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Vehicle Emissions Testing

AirCare, Drive Clean, and the Potential of Inspection and Maintenance Programs in Canada

by Paul Coninx

THE FRASER INSTITUTE

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About the author

Paul Coninx has written on consumer, safety, and technical issues for over 15 years and his works in these areas have been cited in peer-reviewed scientific and medical journals. He has taken part in I/M stakeholder meetings and has written three comprehensive reports, financed by grants from Industry Canada, on vehicle emission inspection and maintenance programs for the Automobile Protection Association (APA). For many years, Mr. Coninx designed and implemented covert garage investigations revealing fraud and incompetence for the APA. Mr. Coninx holds a degree from McGill University and has held technical positions at IBM (New York) and with television stations in the United States.

Executive summary

Inspection and maintenance (I/M) programs place a legal requirement upon the owners of private cars and light trucks to submit their vehicles to a scheduled test for excessive emissions every year or every two years. Vehicles that fail the test must either be repaired and pass a re-test or receive a waiver to remain on the road. The owners of the vehicles must pay for both the test and the repairs.

I/M programs were developed during the 1970s in the United States, where government regulations imposing I/M programs spawned a billion-dollar vehicle-testing and consulting industry. In spite of the fact that in the United States, I/M programs have never been shown to provide anywhere near the benefits its supporters promised, the programs continue to be very popular with industry, government bureaucrats, and non-profit organizations.

In 1992, British Columbia launched AirCare, the first I/M program in Canada. AirCare administration is now in the process of designing AirCare II to replace the original AirCare program when the testing contract expires in 1999. Although I/M programs fall within provincial jurisdiction, Environment Canada has been promoting I/M for 10 years and has developed an I/M Code of Practice through the Canadian Council of Ministers of the Environment (CCME). Ontario had originally announced that it would introduce its first I/M program during 1998, but the launch of the program has since been postponed.

The fact that I/M is popular with governments and has powerful friends in the private sector, and that it is paid for (and usually tolerated by) individual citizens has allowed it to escape both organized opposition and the scrutiny appropriate for government programs. Questioning I/M programs may incorrectly be considered tantamount to questioning the value of cleaner air.

Let's question the value of I/M programs

During the first five years of AirCare, the average annual cost of the program, including test fees, repairs, expenses, and lost time is conservatively estimated to have been nearly $63 million, or $1 million every 6 days (see table E1). This amount does not include the environmental damage resulting from two million extra vehicle trips per year to and from testing and repair facilities.

Table E1: Cost of AirCare to consumers in the Vancouver area

Year	Number of vehicles tested	Fee for testing	Number of vehicles failing test	Average cost for repair	Annual costs: Tests	Repairs	Inconvenience and expense*	Total per year
1993	743,506	$16.05	126,894	$208	$11,933,271	$26,393,952	$17,408,000	**$55,735,223**
1994	1,182,294	$16.05	132,113	$177	$18,975,819	$23,384,001	$26,288,140	**$68,647,960**
1995	1,125,309	$16.05	104,373	$188	$18,061,209	$19,622,124	$24,593,640	**$62,276,973**
1996	631,504	$18.00	79,841	$216	$11,367,072	$17,245,656	$14,226,900	**$42,839,628**
1997	1,235,551	$18.00	143,499	$243	$22,239,918	$34,870,257	$27,581,000	**$84,691,175**
Total of annual costs over the 5 years from 1993 to 1997 =					$82,577,289	$121,515,990	$110,097,680	$314,190,959
Annual average: $62.8 million **Daily average:** $62.8 million / 365 days = $172,000 per day or $1 million every 6 days								

* Using standard EPA estimate of the value of 45 minutes (including the drive to and from an inspection station, the waiting and testing time) x US$20/hour = US$15 = CDN$20: see USEPA 1991a: 13. The same estimate is applied to trips to a repair garage.
Source: AirCare 1998, US EPA 1991.

What kind of value does AirCare give residents for their $63 million? The value of any reduction in emissions depends upon the adverse effect that the pollutant has on human health and the environment. According to a draft study done by ARA Consortium Sholtz & Associates (1995) for the GVRD, the British Columbia Ministry of Environment Lands and Parks, and Environment Canada:

> the benefits per tonne of emissions reduced (calculated . . . in terms of averted damage to human health, materials, crops, etc. per tonne) vary as follows:
>
> - CO: <$1/tonne[A]
> - VOC: $84/tonne[B]
> - NO_x: $120/tonne[C]
> - SO_x: $320/tonne [sulphur oxides; not reduced by AirCare]
> - PM_{10}: $75,150/tonne [particulate matter 10 microns or less in size; not reduced by AirCare]
>
> [A] No discernible damage to human health or the environment was identified for CO.
> [B] The damage averted per tonne of VOC reduced includes ozone-related damage. [In the presence of sunlight, VOCs and NO_x combine to create ozone. See Appendix 4 for details.]
> [C] The damage averted per tonne of NO_x reduced includes ozone-related damage.
>
> (ARA Consortium Sholtz & Associates 1995: 2–16)

AirCare has virtually no effect on either SO_x or PM_{10}, the pollutants considered the most harmful. Table E2 gives the amounts and the value of the reductions in emissions of VOCs, NO_x, and CO as claimed by AirCare and as calculated by an Automobile Protection Association study of the third year. Even AirCare's *best* claimed reduction in emissions reveals that consumers received *less than a one percent return* in environmental and health benefits for the average annual $63 million they were required by law to pay.

AirCare figures show that CO is the emission that accounts for the greatest number of tonnes reduced. Supporters of AirCare and I/M programs in general tend to lump emissions of CO together with VOCs and NO_x. For example, in the *Vancouver Sun* June 7, 1996, Moe Sihota, then British Columbia's Environment Minister, was quoted as claiming that during its first three years AirCare had reduced emissions by 165,000 tonnes. However, 93 percent of those claimed reductions in emissions are for CO, the value of which is less than $1 a tonne. The total environmental and health value of the first three years of AirCare amounts to less than $154,000 from the reduction of CO, $937,700 from the reduction of VOCs, and $94,300 from reduction of NO_x—a total of $1.2 million of claimed benefits that, after three years, cost residents of British Columbia 150 times that amount.

Reviewing I/M programs

Independent scientific evaluations of I/M programs are rare. Evaluations of I/M benefits are usually made by the I/M program staff itself or by consultants who are hired by, and report to, the same authorities that are promoting the program. These reports often contain unjustifiable assumptions, strange methodology, and "leaps of faith" that tend to overstate the benefits of I/M programs. For example, 1500 tonnes (over 30 percent) of the reduction in VOCs that AirCare claims for year 2 are calculated on the basis of two assumptions that have no evidence to support them.

The Canadian federal government also supports I/M programs. The Canadian Council of Ministers of the Environ-

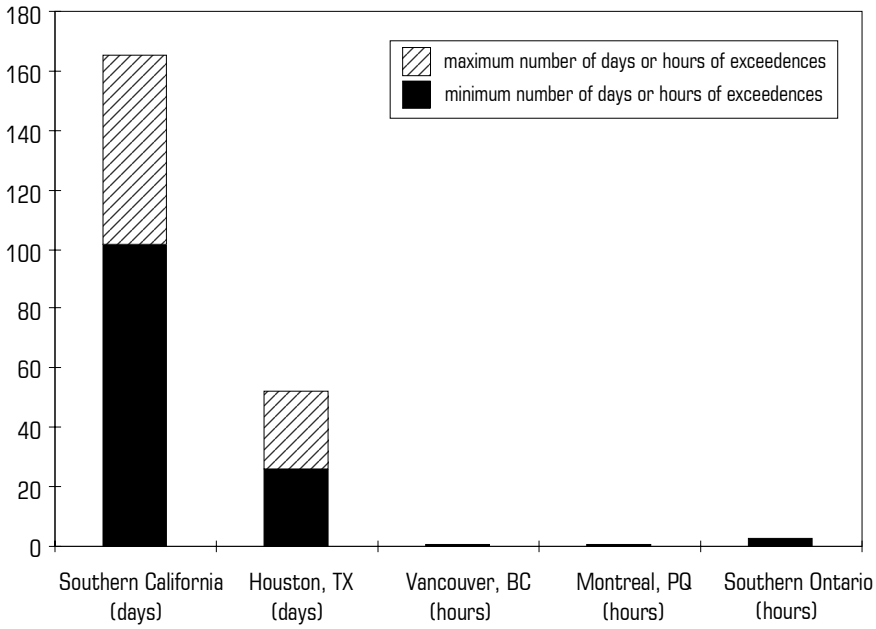
Table E2: Emission reductions and their value as claimed by AirCare and as calculated by the Automobile Protection Association

	AirCare claims						APA calculations	
	Year 1 (1992/1993)		Year 2 (1993/1994)		Year 3 (1994/1995)*		Year 3	
	tonnes	value	tonnes	value	tonnes	value	tonnes	value
VOCs	2,900	$243,600	4,740	$398,160	3,523	$295,932	1,854	$155,736
NO_x	95	$11,400	460	$55,200	231	$27,720	134	$16,080
CO	36,000	$36,000	68,000	$68,000	49,960	$49,960	59,952	$59,952
Total value		$291,000		$521,360		$373,612		$231,768

Sources: AirCare claims, years 1 and 3: AirCare 1996b; year 2: Weyn and Klausmeier 1994. APA calculations: Coninx 1996b; values calculated as per ARA Consortium Scholtz 1995.
* Latest available data.

ment (CCME) mandated Environment Canada to co-ordinate the development of a national Code of Practice for I/M programs. Neither Environment Canada nor the CCME have been able to provide any scientific evidence that I/M either has been or will be effective. During the development of the Code of Practice, the CCME ignored virtually all the scientific evidence that casts doubt on the effectiveness of I/M strategies. The Code of Practice was not intended to provide a critical review of I/M programs but rather to sell the concept to bureaucrats and elected officials in Canada: "The existence of a CCME Code of Practice will also assist provincial agencies in convincing both management and politicians that I/M should be implemented" (CCME 1993: 2–8).

Figure E1: Average annual ozone exceedences greater than 120 ppb (US: 1984–1993; Canada: 1980–1993)



Note that this chart understates the real differences because the data for the United States is in "days," each of which may contain many 1-hour exceedences. Data from a Canadian study suggests that "1 day" is roughly equivalent to 5 hours (CCME 1997: 4).
Sources: CCME 1997; US EPA 1994a.

I/M programs in Canada

Even if I/M programs were reasonably effective in reducing vehicle emissions, such an expensive and inconvenient program is certainly not needed in British Columbia and it would have little or no impact in southern Ontario, because the marginal ozone problem that exists there is largely created by air flowing in from the United States, where half the ozone and its precursors originate. As the figure E1 shows, ground-level ozone is an American problem. Canadian exceedences of the levels of ozone acceptable to the US EPA are minuscule compared to ozone levels in the United States.

The original American ozone standard was established at 120 parts per billion (ppb) to protect the public health and allow for "an adequate margin of safety". Those to be protected include "particularly sensitive citizens such as bronchial asthmatics and emphysematics who in the normal course of daily activity are exposed to the ambient environment" (Rogers 1994: 158n.). On average, Vancouver experiences ozone levels above 120 ppb for only 30 minutes (0.006 percent) per year, Montreal only 48 minutes (0.01 percent) per year, and southern Ontario (Toronto is slightly less), only 2 1/2 hours (0.03 percent) per year. Exceedences in southern Ontario and Toronto are largely due to polluted air blown across the border from the United States.

Even using the Canadian standard, the number of ozone exceedences are extremely small. Between 1986 to 1993, Vancouver had an annual average of only 5 hours (0.06 percent) when ozone levels were over the "acceptable" 82 ppb standard. Montreal had an annual average of 16 hours (0.2 percent) and Toronto an annual average of 69 hours (0.9 percent) (CCME 1997: 99).

In Canada, as in the United States, the lobby for I/M programs has successfully crowded out more promising, more convenient, and more cost-effective alternatives in favour of the highly lucrative, scheduled testing of vehicles for excessive emissions. In the absence of compelling scientific evidence of the effectiveness of I/M programs, the only reasonable action is to cancel AirCare and abandon any future plans for I/M programs in Ontario and the rest of Canada.

Background

> *Ignorance of naturall causes disposeth a man to Credulity, so as to believe many times impossibilities: For such know nothing to the contrary, but that they may be true; being unable to detect the Impossibility. And Credulity, because men love to be hearkened unto in company, disposeth them to lying: so that Ignorance it selfe without Malice, is able to make a man both to believe lyes, and tell them: and sometimes also to invent them.*
>
> Thomas Hobbes (1651)

In 1970, the United States federal government passed the Clean Air Act (CAA) to address the increasing degradation of urban air quality. The Environmental Protection Agency (EPA) was created under the CAA to enforce the Act primarily through a "command and control" process that set increasingly more stringent emission limits on pollution sources (Griffin 1994: 276). Two major strategies were pursued to control the increasingly serious air pollution problems created by the growing number of motor vehicles in use in urban areas.

One strategy was to establish strict emission certification standards for new vehicles. Meeting these standards placed a substantial economic burden on manufacturers and their customers.[1] Certification standards did, however, provide a level playing field by requiring similar efforts from competing manufacturers. This strategy was successful. Less than three decades later, dependable catalytic converters, fuel injection, computer-controlled engines, and sophisticated diagnostic devices have cut new car emissions by over 90 percent,[2] requiring little or no maintenance.[3]

The second strategy was to make vehicle emissions subject to inspection and maintenance (I/M) programs in regions not meeting national standards of ambient air quality for carbon monoxide (CO), nitrogen oxides (NO_x), volatile organic compounds (VOCs) or ground-level ozone, pollutants linked to motor vehicles. Inspection and maintenance programs require that all the light-duty vehicles in the area must undergo a brief scheduled test—the inspection—that is supposed to identify those vehicles that have mechanical faults causing excessive emissions. The owners of failed vehicles are then required by law to have them repaired–the maintenance—and the efficacy of the repair is subject to another inspection. I/M programs are targeted almost exclusively at cars and light trucks owned by consumers. Under 1990 amendments to the United States Clean Air Act, 179 cities in 38 states were required to implement I/M programs (US EPA 1995: s. 3, 2).

For some companies, the legal requirement for millions of annual I/M tests was very profitable. Unlike many pollution reduction programs, I/M programs do not increase the production costs of special interest groups but rather creates an entirely new source of business income for them. In the United States, a billion-dollar emissions-testing industry grew from nothing. A small number of companies specializing in designing and evaluating I/M programs for governments also sprang up. I/M legislation generated millions of additional customers for the vehicle repair shops and, depending upon the program design, provided them with guaranteed revenue from testing fees. I/M programs also expanded the market for expensive test equipment.

At the same time, I/M programs do not interfere with the interests of other politically and economically powerful groups. For example, conventional I/M legislation does not apply to the heavy trucks and buses owned by governments and large companies. It does not impose additional investment costs on the oil industry for cleaner fuels or delivery systems and, because I/M programs mostly affect older vehicles that are no longer under warranty,[4] there is no adverse effect upon auto manufacturers. In general, I/M programs allow these industries to adopt a "green" public image at no cost to themselves. I/M programs also provide various health and environmental pressure groups with a high-profile issue to rally around. Finally, I/M programs are attractive to government, which can expand its influence and create additional career opportunities for bureaucrats while the cost of the programs is almost entirely borne by consumers and does not appear in government budgets.

Together, all these groups—the stakeholders—have a vested interest in I/M programs and make up a powerful lobby group. Only consumers (as motorists) and taxpayers[5]

are adversely affected by I/M programs directly, being forced by law to participate in and pay for the program. And, motorists are often easily persuaded to comply after many years of being told by government agencies and environmentalists that the cars they rely on are the cause of great harm.[6] Also affected are other enterprises that lose revenue when consumers must spend part of their disposable income for tests and repairs instead of buying their products. These are soft targets with neither the resources nor the expertise to determine whether or not I/M programs really deliver on the promise of cleaner air.

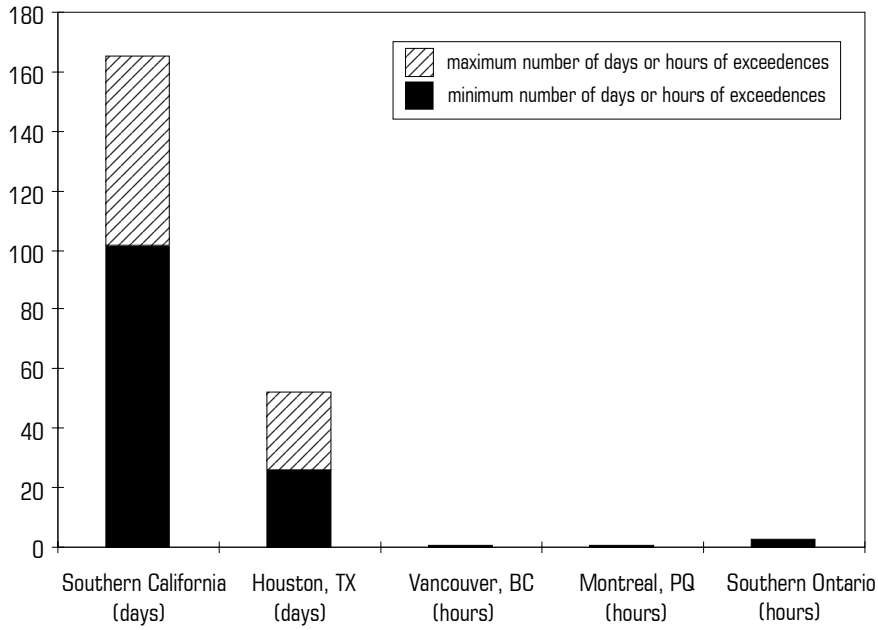
Stakeholders design, promote, operate, and evaluate I/M programs while participation by scientists and scientific research are conspicuously absent from the entire process. In general, the bigger and more expensive the program, the better it is for the stakeholders. The only constraint is how much cost and inconvenience can be imposed on motorists before they balk and make their displeasure known at the polls.[7] At meetings of stakeholders, the main design issue discussed is who should perform the tests and collect the fees, a central contractor or independent repair garages. Meanwhile, any real cost-benefit analysis and the program's real effect on the environment is ignored.

Which pollutants?

Inspection and maintenance (I/M) programs are often promoted in the media with visuals of cars, heavy trucks, and buses spewing thick, presumably foul-smelling, exhaust. This is misleading for three reasons: heavy trucks and buses are typically exempt from I/M programs; I/M programs do not test for soot or other particulate matter so that smoking vehicles may still pass inspection (AirCare 1996a); visibly smoking vehicles can be identified without inspection through normal police enforcement of nuisance laws.[8]

In fact, I/M programs identify at most only three of the many pollutants vehicles produce: carbon monoxide (CO), volatile organic compounds (VOCs),[9] and nitrogen oxides (NO_x). It is estimated that, in the Greater Vancouver Regional District (GVRD), cars and light trucks—the vehicles subject to I/M programs—emit 90 percent of CO, 43 percent of VOCs, and 35 percent of NO_x introduced into the atmosphere (GVRD 1994b: 11). None of these pollutants are visible and none represents any proven environmental or health threat at the ambient levels found in Canada. However, at the higher concentrations found in some areas of the United States, these pollutants may be causing real negative health effects. For example, ambient CO has previously reached high enough levels to be considered to be a potential health problem in Denver although it is not considered a problem in any region of Canada.[10] In fact, Canada has experienced a dramatic 70 percent reduction in the ambient level of CO between 1974 and 1992 even though the number of vehicles increased and no I/M program was in operation (Environment Canada 1997a). This reduction is primarily the result of older vehicles wearing out and being replaced by newer vehicles equipped with much better pollution control systems. The benefit of further reducing ambient CO in Canada by I/M or any other means is virtually zero.[11]

Figure 1: Average annual ozone exceedences greater than 120 ppb (US: 1984–1993; Canada: 1980–1993)



Note that this chart understates the real differences because the data for the United States is in "days," each of which may contain many 1-hour exceedences. Data from a Canadian study suggests that "1 day" is roughly equivalent to 5 hours (CCME 1997: 4).
Sources: CCME 1997; US EPA 1994a.

None of the three pollutants identified by I/M programs raises much official concern in Canada. The GVRD's Air Quality Management Plan (AQMP) assigns four levels of priority to emissions. Carbon monoxide (CO) and nitrogen oxides (NO_x) are considered Priority Three: "Issues that are intermittent and *do not pose a major threat to public health and the environment*" (emphasis added); volatile organic compounds (VOCs) are considered Priority Four: having "no significant impact on air quality at current levels" (GVRD 1994b: 15).

Ozone

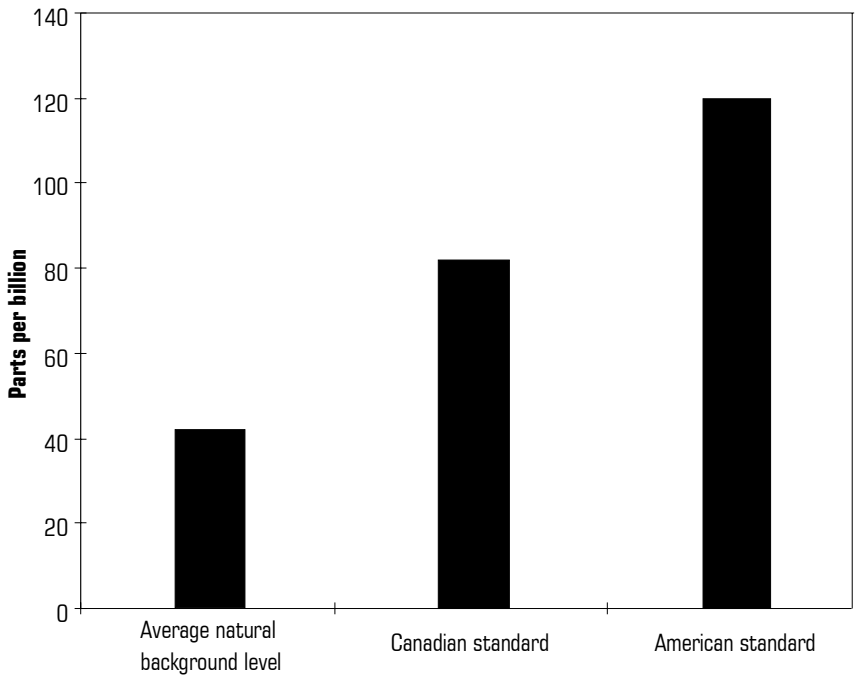
The justification for implementing I/M programs in Canada is an alleged need to reduce urban ground-level ozone,[12] which is a major component of photochemical smog. Ozone is produced when VOCs and NO_x react in the presence of sunlight. Ozone levels are strongly influenced by weather conditions. Motionless air over a city allows locally produced ozone precursors, VOCs and NO_x, to build up over a period of days. Moving air masses can transport ozone or its precursors from one region to another. In southern Ontario, for example, over one-half of the ozone or ozone precursors originate in the United States (CCME 1997: 258).

High ambient ozone levels are still a serious problem in many regions of the United States, but how serious is the environmental or health threat of ozone in Canada? Exposure to ambient ozone is conventionally expressed as the number of times a region's ozone level exceeds certain concentrations for a given period of time. In the United States, the previous National Ambient Air Quality Standard (NAAQS) is an average of 120 parts per billion (ppb) for one hour.[13] As figure 1 indicates, ozone levels in Canada are minuscule compared to those in the United States.

The American standard for ozone was established at 120 ppb to protect the public health and allow "an adequate margin of safety." Those to be protected include "particularly sensitive citizens such as bronchial asthmatics and emphysematics who in the normal course of daily activity are exposed to the ambient environment."[14] Canada's "acceptable" ozone standard of 82 ppb over one hour is much stricter than the 120 ppb standard of the United States and is only twice the average daily maximal background level of natural ozone production (35–48 ppb) (CCME 1997: 1–2). Under favorable meteorological conditions, there are enough natural VOCs from trees and other vegetation to combine with NO_x emissions to create ozone levels well above the Canadian standard (see figure 2).[15]

Even using the Canadian standard, the number of ozone exceedences are extremely small. Between 1986 to 1993, Vancouver had an annual average of only 5 hours (0.06 percent) when ozone levels were over the "acceptable" 82 ppb standard. Montreal had an annual average of 16 hours (0.2 percent) and Toronto an annual average of 69 hours (0.9 percent) (CCME 1997: 99). That would be only 0.006 percent, 0.01 percent and 0.03 percent of the total annual exceedences, respectively, if the American standard were used. Further, exceedences in Toronto and southern Ontario are largely due to polluted air blown across the border from the United States.

Figure 2: Ozone: average natural maximum daily background level compared with Canadian and American 1-hour "acceptable" standards



Sources: CCME 1997.

Health Effects

According to the Canadian Lung Association:

- between 1989 and 1992, asthma, allergies and other chronic breathing problems increased by as much as 60 percent
- one Canadian in five now has some form of respiratory problem
- lung disease is now the third leading cause of death in Canada and is on the rise
- between 5 percent and 10 percent of Canadian children have childhood asthma (Lung Association 1997).

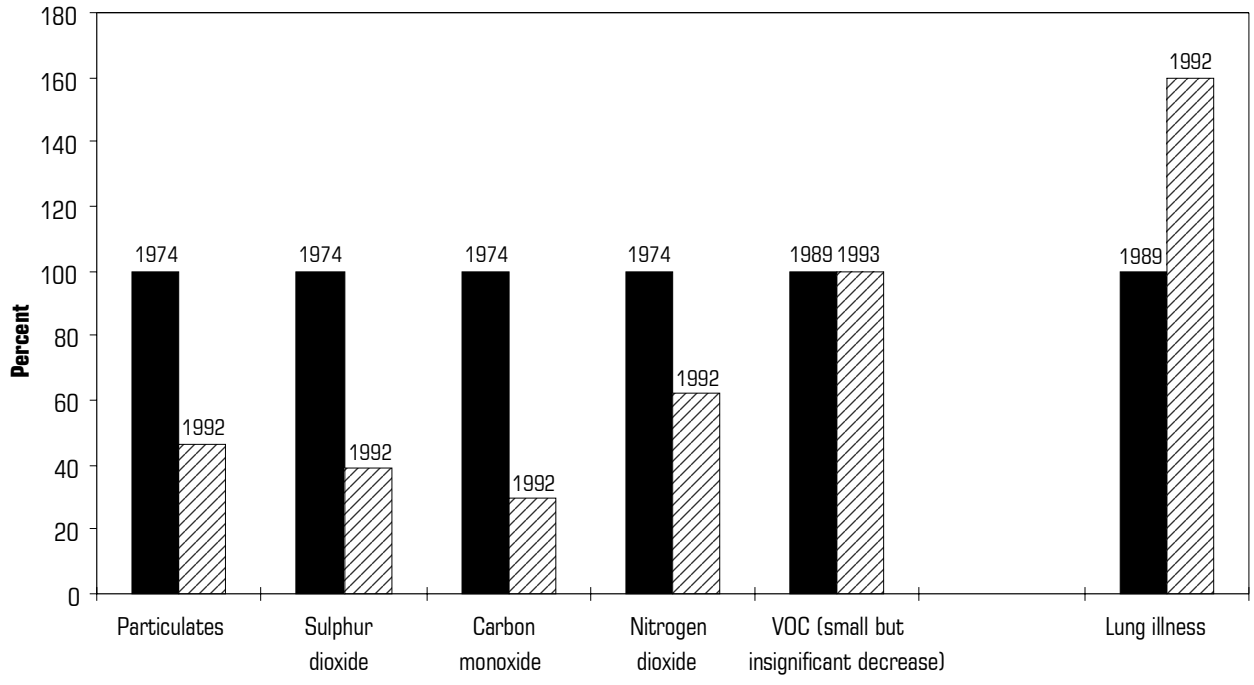
However, as figure 3 illustrates, average pollution levels have been declining for many years, with the exception of levels of VOCs, which have remained stable. Why are we getting sicker if those pollutants are decreasing? This evidence clearly suggests that the real cause of the apparent increase in respiratory health problems lies elsewhere.

There is no doubt that exposure to very high levels of ozone for extended periods has a negative effect upon human health. And, there is no doubt that ozone is still a serious problem in some regions of the United States and that motor vehicles are major contributors. However, are the ozone levels found in Canada causing health problems?

Answering this question is not easy because there are so many confounding factors involved in measuring the effects of small changes in ozone levels upon human health. Weather conditions, such as inversions, that raise ozone levels may also raise the levels of other pollutants as well. Heat and humidity can, by themselves, aggravate the respiratory condition of sensitive individuals. As well, ambient air measurements do not accurately reflect individual exposure (Brauer and Brook 1997). It is not surprising, therefore, that scientific studies have produced mixed results, some finding no significant relationship between real-life levels of ozone and respiratory illness and others—not the most compelling—finding some relationship. Some studies examined the effects of ozone levels many times higher than those found in Canada or exposure at Canada's maximum level for many hours while exercising. Others found weak statistical links or very minor physiological effects (with 0, 1, 2, and 3-day time lags), or contained results that could lead to conflicting conclusions.

For example, a review of the literature (Bates 1995a) mentions one study that exposed primates to 250 ppb (over three times the Canadian hourly standard) for 8

Figure 3: Change in average pollution levels and lung illness in Canada



Sources: Environment Canada 1997a; CCME 1997; Lung Association 1997: 3.

hours a day, 7 days a week, over 18 months. Another exposed rats to 950 ppb (nearly 12 times the Canadian standard) for 8 hours a day over 90 days. Other studies exposed healthy human subjects to 400 ppb for 2 hours with exercise or 120 ppb for 6.6 hours each of 5 consecutive days while exercising. Asthmatics were exposed to 400 ppb while exercising on a bicycle ergometer and allergic subjects were exposed to 500 ppb and then exposed to ragweed or grass antigen. Such methods are somewhat like administering massive doses of aspirin to determine if low doses are dangerous. After reviewing dozens of recent studies (122 citations) including those mentioned above, the author concludes:

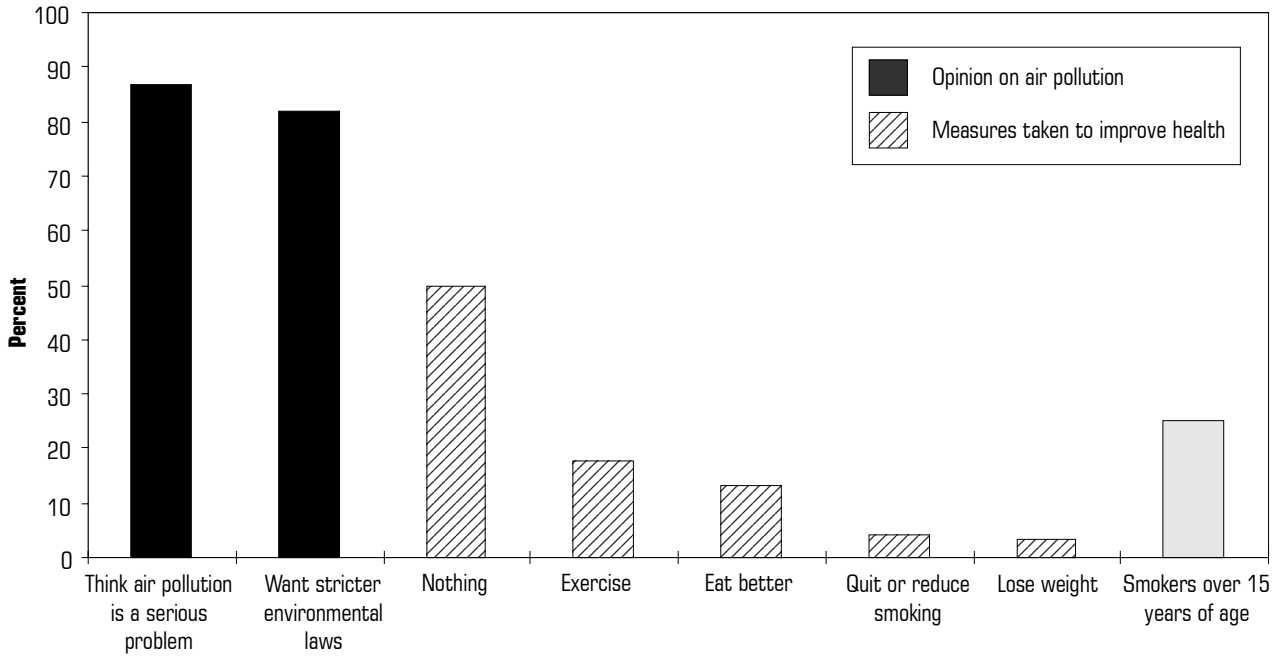
> It is therefore frustrating that precise answers still cannot be given to many important questions. Does ozone increase the prevalence of asthma, aggravate it, or both? Does ozone affect the general population level of airway responsiveness and, if so, what are the implications of this? Do oxidant atmospheres affect the normal development of the lung? Is any penalty paid for repetitive oxidant exposures? In spite of the extensive database, there is clearly a need for continuing investigation. (Bates 1995b: 169)

There seems to be little evidence to link levels of ambient ozone in Canada[16] and the health of even the most susceptible humans. One conclusion that can be drawn from the research is that there are much more productive uses for societal resources than imposing on Canadians costly programs to reduce ozone caused by automobile emissions—especially when these programs do not work.

Public opinion and public policy

Everybody would probably agree, nevertheless, that clean air is a good thing and many worry that air pollution is a threat to health. For example, opinion polls show that 87 percent of those living in Toronto believe that air pollution is a serious problem and 82 percent of Canadians would like to see stricter environmental laws (Canadian Environmental Law Association 1997). However, for a number of reasons these polls are poor indicators of what government policy should be. "Air pollution" can refer to any number of different pollutants, including hydrogen sulfide, acrid wood smoke, the smell of pig farms and, to some people, frying hamburgers. More importantly, any call for stricter laws contains the tacit assumption that they will work; that is, it assumes that the law will be effective and will not consume an undue amount of societal resources.

Figure 4a: Survey results of opinion on air pollution; measures taken by individuals to improve their health; percentage of smokers

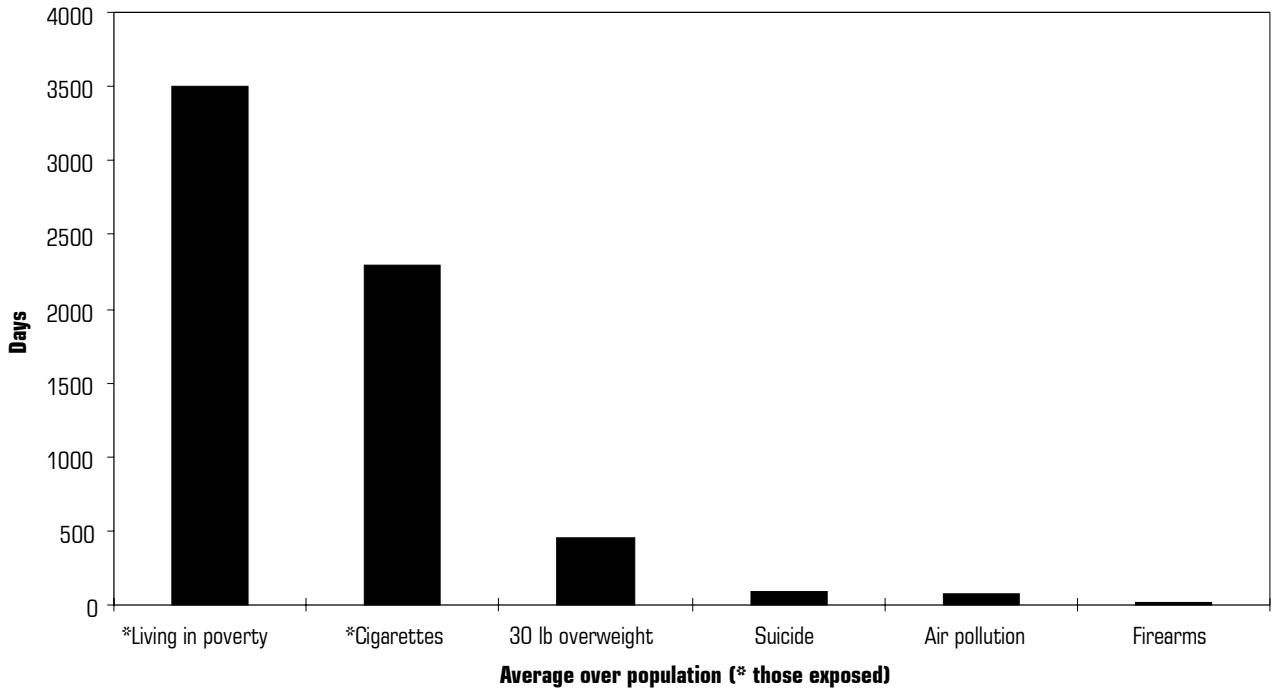


Sources: Canadian Environmental Law Association 1997.

While Canadians claim to be concerned about the effects of air pollution upon their health, they do not appear to be greatly concerned about their health in general. According to Statistics Canada (www.statcan.ca/english/Pgdb/People/Health/health33a.htm), in 1990 (the last year available) only 4 percent of Canadians had quit smoking or reduced the number of cigarettes they smoked, less than 4 percent had lost weight, and 50 percent took no measures at all to improve their own health. In 1995 (www.statcan.ca/english/Pgdb/People/Health/smokg.htm), 25 percent of Canadians continued to smoke daily (see figure 4a, p. 9).

The actual risk that we face from all air pollution (let alone from ozone by itself) is dwarfed by the effect of the unhealthy habits in which we choose to engage. The economic condition in which we live also has a great effect upon our health. Poverty has such a strong association with premature death that any ineffective program that costs a regional economy hundreds of millions of dollars will, by reducing the productivity of the region, tend to have an adverse impact on public health (see figure 4b).

Figure 4b: Loss of life expectancy



Sources: Sutherland 1997: table 3, citing B. L. Cohen, *The Nuclear Energy Option*.

AirCare: British Columbia's I/M fiasco

Levels of the three primary pollutants (CO, VOCs, and NO_x) that I/M programs are supposed to reduce as well as the secondary pollutant, ozone, are much lower in Canada than in the United States. No region in Canada, with the possible exception of southern Ontario (where one-half of the ozone or its precursors originate in the United States) would be required by the criteria of the United States Environmental Protection Agency (US EPA) to establish an I/M program. Yet, for years the British Columbian, Ontario, and Canadian ministries for the environment have been vigorously campaigning for I/M programs, even though there is no scientific research that supports the need for any I/M program and recent research has shown that I/M programs have not provided the predicted benefits (Pierson 1996: i-iii).

In 1992, the government of British Columbia started the AirCare program, the first I/M program in Canada, ostensibly to reduce air pollution in Vancouver and the lower Fraser Valley, which is bordered by mountains that contain the air and hinder the rapid dispersion of pollutants (ARA Consulting Group and Bovar-Concord 1994). Sierra Research, a California consulting firm, were hired to help design what was promoted in AirCare's pamphlet, *A Breath of Fresh Air*, as "the most sophisticated program ever implemented" in North America. Each of the million vehicles in the Greater Vancouver Regional District (GVRD) was to undergo two loaded-mode tests, two idle tests and a visual inspection every year (see Appendix 1). AirCare was to be "self-financing", that is, paid for entirely through the test fees charged to motorists. As a result of problems that became apparent at start-up, newer vehicles were temporarily excused from testing and the inspection procedure was drastically and permanently reduced although the test fee remained the same.

Early in the AirCare program, it was felt that the public should be kept informed, but not too informed. Ellen Baar, a Social Sciences professor at York University, pointed out at the 1993 Annual Meeting of the Canadian Political Science Association in Ottawa that "[p]roposed reporting would focus on the program's successes rather than its failures; on its outputs rather than the success of the program in reducing emissions. Negative feedback to Treasury Board and program implementers would not be made public" (Baar 1993: 15).

The Radian report

Radian, an American consulting firm specializing in I/M programs was hired to "audit" the AirCare program after two years of operation and brought out a glowing report, which was released to the public in April 1995 (Weyn and Klausmeier 1994). Even though AirCare had shortened the test procedure and identified less than one-half the expected number of vehicles having excess emissions,[17] and though 18 percent of the identified vehicles could not be sufficiently repaired to pass another test and had to be issued waivers,[18] the "audit" still claimed that AirCare was close to achieving the targets that it had been designed to achieve; the NO_x reduction target had been conveniently reduced from its original 20 percent to 3 percent for the audit.[19]

The conclusions in the Radian audit are based on test scores of only 79 vehicles. No confidence intervals or other indications of statistical significance were given for any of the results. Emission reductions were calculated using US EPA's unproved and controversial MOBILE 5A computer model. This model so greatly overestimated the poor condition of vehicles in British Columbia that the vehicle emissions predicted by the model after the I/M testing and repairs had been performed were *greater* than the actual emissions from vehicles before they took part in the program (Weyn and Klausmeier 1994: 2–10). Even AirCare's Manager of Emissions Testing and Standards admits that the audit was not "purely scientific" and contained "leaps of faith."[20]

The Radian analysis also contained a number of unsupported assumptions and other methodological flaws:

(1) the assumption that hundreds of tonnes of evaporative emissions were reduced although no evaporative tests were being performed by AirCare;

(2) the assumption that "super-emitters" (that produce 20 times the certification level of CO and VOCs) were identified and repaired, even though there was no evidence of their existence,[21] let alone their repair;

(3) the failure to consider the annual distance traveled by vehicles, especially vehicles of different model years;

(4) the artificial segregation of test scores according to type of failure, which concealed increases in emissions caused by AirCare repairs;[22]

(5) the assumption that there is no cheating on the part of motorists and mechanics and that there will be no deterioration of the vehicle until the next test (the "Clean for a Day" phenomenon);[23]

(6) the exploitation of a statistical quirk that produces apparent benefits from the random variability of the vehicle and the test.

Combined, all of these analytical defects tend to overstate the emission reduction benefits from AirCare. For example, the assumption that evaporative emissions were reduced creates a fictitious reduction of 840 tonnes of VOCs (Weyn and Klausmeier 1994: 2–12) and the assumption that "super-emitters" were identified and repaired supplied another fictitious reduction of 660 tonnes (Coninx1996b: 18–26). Therefore, 1500 tonnes of the reduction in VOCs—over 30 percent of the total claimed reduction of 4,740 tonnes—was based solely on two "assumptions" with no evidence to support them.

Distance travelled by vehicles

The failure to consider the annual distance vehicles travel (methodological flaw number 3), is omitting a factor so basic as to make any conclusion of the audit entirely unsound. Vehicles create exhaust pollution *only* when they are used, yet Radian apparently did not indicate the amount the 79 vehicles in the sample were used and did not consider the usage patterns of vehicles of different ages in calculating AirCare program benefits.[24] Unlike the US EPA, which assumes that vehicle usage declines with increasing vehicle age (for example, the average 20-year old vehicle is considered to be driven only one-third as far each year as the average new vehicle; see US EPA 1994b, default mileages), Radian appears to have calculated on the basis that all vehicles, old and new, were driven the same amount (AirCare 1996b: 4-3).[25] The claims of reductions in emissions as a result of the AirCare program rest largely on repairs to older vehicles. Overstating the distances older vehicles are driven in the region could proportionately overstate the benefits of the program by many times. Because there is a lack of data, it is impossible to quantify to what extent failing to consider vehicle usage and the other flaws mentioned overstate the emissions reduction from AirCare.

Regression toward the mean

Reductions in emissions claimed for I/M programs such as AirCare are typically calculated by comparing each failing vehicle's initial test result with the result of its second test, presumably following repair. This procedure may appear to be straightforward but it introduces a subtle but very powerful statistical bias called regression toward the mean (methodological flaw number 6). Regression toward the mean influences sequential test results if two conditions are met: (1) the subjects under study are selected on the basis of an initial test score—AirCare evaluates its program by retesting only vehicles that record a high level of emissions at the initial test and (2) some degree of variability exists on the part of the test or the subject being tested. According to Huel Scherrer, a researcher at the University of Minnesota,

> [t]he problem [of regression toward the mean] arises from selecting only a small portion of vehicles for analysis (those failing an I/M test) without considering the irreproducibility of the measurement used to identify this small portion of the vehicle population . . . (V)ehicle emission test scores are highly random [and therefore irreproducible] . . . EPA's own data shows this as do the first-hand experiences of many motorists who have taken, and then retaken, emission tests with no repairs or adjustments performed. (Scherrer undated)

Variability in the emissions from individual vehicles has been clearly acknowledged to exist by the I/M industry, including AirCare:

> When one considers the variables involved in an automobile engine and drive train and the complexity of modern emission-control hardware, it is almost surprising that a vehicle could ever produce the same test results twice in a row . . . a discussion of the mechanisms by which a vehicle can exhibit different emission results from one test to another could easily fill a book. (AirCare [undated]: 8-2, 8-13)

Further, the United States General Accounting Office (GAO) reports that, when 64 vehicles that had been tested and failed at one location by the US EPA's "high-tech" IM240—which is more expensive and more accurate than the tests used by AirCare— were tested again using IM240 at another location, 18 (28 percent) passed the second test without any repairs having been performed (US GAO1992). The scores often differed greatly: in two cases the emission levels measured at the first test were over 8 times higher than those measured at the second test.

Emissions levels from a vehicle with an emission control system (ECS) in good order should never vary enough to fail the properly administered initial I/M test. However, the emission levels of a vehicle with a faulty ECS is likely to vary widely. These vehicles are sometimes called "flippers" because they can "flip" between low (passing) and high (failing) levels of emissions. If a "flipper" is having a "good day" (or, more precisely, a "good ten minutes"), it may pass the initial I/M test and be driven for the next year or two without being identified and repaired, even though there is really something wrong with its ECS. In this case, the I/M program not only fails to identify a vehicle producing excess emissions but also incorrectly assures the owner that the car is clean. If a "flipper" is having a "bad day" and fails the initial test, it is correctly identified as a vehicle producing excessive emissions. When, however, such vehicles are tested again, a considerable proportion (28 percent in the GAO report) pass the retest, although no repairs have been made. Counting such spontaneous disappearances of excessive emissions as benefits due to I/M is manifestly incorrect. Yet this is done, and the statistical effect of regression toward the mean inflates by a substantial amount the emission reductions claimed for I/M programs. When evaluating the AirCare program, both Radian and AirCare failed to control for this effect.

Regression toward the mean arises as the result of faulty data handling techniques, specifically, the failure to include control groups. Lack of proper experimental controls is a tradition in I/M evaluation and its effect extends well beyond regression toward the mean.

> Thus, I/M self-evaluation studies ignore the important question of whether dependency on an I/M test as a basis for maintenance actually decreases vehicle emission levels overall. In other words, are the emission levels of the non-failing population increased due to deferral of scheduled maintenance? And, what portion of the results being claimed as I/M program benefits is actually including maintenance which would have been performed anyway? . . . [T]wo fundamental points are evident. First, peer-reviewed studies recognize the need for control groups to avoid the pitfall of spurious results due to irreproducible measurements. Second, validated studies recognize the need to measure net results for the entire population impacted by the variable under study. (Scherrer n.d.)

Pseudoscientific evaluations are one of the most powerful tools used to sell I/M programs to the general public. It is unlikely that the I/M industry or its non-profit and government supporters will demand any controlled scientific studies to prove the effectiveness of I/M programs.

AirCare's Technical Review

In March 1996, AirCare produced a draft in-house Technical Review of Program Year Three "utilizing Radian's methodology as much as possible."[26] The Technical Review analyzed emission results of 248 failed vehicles before and after repairs were performed. Even using Radian's methodology—including the "leaps of faith"—AirCare could claim barely half its design target. It is interesting that AirCare also noted that Radian had applied the wrong failure rate to the program in its second year, an error that resulted in overstated benefits.[27]

In November 1996, the Automobile Protection Association (APA) released its report using AirCare test data from 268 vehicles[28] and information from the AirCare Technical Review. While the APA was able to calculate emission reductions without segregating test scores and without assuming benefits from fictitious super emitters and evaporative reductions, it could not eliminate other flaws with the available data. Nevertheless, the APA found that AirCare was reducing smog-producing emissions (NO_x and VOCs) by, *at best*, one-quarter of its targeted rate and probably much less. Quite possibly, there had been no significant benefit at all (see tables 1a and 1b and figure 5).

The disappointing figures for reduction of emissions reflect the complexity of vehicle emission repairs. The APA analysis of AirCare showed that repair was problematic: almost one-third of the repairs certified by AirCare were unable to reduce vehicle emissions enough to pass the AirCare retest and the vehicles had to be issued waivers. In some cases, repairs made vehicle emissions worse. APA's analysis of AirCare's own test data of 268 vehicles revealed that, after repairs were performed:

Table 1a: AirCare reductions of smog-related emissions from light-duty vehicles

	Annual Target*		Radian (year 2)		AirCare (year 3)		APA (year 3)	
	tonnes	percent	tonnes claimed	percent claimed	tonnes claimed	percent claimed	tonnes (maximum)	percent (maximum)
VOCs	6,865	25%	4,740	17.3%	3,523	12.8%	1,854	6.75%
NO_x	1,667	10%	460	2.8%	231	1.4%	134	0.81%

* GVRD, Let's Clear the Air, www.gvrd.bc.ca./air/bro/aqsmog/html, September 9, 1997: 3.

Table 1b: AirCare's effect on total GVRD VOCs and NO_x Emissions Inventory

	Light-duty vehicle share**	Target reduction	Radian (year 2) claimed	AirCare (year 3) claimed	APA (year 3) maximum
VOCs	0.434	10.85%	7.49%	5.53%	2.93%
NO_x	0.347	4.34%	1.20%	0.60%	0.35%

** GVRD, Air Quality Management Plan, December 1994: 4-2 (inventory estimates for 1990).

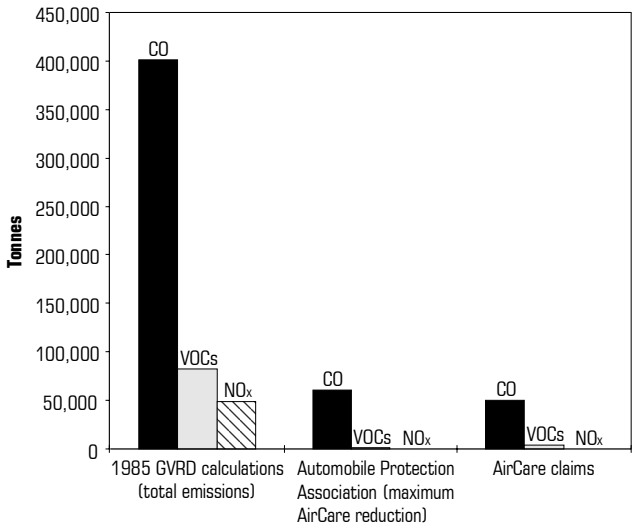
- 69 percent of the vehicles showed an increase in at least one pollutant
- 23 percent of the vehicles showed an increase in at least two pollutants
- 7 percent of the vehicles showed an increase in all three pollutants.

The significance of the failed repairs is illustrated in figure 6. Average pollution levels of vehicles that were repaired under AirCare were *higher* than those of vehicles that passed the initial AirCare inspection in all categories except one, emission of VOCs by vehicles manufactured from 1981 to 1987. This indicates that many, and perhaps the majority, of the vehicles that failed AirCare's test were not fully repaired under AirCare. Yet the AirCare Technical Review proudly claims that "the program continues to be very effective in terms of repairs" (AirCare 1996b: i).

AirCare and its supporters like Moe Sihota, British Columbia's Environment Minister during 1996 (*Vancouver Sun*, June 7,1996), also claim that, over the first three years, the program has reduced emissions by 165,000 tonnes. This is very misleading because 93 percent are reductions in CO, which, according to the British Columbia government's own consultant (ARA Consortium Sholtz & Associates 1995), represents no significant threat to either public health or the environment (see figure 7).

From a broader perspective, the fact that AirCare requires owners of older vehicles to pay for inspections and repairs is more likely than not to work against improving air quality. The more logical strategy for ensuring clean air would be to allow these owners to save up their money so they can buy later-model vehicles with more advanced emission-control technology. Figure 8 shows that, on average, vehicles manufactured in 1988 or later, even when they have failed AirCare's test, still pollute considerably less than pre-1988 vehicles after repairs.

Figure 5: Annual benefits of AirCare compared to total emissions caused by human activity



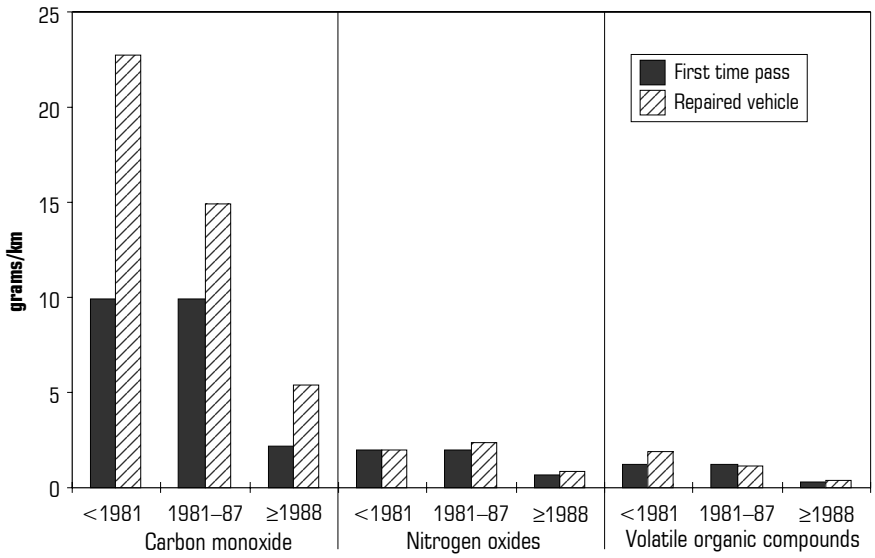
Sources: GVRD 1994; Coninx 1996b.
Note: The reductions in nitrogen oxides found by the APA and AirCare were so small that they cannot be seen on this graph.

The costs of AirCare

Administrative and operational costs

Neither Radian nor AirCare addressed the issues of cost or the cost-effectiveness of the AirCare I/M program. During the first five years of AirCare, the average annual cost of the program, including test fees, repairs, expenses, and lost time is conservatively estimated to have been nearly $63 million, or $1 million every 6 days (see table 2). This amount does not include the environmental damage resulting from two million extra vehicle trips per year to and from testing and repair facilities.

Figure 6: Average emission rates after AirCare repairs for automobiles classified by model year



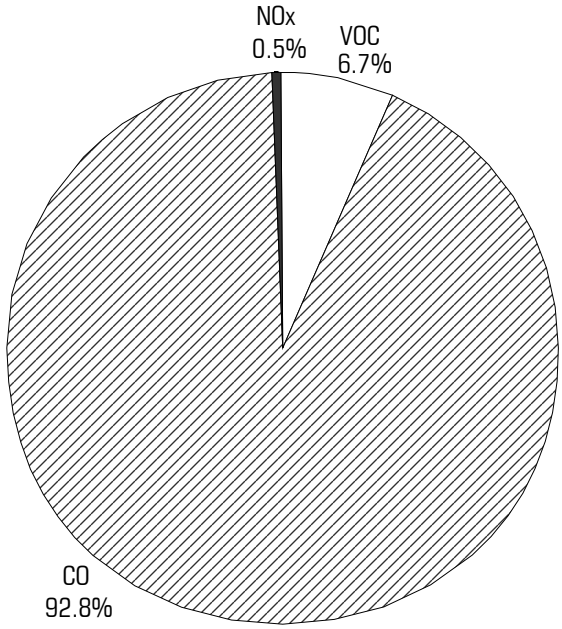
Sources: AirCare 1996b.

What kind of value does AirCare give residents for their $63 million? The value of any reduction in emissions depends upon the adverse effect that the pollutant has on human health and the environment. For example, according to a draft study done by ARA Consortium Sholtz & Associates (1995) for the GVRD, the British Columbia Ministry of Environment, Lands, and Parks, and Environment Canada:

> the benefits per tonne of emissions reduced (calculated ... in terms of averted damage to human health, materials, crops, etc. per tonne) vary as follows:
>
> - CO: <$1/tonne[A]
> - VOC: $84/tonne[B]
> - NO_x: $120/tonne[C]
> - SO_x: $320/tonne [sulphur oxides; not reduced by AirCare]
> - PM_{10}: $75,150/tonne [particulate matter 10 microns or less in size; not reduced by AirCare]
>
> [A] No discernible damage to human health or the environment was identified for CO.
>
> [B] The damage averted per tonne of VOCs reduced includes ozone-related damage. [In the presence of sunlight, VOCs and NO_x combine to create ozone. See Appendix 4 for details.]
>
> [C] The damage averted per tonne of NO_x reduced includes ozone-related damage.
>
> (ARA Consortium Sholtz & Associates 1995: 2–16)

AirCare has virtually no effect on either SO_x or PM_{10}, the pollutants considered the most harmful. Table 3 gives the value of the emission reductions as claimed by AirCare and calculated by APA. According to the estimates in the list above, the AirCare program, which costs residents of British Columbia $63 million annually, provides them with, at most, $521 thousand worth of air reduction benefits, or a value of less than one cent on the dollar.

Figure 7: Proportion of emission types claimed to be reduced by AirCare



Sources: AirCare 1996b.

Table 2: Cost of AirCare to consumers in the Vancouver area

Year	Number of vehicles tested	Fee for testing	Number of vehicles failing test	Average cost for repair	Annual costs: Tests	Repairs	Inconvenience and expense*	Total per year
1993	743,506	$16.05	126,894	$208	$11,933,271	$26,393,952	$17,408,000	**$55,735,223**
1994	1,182,294	$16.05	132,113	$177	$18,975,819	$23,384,001	$26,288,140	**$68,647,960**
1995	1,125,309	$16.05	104,373	$188	$18,061,209	$19,622,124	$24,593,640	**$62,276,973**
1996	631,504	$18.00	79,841	$216	$11,367,072	$17,245,656	$14,226,900	**$42,839,628**
1997	1,235,551	$18.00	143,499	$243	$22,239,918	$34,870,257	$27,581,000	**$84,691,175**
Total of annual costs over the 5 years from 1993 to 1997 =					$82,577,289	$121,515,990	$110,097,680	$314,190,959
Annual average: $62.8 million **Daily average:** $62.8 million / 365 days = $172,000 per day or $1 million every 6 days								

* Using standard EPA estimate of the value of 45 minutes (including the drive to and from an inspection station, the waiting and testing time) x US$20/hour = US$15 = CDN$20: see USEPA 1991a: 13. The same estimate is applied to trips to a repair garage.
Source: AirCare 1998, US EPA 1991.

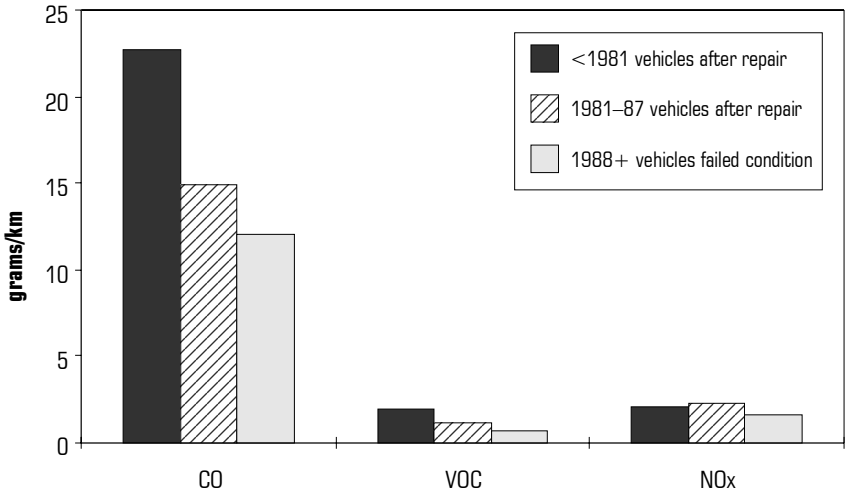
Identification costs

One of the weakest aspects of I/M is the extraordinarily high cost of identifying vehicles that produce excessive emissions. These costs vary according to the vehicles' model year. Using data from program year 3, the APA calculates that it takes an average of only 3.6 tests, costing $58 in test fees ($131 when time and expenses are included) to identify each 1969 vehicle producing excessive emissions. However, an average of 27 tests is needed, at a cost to consumers of $968 for fees, expenses, and lost time, to identify *each* 1988 and newer vehicle producing excessive emissions (1988 and newer vehicles made up over half of those being tested by AirCare at the time; see table 4). It required 217 tests and costs consumers $7,800 to identify *each* 1994 vehicle producing excessive emissions. A total of 57,255 tests of 1994 vehicles, which cost consumers over $2,000,000 in fees, expenses, and lost time, were performed for virtually zero emission reductions.

The environmental cost of AirCare

AirCare claims to save Vancouver-area motorists 12 million litres of fuel every year as a result of the repairs made to reduce emissions (Weyn and Klausmeier 1994: 2-13; AirCare 1996b: 4-4). Clearly the 85 to 90 percent of vehicles that pass the initial inspection do not become more fuel efficient as a result of AirCare, nor do the vehicles that are made worse as a result of AirCare repairs. Exactly how the fuel savings are calculated is not stated, although Radian does explicitly assume that even the most run-down and decrepit vehicles are driven a extraordinary average of 20,000 kilometres each year. This is very unlikely. The firmness of the numbers used by I/M supporters to bolster their cause is also indicated by the fact that the 12-million-litre savings is again claimed for Year 3, even though the claimed effectiveness of the program was substantially lower (see table 3).

Figure 8: Comparison of emissions from pre-1988 vehicles repaired under



Sources: AirCare 1996b.

Table 3: Emission reductions and their value as claimed by AirCare and as calculated by the Automobile Protection Association

	AirCare claims						APA calculations	
	Year 1 (1992/1993)		Year 2 (1993/1994)		Year 3 (1994/1995)*		Year 3	
	tonnes	value	tonnes	value	tonnes	value	tonnes	value
VOCs	2,900	$243,600	4,740	$398,160	3,523	$295,932	1,854	$155,736
NO_x	95	$11,400	460	$55,200	231	$27,720	134	$16,080
CO	36,000	$36,000	68,000	$68,000	49,960	$49,960	59,952	$59,952
Total value		$291,000		$521,360		$373,612		$231,768

Sources: AirCare claims, years 1 and 3: AirCare 1996b; year 2: Weyn and Klausmeier 1994. APA calculations: Coninx 1996b; values calculated as per ARA Consortium Scholtz 1995.
* Latest available data.

Much more robust assumptions based on AirCare's own figures (from AirCare 1996b) can be used to estimate the burden—in addition to the $63 million—that AirCare places on the environment it professes to protect. Over the full 7 years of the contract, just to identify vehicles producing excessive emissions requires

- 70,000,000 extra kilometres driven in the Vancouver area (1 million inspections × an average of 10 km round trip or diversion to have the test performed × 7 years)
- 7,000,000 additional litres of gasoline burned (the oil industry supports I/M programs)

and releases

- 60 additional tonnes of VOCs
- 90 additional tonnes of NO_x
- 535 additional tonnes of CO
- 18,000 additional tonnes of CO_2.

These costs could be avoided. If remote-sensing technology (see page 28) were used to identify vehicles producing excessive emissions instead of scheduled I/M testing, this environmental burden would disappear. However, test fees paid to AirCare—worth between $11 million and $22 million each year—would also disappear, so it is not surprising that I/M stakeholders reject remote sensing.

Cleaner air, whatever the cost?

Any program that reduces air pollution, even by a small amount, has a real value, but only if that value is not off-set by even larger incidental costs. The economic question is whether the $1 million in societal resources spent every 6 days on AirCare could not be used more productively

Table 4: Costs to identify and "repair" each vehicle producing excessive emissions in year 3 of AirCare

Vehicle Group	1988+	1981–1987	pre-1981
Number of inspections	533,538	338,992	130,036
Number of failures	19,854	51,532	32,987
Failure rate (percent)	3.7%	15.2%	25.3%
Inspection fees (total: passed and failed vehicles)	431	106	63
Consumer expenses (total: passed and failed vehicles)	537	132	79
Total inspection costs only	968	238	142
Repair costs[A]	204	204	204
Total average cost	1,173	441	346

[A] AirCare 1996b: 2-2. This is the average certified repair cost claimed in the Review for vehicles for all model years. In fact, average repair costs may differ among vehicles from different model years. Therefore the real figures may vary somewhat from those given in this table.

somewhere else. What could that amount buy in better health care, education, environmental protection, public transport, food, or housing?

Those hardest hit by I/M programs are low-income workers, single parents, and pensioners. Such people often need a car for work, family responsibilities, and, with older people, to retain their independence. The cars these people drive are much more likely to fail an I/M test and require expensive repairs. A recent study found that full and proper emission repairs ranged from US$28 to US$2,811;[29] the average was US$632 (Lawson *et al.* 1996b: 25). And, even when repairs are successful, they often provide insignificant total reductions in emissions because many of the cars, even if they do have high emission rates, are not driven much.

Diverting the scarce resources of the poor, who would be better off if they could spend to improve their living conditions or buy a newer, more efficient car, into an inefficient and perhaps completely ineffective government program is not only unfair, it is also bad economics. The link between poverty and illness is much stronger than the link between ozone and illness. For example, a recent American study found that one-third of asthmatic children living in poor neighborhoods were allergic to cockroaches. When those children were exposed to cockroach allergen in their homes, they were hospitalized three times more often than other asthmatic children in the group (Rosenstreich *et al.* 1997).

It is not only the poor who are unfairly treated by I/M programs. Motorists with moderate or high incomes and who have recently purchased new vehicles, paying, according to the American Automobile Manufacturers Association, an extra $2,000 or more for the compulsory advanced emission-control equipment, are still obliged to incur the costs and inconvenience of undergoing a useless AirCare emissions test. For example, under AirCare hundreds of newer vehicles must be tested to find a single vehicle producing even marginally excessive emissions. There is no rational explanation for such waste except that the government of British Columbia does not want to admit that it was short-sighted when it signed a seven-year contract that guaranteed the testing company a certain number of vehicles a year.

Death and injury

Driving is not a risk-free activity, even when the destination is a testing station. Over its seven-year duration, the AirCare program will require that over 14 million extra vehicle trips or diversions are made just to get vehicles tested and this increases the likelihood of accident, injury, and even death.

AirCare II

Spokesmen for AirCare have contested neither the facts nor the methodology used in the report released in 1996 by the APA; rather they have chosen to ignore it. The 1996 APA report called for a "*thorough, unbiased, genuine* scientific evaluation" of AirCare program by independent scientists, not an in-house technical review or audit by hand-picked private consultants. That too has been ignored. Although the AirCare program will have cost residents of British Columbia over $450 million by the time that the contract expires in 1999, the government clearly does not want the program examined too closely. Instead, Sierra Research was again hired to "study the best possible options for dealing with mobile source emissions" for an AirCare II program to be introduced when the current AirCare mandate expires (see *AirCare Update*, October 1997).

The project management and coordination teams assembled to evaluate the proposals for AirCare II include representatives from Environment Canada, British Columbia's Ministry of the Environment, the GVRD, and, of course, AirCare. Apparently, they are not hampered by the fact that the Radian audit was a flawed analysis of a flawed program. The official Request For Proposals (RFP) for AirCare II not only refers to Radian's findings but exaggerates the program's claimed benefits even more:

> The AirCare program is considered to be the single most effective initiative of the 54 measures recommended in the [Air Quality Management Program] for reducing air pollutants in the Lower Fraser Valley. Audit reports on the performance of the AirCare program indicate that VOCs and CO emissions are being reduced by 20 percent annually, while NO_x emissions are being reduced by about 3 percent.[30]

AirCare admitted privately that there was really only one audit performed, that written by Radian in 1994 (Weyn and Klausmeier 1994); the plural "reports" includes the Technical Review written by AirCare's own staff in 1996. However, even though the Technical Review is a more recent report, contains more data, and uses the same methodology (including the same "leaps of faith"), it reported benefits that were 36 percent to 55 percent lower than those found by Radian. Its findings were not cited.

In addition, not even Radian claimed that AirCare reduced air pollutants in the lower Fraser Valley by 20 percent (VOCs), 20 percent (CO), and 3 percent (NO_x) percent; it

claimed only that emissions from the light-duty vehicles in the region were reduced by those amounts. When these reductions are applied to the total regional inventory of emissions in the lower Fraser Valley, VOCs were reduced by only 7.5 percent and NO_x by 1.2 percent.[31] AirCare's own Technical Review of Year 3 (AirCare 1996b) claims a reduction in VOCs of only 5.5 percent and in NO_x of 0.6 percent. The APA found reductions in VOCs of 3.0 percent and in NO_x of 0.35 percent or less (Coninx 1996b).

Concern over the possible misrepresentation of AirCare benefits were answered by AirCare as follows:

> I fail to see the relevance of your concerns over the 20, 20, and 3 percent numbers included in the Background portion of the RFP. It is unlikely that any other proponent would attach the significance to those numbers that you have as they have no bearing on the task being described by the RFP. They simply provide a sense of the sort of benefits that have historically been considered attainable. What has been calculated in the past is not particularly critical to this new study as it proposes that the entire issue of the need for, and potential benefits of, an I/M program, be revisited.[32]

The "that was then, this is now" attitude is typical of I/M stakeholders whenever their claims of past success are challenged, even while they continue to make the claims. Radian's rosy conclusions also continue to be quoted by Environment Canada and Ontario's Ministry of Environment and Energy (MOEE).

Erratum

Page 20 of this publication states that a major report by Sierra Research had been highly criticized and rejected by the California Inspection and Maintenance (I/M) Review Committee for which it had been written. This is an error. In fact, the Sierra report had been fully and formally accepted by the I/M Review committee and submitted to the California state legislature (as reflected by the reference to it at the end of The Fraser Institute report). Sierra Research's report also had the support of the California Air Resources Board (ARB), the Bureau of Automotive Repair (BAR), and the majority of the air-pollution control districts. After the report was submitted, the scientific methodology and basic conclusions were approved by a three-person peer review committee (Walsh 1993). The Fraser Institute and the author of the report, Paul Coninx, regret any embarrassment or inconvenience that this error has caused Sierra Research. To our knowledge, Sierra Research has never had any of its reports rejected by its clients and has always provided its clients with results they find acceptable.

Promoting I/M and the lack of critical assessment

Although I/M programs fall under provincial jurisdiction, Environment Canada has been sponsoring "clinics" for testing vehicle emissions for 12 years and actively promoting I/M since at least 1989 (Environment Canada 1997b, 1989). In 1992, the Canadian Council of Ministers of the Environment (CCME) gave Environment Canada the mandate to coordinate the development of a national I/M Code of Practice.

It was clearly stated that, for the development of the Code of Practice, "the three major sources of information for I/M programs at this time [were] the AirCare program, EPA's Enhanced I/M program and California's Smog Check" (Ballantyne [undated]). There was apparently no concern that the objectivity of the process would be severely limited by relying upon three government agencies who were avid promoters of their own I/M programs. Nor was there any apparent concern that Sierra Research, the same consultant instrumental in designing AirCare, had a short time before produced a major report (1993) that had been highly criticized and rejected by the California I/M Review Committee (1993) for which it had been written (Klein and Saraceni 1994).

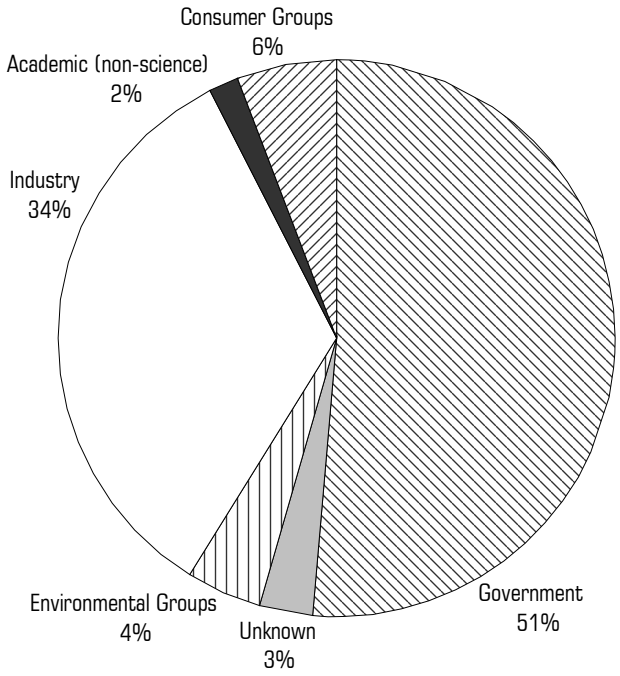
Before fully investigating to what extent excess vehicle emissions had a negative effect upon health or the environment in Canada or whether a I/M program would be an effective strategy for reducing emissions, Environment Canada formed the CCME I/M Working Group to develop the "best" or "most effective" I/M program. Most of the members of the Working Group had a clear vested interest in establishing I/M programs in Canada (see figure 9). Other members of the Working Group had no opportunity to acquire any independent knowledge of I/M programs and therefore had to rely almost entirely on CCME background material for answers to technical and scientific questions. Environment Canada apparently found no need for input from independent scientists who could read technical reports, understand the statistics, and help guide the others.

Formal meetings of the Working Group were held in 1994 to write the original Code of Practice and again in 1997 to make revisions. Environment Canada commissioned two background documents, one for the original Code and the second for the revised code. Both were written by the same consulting firm. Responding to an APA report claiming that the Environment Canada background document for the original code was biased and promoted I/M uncritically, Douglas Cope, the consultant, wrote: "Of course the draft Background Report, produced by D. Cope Enterprises, favored I/M, this was what my firm was contracted to do!"[33]

In his letter, Mr Cope wrote that Environment Canada and the CCME had decided in favour of I/M programs before the contract to develop the Code of Practice was let to his firm. The background report confirms that one purpose of developing a Code of Practice was clearly to promote I/M programs: "The existence of a CCME Code of Practice will also assist provincial agencies in convincing both management and politicians that I/M should be implemented" (CCME 1993: 2–8).

The manner in which the views and interests of both the non-governmental I/M lobby and various bureaucrats

Figure 9: CCME I/M Working Group



Sources: Coninx 1996a.

were promoted is indicated by table 5, which categorizes the list of references found in the Code, the revised Code, and the two background documents[34] that were made available to working group members by Environment Canada.

The US EPA, the CCME, AirCare, and ProtectAir, all recommended or were actively *promoting* expensive centralized, dynamometer I/M programs; Sierra Research was involved in the design of British Columbia's AirCare Program; suppliers and contractors have a clear (and perfectly legal and reasonable) interest in promoting any I/M program where they can sell their equipment and services. References to American states or other Canadian departments generally related to minor technical details or incidental background material. Almost none of this material has gone through the scientific validation process of peer review.

However, among the 9 "other" documents (which include a few newspaper clippings) there are two very interesting reports. The first is a report from the United States General Accounting Office (GAO) that describes a very serious problem:

> [T]here are drawbacks to the [EPA's recommended] IM240 test procedure for both the identification and repair of out-of-compliance vehicles that could hamper the test procedure's effectiveness. Our review of EPA data found that over 25 percent of the vehicles that EPA tested using the IM240 test procedure failed an initial emissions test but passed a second emissions test, even though no repairs were made to the vehicles. These results raise questions about whether the IM240 test procedure is reliable in identifying out-of-compliance vehicles and whether inaccurate identification of emission problems could result in unnecessary repairs. (US GAO 1992: 1–2)

This report should have set alarm bells ringing when it was cited in the first background report, not only because it questions the validity of scheduled testing but also because the first CCME Code of Practice strongly recommended using the IM240 test procedure. Instead, this GAO report was not quoted but merely described as having *"suggested there were repeatability problems"* which were possibly *"not the fault of IM240*;" there followed a couple of sentences of exonerating speculation (CCME 1993: 5–17).

The second "other" CCME reference is to a peer-reviewed article published in 1987 by the Society of Automotive Engineers (SAE). Harold Haskew, the principal author of this article, is a well-respected expert in vehicle emissions. The article was listed among the references to the first background report but it does not appear to be cited anywhere in the text. It states:

> Based on the in-use emission performance of today's [1987] closed loop systems and the cost of inspecting vehicles, it is difficult to support the need for an I/M program. If there are other justifications for an I/M program, a more meaningful approach would be to use a combination of a parameter [*i.e*., visual] inspection and the on-board diagnostic system. (Haskew *et al*. 1987)

If the interrogation of a modern vehicle's on-board diagnostic (OBD) system were made the primary feature of a modern emissions reduction program, it could cost less, be more convenient, and provide a better means of identifying

Table 5: List of references for CCME I/M codes of practice

	Background (Mar. 1993)	Code of Practice (Oct. 1994)	Background (Dec. 1996)	Code of Practice (draft, Dec. 1996)	Total
US EPA	23	2	6	2	33
CCME/Environment Canada	20	2	13	3	38
British Columbia/AirCare	15	1	5	2	23
Sierra Research	4				4
Ontario/ProtectAir	1		4	1	6
Industry (contractors, suppliers, etc.)	5		3		8
American states	11		5	1	17
Canadian government (Transport, EMR)	4		2		6
Other	5		4		9

vehicles with emissions problems than the dynamometer testing recommend by the CCME. However, this option was never seriously explored in the CCME material.

Environment Canada also overlooked a large number of scientific works that raise doubts about the effectiveness of its recommended I/M program and about I/M in general. For instance,

> We compare roadside survey results at I/M and non-I/M locations in California, and observe identical tampering and overall failure rates at the two types of locations. We also show that motorists are taking steps to "pass the test" and that the high-emitting vehicles' idle-emissions performance and tampering rates in the roadside surveys are unaffected by the Smog Check test . . . EPA's national tampering surveys also show little difference in tampering rates among areas with decentralized, centralized and no I/M programs in the United States. (Lawson *et al*. 1993: 1567)

Although the CCME strongly recommends the IM240 procedure, it does not accurately reflect reality:

> Ironically, the IM240 [recommended by the CCME] is derived from Federal Urban Dynamometer Driving Schedule (FTP), which both the EPA and CARB [California Air Resources Board] have stated does not represent real-world driving and emission patterns.
>
> . . . there is no solid scientific base to presume success of the enhanced I/M programs in reducing on-road emissions, the goal which they were originally supposed to meet. (Zhang et al. 1996: 1449)

Another study showed that Colorado's IM240 test produced a 12 percent average false high emitter identification rate (14 percent for 1991-1996 vehicles) and a 23 percent average false pass rate (Gallagher *et al.* 1997: 3–4).

I/M programs evaluated with the US EPA computer model often show impressive emission reductions, but when ambient air measurements are made, or other real-world means of measuring effectiveness such as remote sensing or roadside pull-overs are used, those reductions all but disappear, indicating a flawed computer model.

> Unfortunately, our investigation and synthesis leaves us with little confidence in the ability of existing regulatory agency methodologies (including computer based models, and supporting data and analyses) to realistically and reliably assess and forecast performance, compare alternatives and provide a rational guide to policy. (Aroesty 1994: ix)

Ambient air measurements show that Minnesota's centralized I/M program provides no significant reduction of the target pollutant (carbon monoxide) (Scherrer and Kittelson 1994).

Although roadside remote sensing (RRS) has been summarily dismissed in the CCME background document, it is a technology that can cut identification costs by over 90 percent and has many other advantages over conventional I/M techniques.

Use of roadside remote sensing resulted in very low cost identification of high emitting vehicles (HEV). The HEV identification costs for this study were about $100 per vehicle; they would have been as low a $9 per vehicle if had we been able to pull over every passing HEV for repairs [35] (Lawson *et al*. 1996b).

- On-road remote sensing of CO and HC (VOCs) emissions in California find that only a small percentage (10 to 20 percent) of gross polluters dominate CO and HC hot exhaust emissions.
- The remote sensor is a highly effective tool for identifying high emitting vehicles on the road, and in also effective at targeting tampered and defective vehicles.
- A significant finding is that high-emitting vehicles exhibit greater variability in their emissions than clean vehicles, regardless of the test method used. The vehicles most likely to exhibit variable emissions are late-model computer-controlled vehicles that are not deliberately tampered but have broken emission control components. (Stedman *et al*. 1994; 130,000 measurements)

Finally, it is clear that the CCME is recommending an antiquated technology:

> Improving the inspection part of I/M, including separating inspection from maintenance facilities, does not hold much promise for widespread effective repairs. Moreover, EPA's inspection programs, either existing or enhanced, will probably not be justified for modern vehicles, in competition with the new identification technologies. (Ross *et al*. 1995: 39)

Recent research continues to confirm the sorry record of I/M. A peer-reviewed study of the Colorado "high-tech" I/M program showed a CO reduction that was between 4 per-

cent (±2 percent) and 7 percent (±2 percent), much less than the 23 percent claimed by the program's administration; reductions in VOCs and NO_x were not detectable. The study also provides strong evidence of the "summer cottage effect" whereby motorists with vehicles emitting excessive emissions register them outside the I/M area to avoid the test, and suggests that the program might even be increasing NO_x emissions (Stedman *et al*. 1997, 1998).

I/M programs and the US EPA

Even in Canada, the US EPA's Office of Mobile Sources is the prime authority on I/M programs. Federal and provincial bureaucrats in Canada rely on the US EPA for I/M program design, computer models, and claims of effectiveness; they have also adopted the EPA's strategy of ignoring all the science that has shown I/M programs to have little or no impact on air quality.

Before the 1990s, there was very little information about I/M programs except for a number of technical reports—most were no more than drafts—issued by the US EPA that invariably concluded I/M programs to be effective. A review of nearly 30 of the US EPA's technical reports found that every one suffered from one, and often many, very serious flaws (Coninx 1996a):

- no independent peer (scientific) review
- no proper citations and references
- no attention to uncertainty and the degree of confidence that can be placed on results
- no controls
- no attention to clear statistical bias
- very small sample sizes
- questionable selection criteria or criteria not fully disclosed, which may lead to bias
- naive, self-serving, or incorrect assumptions and conclusions
- no attention to potential conflict of interest in evaluation or self-evaluation by contractors
- inappropriate rejection of results that do not support the concept of I/M programs
- incomplete and biased summaries and abstracts of the reports.

Virtually all the US EPA research on I/M programs found in the technical reviews is of such poor quality that it is unlikely that a reputable scientific journal would consider any of them for publication. It is difficult to imagine how any government official who has taken the trouble to read the technical reviews—rather than skimming over the abstracts—could be convinced of the value of I/M programs as an effective strategy for the reduction of emissions.

In the early 1990s, research on I/M programs from sources other than the US EPA began to be published. These articles showed that existing I/M programs provided little or no environmental benefit (see, for example, Lawson *et al*.1990, 1993). In 1991, the US EPA's entire strategy of ozone reduction was questioned in a 500-page book published by the US National Research Council (US NRC 1991) and the US General Accounting Office (GAO) began a series of reports that were highly critical of the quality of the science done by the US EPA and of the computer models that the US EPA used to predict the effectiveness of its I/M programs (*e.g*., US GAO 1992 1994, 1997).

Instead of encouraging independent research into I/M programs, the US EPA has either ignored it or attacked it. See, for example, the letter that the EPA sent to Congressman Robert K. Dornan of California following a University of Minnesota study that found the Minnesota I/M program to have produced no significant air quality benefit (Scherrer and Kittleson 1994; full response, including the substance of the letter, reproduced in Coninx 1996a). The US EPA attacked the Minnesota study again in its *Briefing Book*, which is used to promote I/M programs (US EPA 1995).

In fact, there is little official will to find the truth about the effectiveness of I/M programs. The US EPA, which in 1993 had 706 active contracts worth an estimated total of $13.7 billion (US) (US GAO 1994: 17), claims that it does not have the resources to submit the computer model that it uses to predict and evaluate I/M effectiveness to the standard scientific validation method of peer review even though the GAO lists 14 "major limitations" in the EPA computer model (US GAO 1997). Some of the most compelling proof of the computer model's tendency to greatly overestimate the benefits of I/M programs comes from analyzing the US EPA's own field data, which consisted of data from 44,000 vehicles collected between 1985 and 1992 (Lawson et al. 1996a). The US EPA will not suffer such embarrassment again because they stopped collecting the data after 1992.

Environment Canada and the ministries of the environment in British Columbia and Ontario have long used the US EPA computer models or slightly modified models to sell I/M programs. The contractor hired to design AirCare II is

required to use a MOBILE 5C (the US EPA MOBILE model 5 modified for Canadian vehicles, which were subject to less stringent emission standards before 1988) or similar computer model to determine the impact of AirCare on regional emissions (AirCare 1997: para 1.3.2). A recently published scientific study using two Canadian computer models based on the US EPA's models found that one under-predicted emissions by up to 36 percent, while the other over-predicted emissions by up to 24 percent (Gertler *et al*. 1997). RAND, the American think tank, expressed little confidence in such computer models and found that an independent inquiry into I/M models and evaluation methods was urgently needed (Aroesty 1994).

The almost pathetic weakness of the US EPA's claims about the effectiveness of I/M programs is illustrated by the 1995 Congressional testimony of Mary D. Nichols, EPA Assistant Administrator for Air and Radiation and the US EPA's spokeswoman for I/M programs (Nichols 1995). On page 196 of the testimony, Ms. Nichols claims that the EPA has "not only one study but many studies" that show that emission reductions as a result of the I/M program in Minnesota are 30 percent for VOCs, 30 percent for CO, and 15 percent for NO_x. On the next page, she says that these studies are based on "actual emissions of automobiles" and not on a computer model. Ms. Nichols then refers to a study by "someone named Tiao." This was George Tiao who had, in fact, conducted studies on the I/M programs in Oregon and Arizona (Tiao et al. 1982, 1989). The latest was published two years before the start of the Minnesota I/M program and a close review of both studies reveals that neither showed any significant air quality improvement as a result of an I/M program without considerable non-scientific manipulations. Finally, near the bottom of the next page of her testimony, Ms. Nichols admits that she does *not* have a study that contradicts a University of Minnesota study (Nicols 1995) that showed that the Minnesota I/M program produced no significant improvement in air quality.

This slippery type of response from I/M stakeholders both inside and outside of government is typical. If I/M programs really work so well, where is the science that confirms this? Instead, I/M stakeholders often quote from reports that were commissioned, and paid for, by the same government agencies that are charged with running and promoting the I/M program. Consultants who write such reports have revealed an uncanny tendency to find the results that please their clients.

Ontario's Drive Clean

Despite the lack of results from I/M programs already in operation, in April 1995 Ontario's Ministry of Environment and Energy (MOEE) established ClearAir, a voluntary I/M pilot program that was meant to run for one year. In September 1995, the MOEE gave a presentation describing the ClearAir program at the 11th Annual Mobile Sources/Clean Air Conference held in Colorado. In that presentation, the emissions reductions *estimated* by Radian for the AirCare program (Weyn 1994: 12-2)—24 percent for CO, 20 percent for VOCs, and 3 percent for NO_x—were upgraded and presented as *observed* reductions (Young 1995). In April 1996, the MOEE held a "stakeholder consultation" where participants were told that I/M *"is a proven way to reduce pollutants"* (Campbell 1996: 22), that I/M programs could reduce "emissions" by up to 30 percent and ozone exceedences in Ontario by 20 percent, and would improve fuel economy, thereby saving motorists $50 to $100 per year (Campbell 1996: 17). There was no mention of the cost of the program, except for discussions on how much consumers would be willing to pay for the test and the limits on repair costs.

Later in April 1996, Pollution Probe co-sponsored a 2-day conference entitled Clearing the Air: Transportation, Air Quality, and Human Health Conference, to which they invited politicians and officials from Environment Canada, Health Canada, the British Columbia Environment Ministry, and the Ontario MOEE, bureaucracies which, along with other participants, funded and supported the conference. The second of 14 recommendations was that an I/M program similar to British Columbia's AirCare be established in Ontario. *The Toronto Star* covered the conference and continues to write uncritical articles strongly supporting I/M programs.

After fully testing approximately 11,500 vehicles at a cost to Ontario taxpayers of $4.8 million (David Hall, personal communication, July 30, 1998), or about $400 per test, ClearAir came to an end in late 1996. The future of the I/M project in Ontario was in doubt. However, the pressure to start an I/M program in Ontario continued and on March 3, 1997, Pollution Probe hosted a "National Workshop" on I/M programs[36] that coincided with a CCME workshop held to finalize changes to its revised I/M Code of Practice. In a press conference held at the event, the Ontario Government was publicly scolded by Sergio Marchi, the federal Minister of the Environment, for not acting to establish an I/M program.

On July 18, Norman Sterling, Ontario's Environment and Energy Minister, launched Smog Rover, a monitoring program to "tune" an impending I/M program. Smog Rover was operated by an MOEE supervisor and three students who used remote-sensing equipment and a van that the government already owned. Four days later, on July 22, a group of 100 car repair companies called "Emissions Ontario" took it upon themselves to issue a media release announcing their program to reduce smog on behalf of their fellow citizens. Not only would this vocal new group of environmentalists test vehicles "at half-price" ($15 instead of $30), but "$5 of the $15 test fee will be donated by Emissions Ontario members to The Hospital for Sick Children." They claimed in a news release of July 22, 1997, however, that this initiative by the private sector would not be enough: "What Ontario really needs, as soon as possible, is a mandatory government program"—a program, that is, where the government would force consumers to be customers of the companies that make up Emissions Ontario.

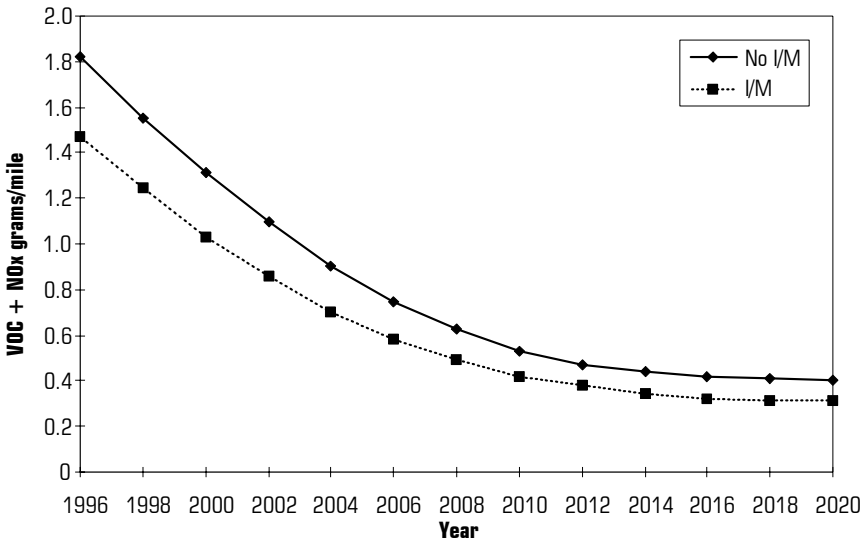
On August 22, a team of 7 experts led by Carl Andognini, a 30-year veteran of the nuclear industry, released a report on the dangerous condition of the province's nuclear reactors that implied the need for burning more fossil fuel for electric power with a consequent increase in air pollution. After the release of this report and the occurrence of a serious fire in a plastics recycling facility, the Ontario government announced that its Drive Clean I/M program would start in the summer of 1998. (This has subsequently been delayed to some time after 1998.) The Drive Clean program would be a hybrid, allowing motorists to choose to have their vehicles tested at either a centralized test-only facility or at a certified repair garage—a design very different from Ontario's previous centralized ClearAir pilot program (see Appendix 1 for types of programs). According to the news release, the program will reduce emissions of VOCs and NO_x by

62,000 tonnes per year, which is many times more than the reduction per vehicle that AirCare claims and over twice as much as the amounts that the US EPA claims is possible. The total cost of the program was not mentioned[37] but we can calculate that Drive Clean will eventually cost the 4.7 million Ontario motorists covered by the program over $70 million a year in test fees alone; $60 million of that figure will be wasted by testing clean cars. It will also cost Ontario residents another $50 million in lost time and expenses to get to the Drive Clean test. The total cost, then, is $120 million every year or $1 million every three days for testing alone.

Yet, on December 18, 1997, the government of Ontario issued a press release announcing that "Ontario's air quality improved greatly between 1970 and 1995" even while it experienced a large growth in population. In particular, the ambient levels of CO decreased by 87 percent, NO_x by 46 percent. and VOCs by 5 percent (over the 10-year period from 1986 to 1995 during which VOCs were measured). These reductions were obtained without any I/M programs and they are likely to continue without any I/M program as an increasing number of older vehicles are replaced by newer models with modern, highly effective, emissions control systems. Nevertheless, the Ontario government still claims to be committed to launching its full Drive Clean program, although the launch date involving private cars and light trucks has been postponed to sometime after "late 1998" (MOEE, News Release, February 4, 1998).

While the government of Ontario prepares to impose a useless and wasteful I/M program on motorists in the province, it has announced (MOEE, News Release, July 6, 1998) that it will use existing regulations to identify grossly polluting vehicles that emit visible smoke from their exhaust pipes. The owners of such vehicles can be fined up to $500. If properly administered, these on-road "smog patrols" will be much less expensive, much more convenient, and much more effective in reducing excessive vehicle emissions than the proposed Drive Clean or any other conventional I/M program. In fact, such smog patrols should have been in operation a long time ago.

Figure 10: Predicted emission levels



Source: Klausmeier *et al*. 1995: Attachment D.

The future of I/M programs

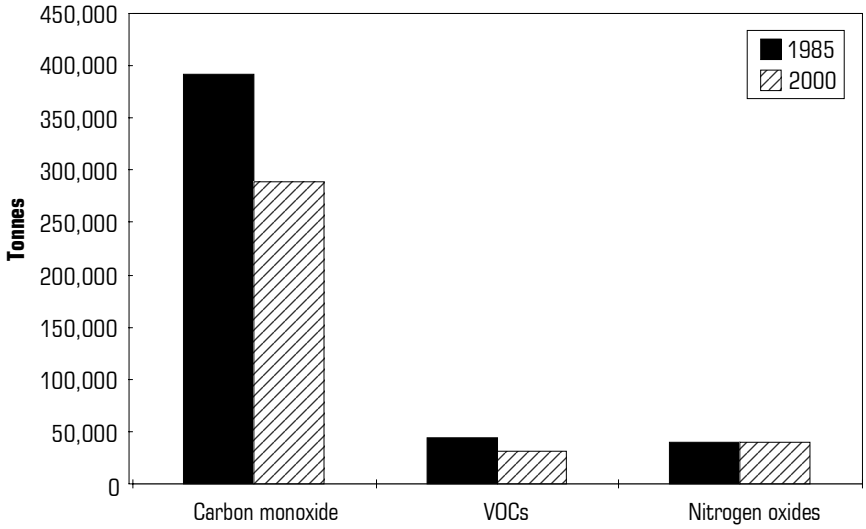
Although I/M programs have never been proven to provide anywhere near the reduction in emissions predicted by their supporters, the governments of Canada, British Columbia and Ontario continue to support and implement I/M programs. On March 12, 1997, it was reported that the Quebec government will soon launch a voluntary I/M program and plans to implement a mandatory I/M program in the coming years (*Montreal Gazette*, March 12, 1997). Would this be rational policy, even if I/M programs did perform as promised?

It would not, in fact, be rational policy because the potential environmental benefit of I/M programs is continually declining, largely because average vehicle emissions have decreased dramatically over the last two decades and will continue to decrease as older vehicles with primitive emission control systems (or none at all) are retired and replaced by superior technology. Figure 10 represents data from a California computer model that predicts the combined future emission levels of VOCs and NO_x, from on-road vehicles without any I/M program and with the IM240 program recommended by the EPA.

The model clearly shows that, at best—that is, *if* the program works as predicted (and no I/M program has yet)—the great cost and inconvenience it imposes on the population would only accelerate the reduction of emissions levels by a couple of years. The magnitude of emissions of VOCs and NO_x by vehicles and the predicted incremental benefit of I/M programs are both rapidly declining as older vehicles are replaced by newer ones with much better emission-control systems (see appendix 3). Already the cost-benefit ratio is extremely high, and it will get higher as potential benefits of I/M programs decline over time. Even with the expected increase in vehicle travel, the GVRD also predicts a reduction in vehicle emissions without AirCare (see figure 11).

The Greater Vancouver Regional District predicts in *Let's Clear the Air, GVRD Air Quality Management Plan* (December 1994: 7-11–7-17) that it will not be I/M programs but rather controls on area and point source emissions, such as those from large smoke stacks and heavy industry, that are predicted to provide by far the greatest reductions in VOCs and NO_x. I/M programs will have virtually no effect in reducing sulfur oxides or particulate emissions. I/M programs were, however, predicted to accelerate considerably the reduction of carbon monoxide (CO) emissions, which are relatively unimportant in the Greater Vancouver Regional District and are already dropping rapidly due to better technology. Because gasoline-powered vehicles are the major source for CO and levels of CO emissions are from 5 to 40 times that of the four pollutants (VOCs, NO_x, SO_x, and particulates). When the predicted reductions in the emissions for all five are combined,[38] AirCare's contribution to cleaner air appears deceptively impressive (figure 12a). However, when the environmental and public-health values of the five emission reductions are calculated, the predicted beneficial contribution of AirCare approaches insignificance (see figure 12b).

Figure 11: Mobile source emission estimates without AirCare



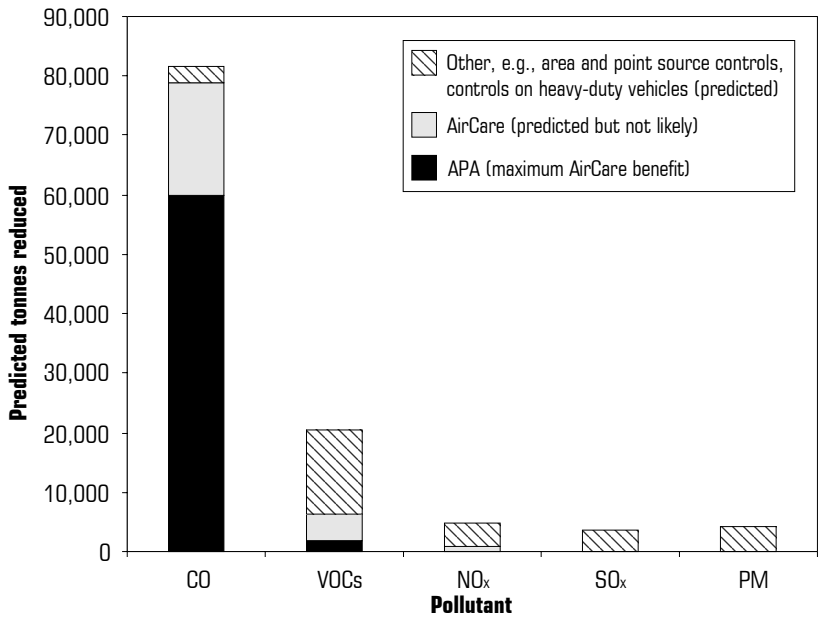
Source: *Let's Clear the Air: GVRD Air Quality Management Plan* (December 1994): S-10.

Financial and political risk

I/M programs involve a substantial investment in equipment, real estate, and training, and require many years to produce the anticipated return on investment. AirCare's 7-year contract with Envirotest, its testing contractor, is of typical length. Committing the population, on the basis of predictions that have been so inaccurate in the past, to such a long-term I/M program in which real benefits have been so elusive, borders on reckless. As many American states have learned, getting out of such contracts can be difficult and expensive. For example, Pennsylvania had to agree to pay Envirotest $145 million to settle a $350 million lawsuit it brought against the state when the state canceled its I/M program (*Harrisburg Patriot*, December 7, 1995).

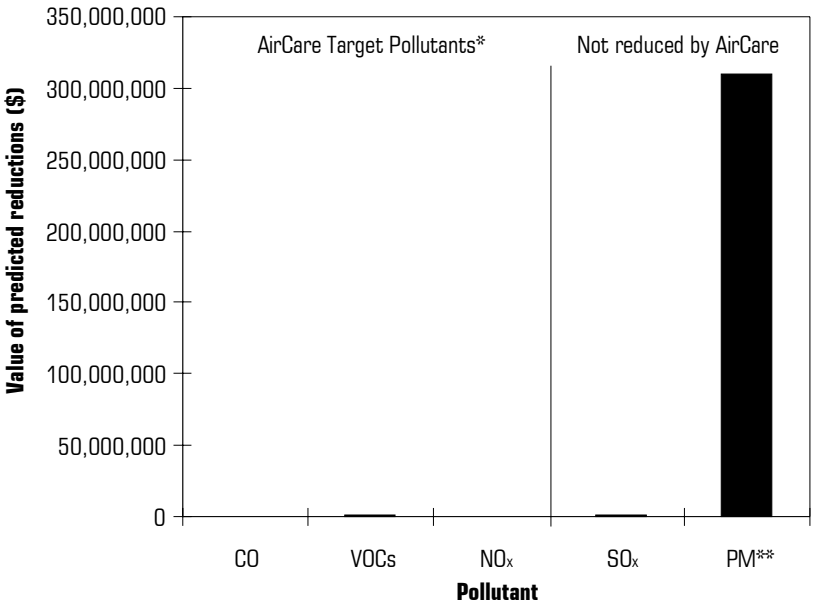
There are, however, two sides to the I/M coin and not everybody loses when an I/M program is implemented. Additional costs and inconvenience for motorists produce revenue for testing contractors, additional profits for repair garages, and additional government positions for bureaucrats. For them, the important question is not whether an I/M program works but whether it exists. These stakeholders will fight to promote and preserve I/M programs that give them so much. Until enough voters become aware of the long history of the failure of I/M programs to improve air quality, politicians will find it safer to accommodate the special interests of stakeholders than to advocate more effective but controversial environmental protection.

Figure 12a: Emission reductions predicted for the year 2000 from AirCare and other measures compared to the maximum reductions found by the APA



Sources: GVRD 1994: S-10; ARA Consortium1996b.

Figure 12b: Value of emission reductions predicted for the year 2000 in the GVRD Air Quality Management Plan



Sources: GVRD 1994; ARA Consortium1995.

* including emission reductions as a result of other strategies in the Air Quality Management Plan.

** maximum value assuming that all PM is PM_{10}.

Alternatives to I/M programs

Pollution from vehicle emissions in Canada is minuscule compared to that in the United States. However, if governments are serious about reducing ozone-causing emissions, there are more cost-effective ways than I/M programs.

1 Co-ordinate Canadian and American standards

The single most effective method to assure that the Canadian vehicle fleet will significantly reduce the air pollution that it creates is to ensure that Canadians can take full advantage of the emissions-control systems already installed in North American vehicles. This would be done by closer co-ordination of Canadian standards with American standards for emissions, fuel composition, emission-control warranties, and maintenance schedules. Canadian consumers are already paying over $2000[39] for the emission-control equipment on every new car they buy but this technology is not always being fully utilized in Canada: vehicle manufacturers have long claimed that the high levels of sulphur found in some Canadian gasoline as well as the widespread use of MMT (methylcyclopentadienyl manganese tricarbonyl) as an octane enhancer impair the effectiveness of emissions control systems, which were designed for American fuel formulations. Vehicle manufacturers claim that both fuel with high levels of sulphur and MMT foul catalytic converters, interfere with the onboard diagnostic (OBD) systems, obligate owners to perform more frequent and extensive vehicle maintenance and, in some cases, require modifications to the emissions controls system (CVMA 1995: 30-31, 1997: Appendix C).

2 Vapor recovery nozzles

Every time gasoline is pumped into the fuel tank of a car, air saturated with gasoline vapors is forced out to make room for the incoming fuel and released into the surrounding air. Approximately one gram of VOCs is released for every litre put into the tank. Vapor recovery nozzles ("stage II") at gasoline pumps, which are common in many American states, can trap 85 percent to 95 percent of that vapor and draw it back into the main storage tank. They have been found to reduce VOCs emissions at a cost of $2,000 to $4,000 per tonne (US$) (GVRD 1996: 3–9), a cost considerably lower than AirCare, which costs at least $33,000 per tonne of VOCs reduced (Coninx 1996b: 57). Use of stage II nozzles is estimated to raise the price of gasoline about 0.6 cents per litre (GVRD 1996: 7–36). However, unlike I/M programs, vapor recovery nozzles involve no extra trips, repairs, or other expenses that must be paid by the consumer. Stage II nozzles are not used anywhere in Canada

The future ambient-air benefit from vapor recovery nozzles will decline as a growing proportion of vehicles in use are equipped with on-board refueling vapor recovery (ORVR) systems but they will still provide substantial reduction in VOCs at least throughout the next decade. With the advent of ORVR, the cost-effectiveness of vapor recovery nozzles in the period from 1996 to 2015 is estimated to be as much as $17,200 per tonne of VOCs (GVRD 1996: 5–28). Finally, reductions in VOCs will have slight effect on ozone levels in areas where the formation of ozone is predominately limited by NO_x (see Appendix 4).

Although less expensive than AirCare, vapor recovery nozzles are still expensive. But, they have an additional benefit over other pollution reduction strategies. Anyone who has used these devices can tell the difference they make when refueling; the absence of a gasoline smell is a clear benefit for motorists, passengers and passers-by both in terms of health and personal comfort. It may well be that, under the right conditions and with the continuing popularity of self-service filling stations, consumers may make a decision to pay an extra 30¢ or 40¢ per tank to avoid the unpleasant smell of gasoline vapors while incidentally improving the environment.

3 Roadside Remote Sensing

Two-thirds of the total cost of AirCare during Year 3 was in fees, lost time, and the expense of having vehicles tested; only one-third went toward repair of emission-control systems. One of the weakest aspects of the conventional I/M strategy is the cost and inconvenience that it causes by requiring every motorist to drive to a test centre once every

year or two as it attempts to identify the 5 to 20 percent of vehicles that produce excessive emissions. Not only is this procedure extremely costly but it is also particularly vulnerable to cheating. As Donald Stedman, professor of chemistry at the University of Denver and the inventor of a remote-sensing device, testified before at a hearing before a United States Congressional Committee, one might as well hold scheduled breathalyzer tests to catch drunk drivers.

Conventional I/M strategy is stuck in the 1970s. Its supporters appear to be oblivious to the impressive technological advances that have been made in the design of motor vehicles and emissions-sensing equipment. One of these advances is in the area of roadside remote sensing (RRS). Remote sensing uses a device similar to the radar gun used for catching speeders to measure VOCs, CO, and NO_x emissions from the side of the road as each vehicle passes by.

A large and growing body of research shows that roadside remote sensing can effectively identify vehicles with high emissions for a tiny fraction of the cost incurred by using fixed-location I/M tests. RRS completely eliminates the cost and inconvenience that is currently imposed on drivers of "clean" vehicles and also eliminates many of the fundamental flaws found in scheduled I/M tests that permit cheating, short-lasting repairs made only to pass the I/M test, and the "summer cottage effect," *i.e.*, registering vehicles outside an I/M region to avoid the required test. Unlike I/M, RRS provides a constant deterrent to motorists who may well be aware that their vehicles are polluting excessively because of an illuminated OBD indicator on the dash (see below) but are tempted to drive anyway. RRS can provide authorities with an effective means to ensure that the OBD systems now found in vehicles will be fully utilized.

RRS is also much more equitable than I/M because the more a vehicle is driven, the more often it will be tested. Vehicles that are not driven very much do very little damage to the regional air quality, regardless of their condition, and may seldom, if ever, be tested by RRS. This automatically reduces the number of cases where equity issues arise (*e.g.*, how much does the government force a poor person or pensioner to pay in repairs in order to keep the vehicle) with no significant loss to the effectiveness to the program.

Just before announcing its conventional I/M program, Ontario had put RRS into service for a short period. The RRS device was set up in a van dubbed the Smog Rover, which was run by a crew of three students and a supervisor from the Ministry of Environment and Energy (MOEE). Although the Smog Rover was capable of measuring the two ozone precursors, VOCs and NO_x, it was only used to measure CO, which is not a smog-related emission. In fact, the whole exercise appeared to be only a public relations gimmick to "increase public awareness about the importance of driving well-tuned vehicles to reduce smog" (MOEE, News Release, July 18, 1997).

A close look at the results from the operation of the Smog Rover, however, further confirms the absurdity of conventional I/M programs in light of readily available alternatives. Working no more than 3 hours per day over 26 days, and with a reported budget of $15,000 (*Toronto Star*, July 23, 1997), the Smog Rover was able to perform 20,908 measurements at no inconvenience to motorists. The cost of testing the same number of vehicles—including motorist expense and inconvenience—in Ontario's proposed Drive Clean I/M program will be $1,030,400, almost 70 times the identification cost of RRS. If only the highest polluting 5 percent of the vehicles that the Smog Dog measured were repaired, excess pollution from vehicles would be reduced by over 60 percent at very low cost and minimal disruption to motorists. Instead, Ontario announced a program that, when fully implemented, will cost residents of that province approximately $120 million every year (or, $1 million every three days) in test fees, expenses, and time lost just to test the vehicles.

Finally, RRS involves little political and economic risk because unlike conventional I/M programs or even the use of vapor recovery nozzles, an RRS program does not require large investments in land and equipment. RRS can be set up quickly and relatively inexpensively using a number of small vans or small roadside boxes that can be easily increased or decreased as the need occurs. RRS is the most promising strategy in the many regions in the United States where there currently is a real need to identify vehicles producing excessive emissions.

4 On-board diagnostics (OBD)

When a modern vehicle begins to produce excessive emissions, it is almost always because something is broken, not because something "went out of tune." For many years, an increasing number of motorists have been instantly informed of many types of emissions-control failure by a malfunction indicator light (MIL) on the dashboard. The MIL is turned on by an on-board computer that simultaneously sets a code in the computer's memory to inform any mechanic of the probable cause of the failure. This capability, called on-board diagnostics (OBD), has been in widespread use since the early 1980s. A second generation of OBD has been required by law on all automobiles man-

ufactured in the United States after 1994. This OBD II indicates virtually *any* mechanical or electrical failure that is likely to cause emissions of VOCs, CO, or NO_x in excess of the vehicle's certification standard by 50 percent. OBD II monitors the vehicle's emission-control system every second the vehicle is operating and records any significant problems so that even intermittent failures can be easily diagnosed. The arrival of OBD II has made even the so-called high-tech tail-pipe tests used in today's I/M programs hopelessly obsolete.

California is now working on a version of OBD II that incorporates transponders to transmit information about failures in a vehicle's emissions-control system and a vehicle identification code to roadside receivers that can process information from up to six lanes of traffic simultaneously. OBD III will probably never be necessary in Canada but the technology may be useful in such regions as southern California where emissions from cars and light trucks will continue to cause severe pollution problems well into the foreseeable future.

Conclusion and recommendations

Earlier in this century, air quality was not a subject of serious discussion. Urban air polluted by industrial smoke, burning rubbish, and vehicle exhaust was accepted as a cost of living together in an industrial society. This began to change a few decades ago when increasing numbers of people began to feel that both their health and their standard of living were being threatened by air pollution and that this pollution was getting worse. Cars were blamed for much of the problem. Pressure was put on governments by voters, environmental groups were formed, and regulations were written. The automobile industry eventually responded by taking advantage of developing technologies to produce vehicles with emission levels so low that they were inconceivable only a generation earlier. Rather than denying environmental concerns, the auto industry now uses them as selling points. For example, Honda and Ford are both airing commercials that do not refer to performance, luxury, or price but rather to how little their vehicles pollute and how environmentally sensitive they are in manufacturing them.

Most of the effort to improve air quality and reduce vehicle emissions was centred in the United States which had, and still has, regions with serious air quality problems. In Canada with its much smaller population, air pollution from vehicles is minuscule compared that found in Texas or California, and vehicle pollution continues to decrease as older cars wear out and are replaced by new, cleaner cars equipped with very sophisticated American pollution control systems. Despite the good fortune they enjoy, reasonable Canadians still want to preserve and to improve the quality of the air they breathe. In response to this legitimate desire for a cleaner environment, Canadian federal and provincial bureaucrats, non-profit organizations, and industry have joined together to lobby governments to require mandatory scheduled vehicle emissions testing, or "inspection and maintenance" (I/M), a strategy that is not only unnecessary in Canada but has had a long history of failure in the United States.

The implementation of I/M programs in Canada is a classic example of the way governments exploit a popular issue to expand their influence and inflate their bureaucracies, first by creating an appearance of a crisis (ambient ozone levels) and then coming to the rescue by implementing a program (I/M). The I/M industry, a powerful, billion-dollar American industry made up of testing contractors, equipment suppliers, and I/M program consultants, depends upon governments to pass laws making I/M programs mandatory and the governments, in turn, rely almost exclusively on the industry to design, operate, and evaluate the programs. Governments also gain support from automobile repair garages, non-profit pressure groups, and other interests that hope to benefit from increased business, government contracts, grants, or public exposure. In Canada, the focus upon I/M programs diverts attention away from more cost-effective programs, programs that may, however, impose financial burdens on the powerful oil and automobile industries.

I/M programs have never been proven to perform according to the optimistic predictions of their supporters. Even when only the direct costs are considered, I/M programs are much less cost-effective than alternative strategies. When all the other social, environmental, and financial costs of I/M programs are taken into account, there are strong indications that the programs do more harm than good to both society and the environment.

For example, AirCare, now in its sixth year, has already created millions of hours of inconvenience and imposed hundreds of millions of dollars of additional costs on motorists in British Columbia. AirCare fees and other costs come from the same transportation budget consumers use to buy new vehicles, even though the data show that replacing rather than repairing older cars is far more effective in reducing emissions. Over the years, motorists making millions of trips to and from AirCare test centres and waiting in line for testing (with engines running) have consumed millions of additional litres of gasoline, added over a hundred tonnes of smog-producing emissions (as well as hundreds of tonnes of additional CO), increased vehicle usage by tens of millions of kilometers, and increased the risk of vehicle accidents and injury. Are the dubious and unproved environmental and health benefits of AirCare worth these very real costs?

When considering the potential effectiveness of a costly and highly technical program, it is unreasonable to rely virtually exclusively on evaluations by those with clear financial interests in establishing or continuing such a program. Yet that is what the Canadian federal government and the British Columbia and Ontario provincial governments have chosen to do.

Recommendations

(1) Environment Canada should make public whatever *scientific* research it relies upon to support its continuing promotion of I/M programs.

(2) Since, by the British Columbia government's and AirCare's own calculations, the AirCare I/M program is not providing the reduction in emissions originally promised or anywhere near a reasonable cost-benefit ratio, the program should be canceled.

(3) Any alleged need for AirCare II should be subject to a full independent scientific evaluation *before* any new program is imposed by law on the public. Implementation of AirCare II should not proceed solely on the basis of opinions from the AirCare staff and from the designer of the original AirCare program.

(4) The government of Ontario should make public whatever *scientific* evidence it has that supports the claims made for its Drive Clean program. A panel of independent scientists (not stakeholders) should be set up to evaluate that evidence and report its findings to the public *before* the Government commits itself to a program that will raise the cost of living for Ontario residents by well over one hundred million dollars per year.

(5) The burden of proof should always rest on those selling the product. In the case of I/M programs, it is for the industry that is to gain financially from laws enforcing I/M testing to demonstrate that the program will provide the reductions promised. Such demonstration should be done at the expense of the I/M industry and not at the expense of the taxpayer.

(6) The future need for any type of emission-reduction programs in Canada should be fully evaluated by independent scientists and economists (not handpicked consultants) *before* any government commitments are made.

(7) If a need to take action is confirmed, the cost-effectiveness of all the alternatives should be carefully evaluated by those with no financial stake in the outcome.

(8) The involvement of I/M stakeholders in the implementation process should be closely examined.

Appendix 1: Types of I/M programs and tests

Programs

Conventional I/M programs come in three types. In a *decentralized* I/M program ("test and repair"), motorists must have their cars inspected at a certified garage that can also perform emissions repairs. Proponents claim that decentralized I/M programs are more convenient because they provide more test locations and because both the test and the necessary repairs may be done at the same location, avoiding additional trips to a remote test centre.

In a *centralized* I/M program (test only), the motorists must drive their cars into a test centre that is completely independent of any repair garage. Proponents, including the US EPA, claim that this separation between test and repair is necessary because there is widespread collusion between mechanic and consumer that results in fraud that reduces the potential benefits of the program by half. British Columbia's AirCare is centralized.

A *hybrid* I/M program provides some centralized and some decentralized testing facilities. Some hybrid programs allow consumers to choose what type of facility they will use; other programs assign the type of testing facility based on criteria such as a vehicle's model year or the place where it is registered.

Which program is best?

The debate about centralized and decentralized programs has important consequences for competing interest groups. Millions of dollars in test fees will either go to one or more testing contractors, or the test fees will be paid to various certified repair garages. Studies indicate that there is little difference between the effectiveness of the two types of program in reducing emissions—or between either type and no program at all (Lawson *et al.* 1996, sample = 44,000 vehicles).

Tests

There are three basic I/M tailpipe tests. The simplest and cheapest is the *idle test* which involves testing the concentration of exhaust gases as the vehicle's engine is running at its normal idle speed and, in some programs, also at a "high-idle" speed, typically 2,500 rpm. This test is designed to identify excessive emission of CO and VOCs but not of NO_x.

To identify excessive emissions of NO_x, the vehicle's engine must be under load, as it would be if accelerating or climbing a hill. During a *loaded-mode test*, tailpipe emissions are measured as the vehicle is running in gear on a roller that provides resistance to the drive wheels. In *steady-state loaded-mode tests*, the wheels of the vehicle are turning at a single speed (*e.g.*, 25 mph) throughout the test. AirCare combines this type of loaded-mode test with an idle test.

A more sophisticated *transient loaded-mode test* requires that the vehicle's engine goes through a pattern of accelerations and decelerations under load. The most common version, the IM240, was once required in the US EPA "enhanced" programs and is still recommended in the CCME Code of Practice. The IM240 tests cars under more driving conditions than the other tests but at a very high price—around $250,000 per unit—so that only relatively few test centres can afford it.

According to the US EPA, VOCs leaking from fuel tanks, fuel lines, and the fuel delivery system are often greater than excess emissions of VOCs from the tailpipe (US EPA 1991a). Therefore, the US EPA had required *evaporative tests* to be performed in its enhanced I/M program. A partial description of the test is as follows:

> The inspector must locate the evaporative canister, remove the vapor line from the fuel tank, and hook up the pressure test equipment to the vapor line. The system is automatically filled with nitrogen using computer controls and hardware flow controls. The pressure supply system is closed off and any loss of pressure is monitored by the computer. (US EPA 1991b: s. 4, 7)

This is supposed to be done in a couple of minutes for every make and model of vehicle by an inspector who is not a trained mechanic and who is typically earning little more than the minimum wage. The test was so poorly devised that it has now been abandoned virtually everywhere, primarily because of the damage it caused to consumers' vehicles.

Which test is best?

Test equipment can vary by an order of magnitude in cost from the least to the most expensive. The more expensive test equipment is claimed to measure emission levels more precisely. However, it is not *measuring* but *identifying* vehicles producing excessive emissions that is the object of the inspection. All three types of tailpipe test, if properly performed, should be able to identify vehicles that are polluting excessively *at the time of the test* while none of them can reliably identify all the vehicles that have serious but intermittent excess emissions. The more expensive equipment more reliably identifies marginally excessive emitters, but such identifications provide no significant environmental benefit because subsequent repairs provide little or no emission reduction, and are just as likely to make emissions worse as better (Lawson 1995: 474). In addition, the precision of the expensive I/M240 used in some I/M programs is hardly impressive. One study, which compared the results of IM240 and idle tests to the results of the much more elaborate Federal Test Procedure (FTP), the official American vehicle certification test, found that the I/M240 mistakenly failed up to 18 percent of vehicles producing low emissions and mistakenly passed up to 33 percent of the vehicles with high emissions (Gallagher *et al*. 1997).

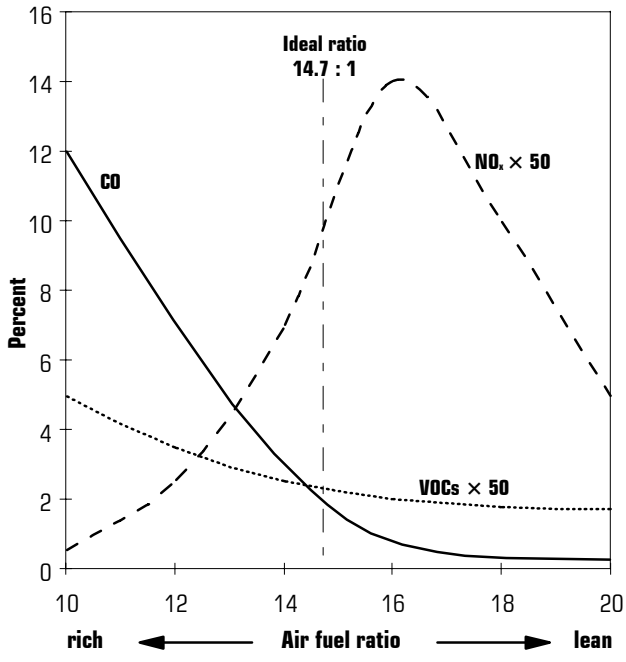
Appendix 2: Engine balance

Emission repairs are not straightforward. The air-fuel mixture and the temperatures in the engine that tend to minimize production of CO and VOCs tend to increase production of NO_x, and *vice versa*. Ideally, the carburetor or fuel injection system of a gasoline vehicle should provide a mixture (mass air-fuel ratio) of about 14.7:1 when the engine is at operating temperature (figure A1). In this stoichiometric condition there is just enough air to allow all the fuel to burn completely.

Excessive emissions of CO or VOCs can often be reduced by adjusting the air-fuel mixture. However, adjustments to decrease emissions of VOCs and CO can cause NO_x emissions to increase dramatically as the air-fuel ratio approaches 14.7:1. As the mixture gets leaner still, all three emissions will begin to decline but conventional engines will no longer operate properly.

Besides a balance of pollutants, there is also a balance of performance. When the air-fuel mixture is slightly rich (more fuel and less air), the engine has more power; when it is slightly lean (less fuel and more air), the engine will run more economically but sometimes produce much less power (*Kirk-Othmer Encyclopedia of Chemical Technology* 1991: 986). Drivers, however, like power and it is this aspect of engine balance that has probably caused much of the cheating in I/M programs. In a survey done for Arizona's I/M program, 88 percent of the mechanics stated that requests by consumers to adjust their vehicles simply to pass the I/M test was "very commonplace" or "somewhat commonplace" and 78 percent stated that requests to re-adjust vehicles after they had passed the I/M test so that they would run better were also "very commonplace" or "somewhat commonplace" (Arizona, Auditor General 1988; this report was based on interviews with 201 automotive mechanics in Phoenix and Tucson.) The air/fuel ratio on an

Figure A1: Effect of the air-fuel ration on emissions



Sources: *Kirk-Othmer Encyclopedia of Chemical Technology* 1991: 987.

earlier model of vehicle could often be changed by a simple adjustment of the carburetor. In modern vehicles, the mixture may be changed by replacing the original controlling chip (PROM) in the on-board computer with an after-market "high performance" chip that gives the engine more power but may not pass an I/M test. The original chip can be reinstalled for a few hours once every year or two to pass a scheduled I/M test.

Appendix 3: The myth of the "tune-up"

The justification for imposing expensive and inconvenient I/M programs on consumers is that it is their fault if their cars pollute excessively and that cars must have regular "tune-ups" to run properly. Yet, on modern vehicles there is nothing left to tune. Parts such as points, condenser, and distributor that regularly wore out during the 1950s and 1960s, have been replaced by electronic ignition. Carburetors, which once were adjusted with a screwdriver, have been replaced by fuel injection systems. Fuel mixture, idle speed, and spark timing are all controlled by an on-board computer that is performing "tune-ups" every second the vehicle is running. With the disappearance of leaded gasoline, spark plugs can last 100,000 miles or longer. American law now requires emission systems to have an effective life of 10 years or 100,000 miles; in Canada, maintenance schedules may be somewhat more stringent for the same vehicles, at least partly because auto manufacturers are concerned about the quality of Canadian fuel. The only maintenance that the consumer has to do that *might* affect emissions is to change the air filter periodically, and it is in his clear self-interest do so. Compare the recommended emissions maintenance schedules of a 1978 and a 1997 vehicle in table A1.

Table A1: Recommended emissions maintenance schedules

Year	Frequency	Emissions maintenance to be performed
1978	**First 7,500 miles, then every 30,000 miles**	• thermo-controlled air cleaner check • carburetor choke check • engine idle speed adjustment • EFE system check • carburetor mounting torque • vacuum advance system and hoses check
	Every 15,000 miles	• fuel filter replacement • PCV system check -- PCV valve and filter replacement • oxygen sensor change
	Every 22,500 miles	• differential vacuum delay & separator valve • spark plug wires check • idle stop solenoid, idle speed up solenoid, or dashpot check • spark plug replacement • engine timing adjustment and distributor check • carburetor vacuum break adjustment
	Every 30,000 miles	• ECS system check and filter replacement • fuel cap, tank and lines check • air cleaner element replacement
1997	**60,000 miles**	• replace PCV (no cost)
	100,000 miles	• replace spark plugs (normal duty service)

Sources: Buick Motor Division, General Motors 1977; Ford Motor Company 1996.

Appendix 4: Formation of ozone

Ozone formation in the lower atmosphere is a highly complex interaction between VOCs and NO_x in the presence of sunlight. The ratio of the carbon content of VOCs to NO_x of about 8:1 is optimal for ozone production. Whenever the concentration of VOCs is substantially more than 8 times that of NO_x, the reaction that creates ozone is limited by the amount of NO_x in the air (NO_x-limited); similarly, when the concentration of VOCs is substantially less than 8 times that of NO_x, the reaction is said to be VOC-limited.

If ozone production is limited by NO_x, reducing emissions of VOCs may have little or no effect in reducing the level of ozone. Naturally occurring VOCs from trees and other vegetation causes the formation of ozone to be NO_x-limited in many regions. The United States National Research Council suggested that the failure to consider the effect of naturally occurring VOCs was a significant factor in the failure of the US EPA's ozone-reduction strategy (US NRC 1991: 4, 6). This strategy includes I/M programs, which have never been effective in reducing NO_x and may actually have increased it in some areas (Coninx 1996a: sec. 2). In Canada, it is not always clear whether the formation of ozone is limited by NO_x or VOCs: the formation of ozone tends to be VOC-limited in urban areas but as urban air moves over rural areas, it typically becomes more NO_x-limited (CCME 1997: 285–86).

In many ways, limitation on the formation of ozone by the relative concentrations of VOCs and NO_x is a moot point in Canada. Ozone levels are already very low all over Canada except in southern Ontario where 50 to 60 percent of the ozone or its precursors (VOCs and NO_x) is transported in the air coming from the United States (CCME 1997: 258). I/M programs have been shown to be largely ineffective in reducing emissions of NO_x by vehicles so I/M programs are not likely to have any significant effect in reducing NO_x-limited ozone. There are alternatives that are clearly more cost-effective than I/M programs in reducing VOCs and these alternatives should be in place in regions where the formation of ozone is VOC-limited before an I/M program is developed.

Appendix 5: I/M assumptions and reality

The basic strategy of I/M programs is straightforward:

(1) periodically test each and every vehicle in a region to identify those producing excessive emissions;

(2) compel owners of such vehicles to repair them;

(3) re-test to verify that the repairs were effective.

This procedure is best suited to controlling major pollution sources such as large factories or utilities. The operating parameters of such "point sources" are narrow and readily tracked, and the emission sources are located at fixed sites (such as smokestacks) so their performance can be easily monitored. As a result, the cost of even elaborate inspections can be relatively small for potentially important environmental gains. Even so, monitoring may have to be unannounced to prevent the possibility of cheating.

Although the passenger car and light truck fleet is often described as if it were a large, single source of pollution, in fact each vehicle is one of millions of unique pollution sources, each one providing only a very small potential benefit when corrected. And, most do not need to be corrected: both supporters and critics of I/M programs agree that only a relatively small percentage of vehicles contribute disproportionately to air pollution. Testing each one every year or two is a very costly and inefficient way to reduce emissions. In the case of AirCare, the average annual reduction of VOCs from testing and repairing the half-million vehicles manufactured in 1988 and later is equivalent to the evaporation of

no more than three teacups of gasoline per vehicle, or about as much as the amount of VOCs released whenever a litre of oil-based paint dries. NO_x reductions were virtually nonexistent (Coninx 1996b).

The assumption that I/M programs must be of *some* benefit is founded on many assumptions, a lot of *if*s:

- *if* vehicles are properly identified
- *if* vehicles are properly repaired
- *if* the repairs last.

These, in turn, are founded on other *if*s:

- *if* the test is reliable
- *if* there is no cheating
- *if* a vehicle's emission levels do not vary

and so on.

However, we *know* from experience and studies that vehicles producing excessive emissions often are not identified, often are not properly repaired, and that the repairs often do not last. We also know that no I/M test accurately reflects real-life driving conditions, that there is cheating, and that vehicle emissions can vary widely. As each assumption is undercut by reality, the effectiveness of the I/M program is reduced accordingly.

Notes

1 According to the American Automobile Manufacturers Association, emissions and safety equipment combined are estimated to raise the average price of a new 1996 car by $3,915 (US) or $5,300 (CDN) compared to such a vehicle without the equipment.

2 In the United States, 1994 new vehicle emissions standards of 0.41gpm VOCs, 3.4 gpm CO, and 0.4 gpm NO_x are only 5 percent, 4 percent, and 11 percent of the standards for pre-control vehicles before 1968.

3 This quiet but very significant advance has gone largely unnoticed. For example, at one I/M "stakeholders" meeting held in Toronto to "invite your advice," a representative of a non-profit organization stated that she did not believe that new cars were cleaner than older cars; nobody corrected her.

4 Newer vehicles are often excused from I/M testing entirely.

5 Although I/M is promoted as being self-financing, taxpayers also contribute in numerous ways.

6 For a discussion on the validity of these claims, see Green 1995.

7 This has happened in a number of American states. For example, in Ohio some incumbents who lost the last election blamed their defeat on their support of I/M (*Plain Dealer*, November 13, 1996). Authorities understand that the environment cannot vote or go to the media and whatever potential environmental effectiveness there may be in an I/M program may be sacrificed to keep the cost and inconvenience within the range that consumers (who are also voters) will tolerate. To appease motorists, I/M programs offer such consumer-friendly features as fast-pass "screening" tests, a "second chance" to pass the test, and "waivers" that the limit the cost of repair. Such relaxation of the procedure undermines the whole environmental goal of the program because it reduces the number of vehicles that are fully repaired after being identified as producing excessive emissions.

8 For example: "The engine and exhaust system shall be equipped and adjusted to prevent the escape of excessive fumes or smoke as compared to other motor vehicles of the same or similar types and sizes" (British Columbia Motor Vehicle Act Regulations. Division 7, Schedule 1, s. 16). This is confirmed in the Radian "Audit": "Radian does not believe it is necessary to actually measure exhaust smoke opacity since any visible smoke indicates a significant problem in a gasoline-powered engine" (Weyn and Klausmeier 1994: 5-5). This effective enforcement may now be taking place in Ontario.

9 Sometimes referred to as hydrocarbons (HC) though, to be precise, VOCs are a subgroup of hydrocarbons.

10 This fact does not prevent the Canadian Council of Ministers of the Environment (CCME) from using it as a justification for imposing I/M: "Ambient levels of CO are of concern in Toronto, Edmonton, Calgary, and Vancouver where CO levels have occasionally exceeded the Canadian maximum acceptable 8-hour objective of 13 ppm. However, although CO emissions are still of concern in Canada, the eight-hour Air Quality Objective has not been exceeded since 1990, and ambient CO levels have been decreasing" (CCME 1996a: 1). GVRD 1994a: 17. The 1-hour "acceptable" level of 30 ppm CO has not been exceeded since 1988 (Environment Canada 1994: 26). Perhaps CO is not a problem in Canada because there is sufficient biomass to absorb it. CO tends to get in water and be converted to other compounds through natural biological action (see Griffin 1994: 81).

11 CCME 1995: 2–6. This, of course, does not mean that a further reduction in ambient levels of CO is not desirable but only that the cost of any action should be extremely low or zero.

12 Not to be confused with stratospheric ozone (the "ozone layer") that protects the earth from ultraviolet radiation.

13 Another standard of 80 ppb average over 8 hours has been added to the original standard of 120 ppb over one hour but, because ozone levels tend to peak at certain times of the day, this change is considered to be only minor and will have little effect on the total num-

ber of exceedence days most regions will experience. See *US Federal Register* 62, 138 (July 18, 1997): 38855.

14 United States Senate Committee on Public Works, National Air Quality Act of 1970, Report No. 1196 91st Cong., 2d Sess 9 (1970) in 1 Legis.Hist at 410, in Rogers 1994: 158 fn.

15 "Biogenic VOCs, in combination with anthropogenic NO_x, are capable of generating ozone concentrations above 80 ppb in favorable meteorological conditions across much of the eastern United States, with values of more than 100 ppb downwind of a number of major cities. Further assessments of control strategies must include biogenic emissions, given their potential for generating ozone concentrations close to the [US 120 ppb] concentration" (US NRC 1991: 377).

16 Perhaps certain regions in southern Ontario (such as Long Point) should be excluded since they are covered by polluted air (over which the residents have no control) from the United States.

17 Weyn and Klausmeier 1994: 2–11. The anticipated failure rate was 30 percent; the real failure rate found by Radian was 11 percent to 14 percent.

18 Waivers are, in effect, licenses to pollute issued to owners of vehicles that still cannot pass the re-test, even after spending a certain amount of money for certified repairs. Waivers can devastate the effectiveness of an I/M program. The US EPA model I/M program specifies a maximum waiver rate of 1 percent of identified vehicles (vehicles that fail the initial test) for its enhanced program (US EPA 1991a: 30).

19 In the October 1992 issue of *NO_x/VOC News* (its motto is "Working together for healthy air") the Canadian Council of Ministers of the Environment (CCME) predicted that AirCare would reduce NO_x by 20 percent (CCME 1992: 6). This claim was repeated two years later in the CCME's *Environmental Code of Practice for Motor Vehicle Emission Inspection and Maintenance Programs* (1994:2). Meanwhile, the 10 percent target still lives! On September 9, 1997, five years into a 7-year contract, the GVRD website claims: "When fully implemented, AirCare is expected to reduce NO_x emissions by 10 per cent" (www.gvrd.bc.ca/air/bro/aqsmog.html). When exactly will AirCare be "fully implemented"?

20 "One of the main reasons that Radian was hired to evaluate the program was because of the small sample of 'before and after' test data available to calculate an emissions benefit at the time the report was needed. Since a purely scientific calculation of the benefits was not available, a firm with proven expertise in the field was hired to make an assessment of how well the program was working. Although some leaps of faith are made in the report, it was apparent to Radian that the vehicles failing the AirCare inspection almost always had lower emissions on reinspection and that the reductions often lasted into the next inspection year" (fax from David Gourley, Manager, Emissions Testing and Standards, AirCare Program Administration, to APA President George Iny, May 24, 1996).

21 Even if they did exist, the reductions as the result of their repair would already have been counted.

22 This was only partially done in the Radian report, as can be seen by the fact that Radian reports that NO_x emissions increased as a result of AirCare repairs for the group of vehicles manufactured from 1981 to 1987. In the following Technical Review of Year 3 (AirCare 1996b) use of this artful methodology was expanded.

23 I/M repairs often provide little long-term benefit, largely because they a motivated by the owner's desire to pass the test and not to improve the vehicle (see Lawson 1995). Note as well: "there is no doubt that this [Clean for a Day] phenomenon occurs, but it is an unavoidable part of a program that only looks at a vehicle once a year" (fax from David Gourley, Manager, Emissions Testing and Standards, AirCare Program Administration, to APA President George Iny, May 24, 1996). Considering the acknowledged day-to-day variability of individual vehicle emissions, the wide range of difference in vehicle usage patterns, and a potential for cheating, this "unavoidable part of a program that only looks at a vehicle once a year" (at a time chosen by the owner) is by itself a very serious, and perhaps fatal, flaw in the entire I/M strategy. How meaningful can a single I/M test score be?

24 "Radian gave no details of the weighting factors they used but they appear to have only considered the number of vehicles and ignored the usage" (AirCare 1996b: 4-3).

25 So, are older vehicles driven as much as newer vehicles—yes or no? According to AirCare, both yes and no. On the one hand, Radian and AirCare assume that both old and new vehicles are driven the same amount (Aircare 1996: 4-3); otherwise the emission reductions that could be claimed by AirCare would be much less. According to a paper by S.J. Stewart, AirCare Project Engineer for emissions and data analysis, AirCare data revealed that kilometres travelled "does not drop off

with age anywhere near as rapidly" as was previously estimated and that the most significant factor in determining the aggregate distance travelled for a particular vehicle group is "simply the number of vehicles in that group" (Stewart 1996: 28, 32). On the other hand, in an article to justify AirCare's testing of hundreds of newer vehicles (and costing the residents of British Columbia thousands of dollars) to find each vehicle with excess emissions, David Gourley, AirCare Manager for emissions testing and standards, declares that "[s]tatistics gathered over the first three years of testing [the same statistics used by Mr Stewart] confirm that newer vehicles are driven much further distances than older vehicles" (AirCare Update, January 1997: 1).

26 The in-house AirCare report was "peer reviewed" by the writer of the Radian report (fax from David Gourley, Manager, Emissions Testing and Standards, AirCare Program Administration, to the writer, 1 August 1997).

27 That does not stop AirCare from continuing to quote those benefits.

28 These were the same 248 vehicles used in the internal Technical Review from AirCare plus 20 more that had subsequently been added to the data base by AirCare.

29 The maximum repair cost was limited to the book value of the car.

30 AirCare 1997. Response deadline was August 15, 1997. Jointly sponsored by the GVRD, British Columbia Ministry of Environment, Lands and Parks, Environment Canada, and the Insurance Corporation of British Columbia with a budget of $80,000. Note that the 3 percent target is back again.

31 CO reductions in British Columbia provide little or no significant health or environmental benefit.

32 Fax to the writer from David Gourley, Manager, Emissions Testing and Standards, AirCare Program Administration, 8 August 1997.

33 Letter from Douglas Cope to APA President George Iny, November 23, 1996.

34 Which includes the first draft of the revised code, the final version has not been released at the time of writing.

35 Compared to AirCare, where the cost of identifying each 1988 and newer vehicle with excessive emissions is $968.

36 Sponsored by Environment Canada, Ontario MOEE, Canadian Petroleum Products Institute, Automotive Industries Association of Canada, and Canadian Vehicle Manufacturers Association.

37 The total cost of I/M is rarely mentioned since I/M supporters prefer to express it as "only $18 a year for your car" or something like that.

38 As they frequently are, for example in Let's Clear the Air: 7-17.

39 Some emission control system components are also components of the vehicle operating system, so it is difficult to precisely apportion, for example, the cost of the fuel injection system to emissions control or to another purpose. At vehicle emissions conferences, the figure of $1,800 (US) has been used as an estimate. The American Automobile Manufacturers Association claims that an average of $3,915 (US) or $5,300 (Can) of the price of a new vehicle is attributable to the combined cost of emissions control and safety features.

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