processes on-line into the Global Environmental Multiscale weather prediction model – GEM. Due to the multi-scale features of the GEM, the integrated model, GEM-AQ/EC, is able to investigate chemical weather at scales from global to urban domains. The current chemical mechanism is comprised of 50 gas-phase species, 116 chemical and 19 photolysis reactions, and is complemented by a sectional aerosol module CAM (The Canadian Aerosol Module) with 5 aerosols types: sulphate, black carbon, organic carbon, sea-salt and soil dust. Monthly emission inventories of black carbon and organic carbon from boreal and temperate vegetation fires were assembled using the most reliable areas burned datasets by countries, from statistical databases and derived from remote sensing products of 1995–2004. The model was run for ten years from from 1995–2004 with re-analyzed meteorology on a global uniform 1° × 1° horizontal resolution domain and 28 hybrid levels extending up to 10 hPa. The simulating results were compared with various observations including surface network around the globe and satellite data. Regional features of global aerosols are reasonably captured including emission, surface concentrations and aerosol optical depth. For various types of aerosols, satisfactory correlations were achieved between modeled and observed with some degree of systematic bias possibly due to large uncertainties in the emissions used in this study. A global distribution of natural aerosol contributions to the total aerosols is obtained and compared with observations.

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This image, photographs taken from an F-15C, shows a much closer view of a developing pyrocumulus cloud above the Oregon Gulch fire, a part of the Beaver Complex fire. They were taken from an Oregon Air National Guard F-15C by James Haseltine on July 31, 2014, at 8:20 PM Pacific Daylight Time. Photo: Public Domain – Wikipedia

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