Chapter 17

Air Pollution-Control Policy

Earth would be unable to sustain life as we know it without its atmosphere. The surface air (the troposphere) normally contains about 78 percent nitrogen, 21 percent oxygen, small amounts of other gases, varying amounts of water vapour, and many other compounds put there through acts of nature and human activities. The upper layers of the earth’s atmosphere (the stratosphere) contain only about 5 percent of the planet’s air, but have a critical role to play in making the planet habitable. Trace gases in the stratosphere, particularly ozone, filter out about 99 percent of incoming ultraviolet radiation, acting like a giant sun block without which we would be exposed to damaging levels of radiation. Other trace gases in the stratosphere provide greenhouse services: they trap some of the infrared radiation that is reflected back from the earth’s surface, warming it and making it more hospitable to living organisms. Both of these vital phenomena can be disrupted by human activity.

Human disruptions of the atmosphere are not new; instances of local smoke pollution have occurred for centuries. But in the last few decades the severity of air-pollution problems has grown more acute, owing to the sheer scale of airborne residuals released and the nature of some of the emitted substances. There are thousands of potential air pollutants—for example, oxides of carbon, nitrogen and sulphur, volatile organic compounds, suspended particulate matter, photochemical oxidants, radioactivity, heat, and noise. These pollutants cause a diverse set of damages. Prolonged exposure to airborne substances can lead to lung cancer, bronchitis, emphysema, and asthma; accidental releases can have acute impacts. Air pollution damages plants—agricultural crops and forests. Air pollution can lead to severe damage of exposed materials, such as the surface erosion and discoloration of stone and concrete work and the corrosion of metals. Stratospheric ozone depletion and enhanced global warming have
significant implications for the sustainability of humans and the earth’s ecosystem. Not all air pollution is outdoors; in fact, indoor air pollution is a critical problem in many homes, factories, mines, and farms.

Many airborne pollutants are emitted on a continuous basis. The sulphur dioxide (SO\textsubscript{2}) emissions from coal-fired electric power plants, for example, are continuously produced as long as the plants are in operation. For individual motor vehicles, emissions start and stop with their operation, although for an entire urban area auto and truck emissions vary continuously throughout the days and seasons. Episodic, especially accidental, emissions have been the cause of severe air-pollution incidents, for example the Bhopal disaster in India and other industrial releases of toxic materials into the air. The links between emissions and ambient air-quality levels can be complicated because of the complexities of meteorological phenomena. The best-known example of this is the creation of local weather conditions that trap air pollutants, sometimes for extended periods of time. These are called temperature inversions. The major air pollutants Canadians are exposed to are summarized below.\textsuperscript{1}

\textsuperscript{1} Environmental policies covering emissions of greenhouse gases and CFCs are discussed in Chapter 20. Review Table 2-2, which summarizes sources and probable impacts of pollutants.

**The “Big Five” Criteria Air Contaminants (CACs)**

- **Nitrogen oxides (NO\textsubscript{x})**. A brownish, highly reactive gas present in urban atmospheres. Primary sources are transportation and stationary fossil fuel combustion (e.g., power plants). They are an ingredient of smog. Environmental impacts include lung irritation; nitrogen oxides contribute to lung diseases and lower resistance to respiratory infections.

- **Sulphur oxides (SO\textsubscript{x})**. Primarily from stationary sources from combustion of fossil fuels (e.g., oil refineries, fossil-fuel-fired electricity generators), steel mills, pulp and paper mills, non-ferrous smelters. Sulphur dioxide is a pungent gas that irritates people’s upper respiratory tract. Those particularly affected are children, the elderly, and people with chronic lung diseases such as asthma. It is also the key compound responsible for acid precipitation, a problem in eastern Canada.

- **Particulate matter (PM)**. Particulates come in a number of measured sizes (e.g. PM–2.5, and PM–10 are 2.5 and 10 microns, respectively) and include dust, dirt, soot, smoke, and liquid droplets. PM–2.5 is thought to be particularly damaging to the lungs because the particulates are so small that our bodies cannot filter them out. They accumulate in the lungs and contribute to lung and heart disease. They also damage the body’s immune system and are carcinogens. Sources of PM are emissions from motor vehicles, point sources from various industrial processes, power plants, fires, and natural sources of dust.

- **Carbon monoxide (CO)**. Carbon monoxide is released from incomplete combustion of a fossil fuel. The primary source in urban areas is motor vehicles. This colourless and odourless gas replaces hemoglobin in our bloodstream and reduces the delivery of oxygen to the tissues and organs. At high enough concentrations in the blood, it is fatal. CO poisoning is associated with faulty gas appliances in the home and poorly maintained exhaust systems in cars and trucks. Its concentration in the atmosphere is clearly far from lethal, but in urban areas it can be at levels sufficient to cause headaches, tiredness and irritation, and impaired visual perception, manual dexterity, learning ability, and performance of complex tasks.

- **Volatile organic compounds (VOCs)**. VOCs include gases such as propane and benzene. They come from stationary and point sources. The stationary sources are the production and use of paints (oil-based) and solvents, refineries, dry cleaners, gas stations, and a natural source—forests. Motor vehicles are mobile sources of VOCs. VOCs are another contributor to smog. Some, such as benzene, are carcinogenic.

**Ambient Air Quality in Canada**

Recall from Chapter 2, Figures 2-3,2-4, and 2-5 that ambient levels of three of the five criteria air contaminants (sulphur dioxide, particulate matter, and volatile organic compounds) have fallen over time. Ground level ozone has not declined over time. Recent data for nitrogen oxides and carbon monoxide is not readily available. These are national figures, and therefore may camouflage areas of both higher and lower air quality. While these numbers provide some optimism about the state of our environment, a number of questions and issues remain:
1. To what extent are the regulations (discussed below) responsible for the improvement? This is a difficult question that economists wrestle with. To analyze the impact of regulations, the analyst typically needs a statistical model to help sort out the various factors that may influence emissions and ambient levels of a pollutant. A question one wants to ask is what would ambient air quality be if the regulations had not been in place.

2. Are the policies cost-effective? Studies have been done in the United States comparing the country’s air-quality standards to cost-effective policy alternatives. They find that total compliance costs could be much lower with alternative policies, especially incentive-based policies that price the pollutants. While research is needed in Canada to examine this question, the U.S. results suggest that introducing more incentive-based policies may help reach environmental targets at lower costs to society.

3. Are the guidelines themselves sufficient to safeguard the health of Canadians and our ecosystems? Scientific and economic studies to help determine the marginal damages and marginal costs of abatement for air pollutants are necessary to answer this question.

4. Why have Canadian governments been so reluctant to use incentive-based instruments? There are many reasons; some were covered in Section 4. But conditions can change, and economic analysis of environmental problems and policy options is one tool that can assist governments in choosing among the available policy instruments.

Air Pollution-Control Policies in Canada: A Brief Sketch

Ambient air-quality targets have been set for the criteria pollutants. To achieve a target level of ambient air quality, emission targets for point and nonpoint sources must also be set. Air-pollution regulations have followed a path similar to that for water pollution—national targets for the criteria air contaminants are established as guidelines, not binding standards. The first air-pollution legislation was at the provincial level; the federal government entered in the late 1960s and 1970s. The federal government works in conjunction with the provinces to set guidelines. However, one difference from water quality regulation is that in June 2000, the ministers of environment for all provinces except Quebec approved the Canada Wide Standards (CWS) to be set for particulate matter (PM$_{2.5}$—the small particles most dangerous to health), and ground-level ozone. The standards were established under the purview of the Canadian Council of Ministers of the Environment (CCME) who set a target of 2010 for compliance across all provinces except Quebec. More details on the CWS are found below. For intraprovincial air emissions, the provinces establish their own targets and policies. There are no emission standards at the federal level for the criteria pollutants. Binding federal standards exist for a handful of toxic compounds, with plans to establish more for other toxics. Virtually all of Canada’s air-pollution policies are command and control. This is contrasted with the use of TEPTEP transferable emission trading in the United States to address sulphur dioxide emissions. Federal and provincial policies will be examined together.

Guidelines for Criteria Air Contaminants

The federal Clean Air Act (CAA), enacted in 1971, is the backbone for ambient air-quality guidelines in Canada. The act gave the federal government the authority to

- conduct a national program of air-pollution surveillance;
- establish air-quality objectives (i.e., targets);
- establish regulations including standards at the source; and
- establish guidelines, which were recommended limits on pollutants.

Under the CAA, the federal government adopted national ambient air quality objectives (NAAQOs) for the criteria pollutants defined above. A federal–provincial advisory committee on air quality developed the objectives. The provinces can adopt these NAAQOs as objectives or enforceable standards if they wish. Most have chosen to adopt them as guidelines; some have more stringent targets. The objectives are set at three levels:

1. The maximum desirable level is the long-term goal for air quality to protect the population and ecosystems. It provides a basis for preventing degradation of air quality in relatively unpolluted parts of the country.
2. The maximum acceptable level is the next lower level of air quality. It is seen as the level of air quality needed to provide adequate protection against adverse effects of air pollutants on human health and comfort, soil, water, vegetation, animals, materials, and visibility. At or near the maximum acceptable level, susceptible populations (children, the elderly, and those with chronic lung and cardiovascular disease) may incur adverse impacts. This is the target against which Environment Canada typically reports ambient air quality.

3. The maximum tolerable level represents the lowest boundary before immediate action is required to protect the health of the general population. Currently, only ground-level ozone exceeds the maximum acceptable level in major urban areas of Canada on an average annual basis. In 2000, the government determined that the CACs had either no or a very low threshold above which damage to health and the environment occurs. The implications are that there is to be a new NAAQO framework that has two levels:
   - A reference level above which there are demonstrable effects on human health and/or the environment;
   - Air quality objectives that provide a level of protection for the general population and the environment that also incorporates the technical feasibility of controlling emissions.

The Environment Canada webpage (www.ec.gc.ca, accessed 10 October 2010) indicates that the existing NAAQOs have not yet been revised with these two levels in mind. Environment Canada publishes the maximum desirable concentrations and the maximum acceptable concentrations. Health Canada continues to define the NAAQOs for the three levels. It remains to be seen how the conversion to two levels will alter the levels specified in the guidelines.

Table 17-1 lists the current NAAQOs for the five pollutants covered. These objectives were designed to stimulate the provinces to enact their own regulations. In establishing these objectives, the federal–provincial committees apparently reviewed scientific information as well as economic, social, and technological factors. The deliberations of these committees were not public, so there is no evidence on exactly how a particular air-quality objective was chosen. However, Canadian objectives are closely related to those in the United States as well as to the World Health Organization’s guidelines.

There are guidelines and standards for emissions of certain air pollutants. Under the Clean Air Act (now CEPA), emission guidelines were created for the cement industry, coke ovens, asphalt paving, mining in the Arctic, types of incinerators, the wood pulp industry, and thermal power generators. In each case, there is a distinction between old and new plants. The guidelines are less stringent for old plants, that is, those already in existence at the time the guidelines were introduced. In some cases, the old plants are required to meet the guideline, but are given a longer time in which to do so than the new plants. There are federal standards for lead from secondary smelters, asbestos from mining and milling, mercury from chloralkali plants, and vinyl chloride from vinyl chloride and polyvinyl chloride manufacturing. Note the overlap between this list and that of the federal water-pollution standards. In the case of these standards, old and new plants are treated symmetrically. This might be because some of these compounds, such as mercury, are quite toxic.

Table 17-1: Canada’s National Ambient Air Quality Objectives (NAAQOs)

The first specific air-pollution standards were established in 1963 in Ontario, under its Air Pollution Control Act. Maximum concentrations for 13 substances at the point of impingement were established for stationary sources of pollution. This is defined as the point where pollutants from a factory stack or other discharge point first encountered the ground, a building, or other object. Point of impingement is therefore an ambient standard that is applied to all pollution sources. No source can release emissions that result in a concentration exceeding the standard
at each point of impingement. By 1974, the list of regulated substances reached 100. The key difference between air-pollution and water-pollution regulations in Ontario is that the former apply to any source. Recall that water-pollution discharge guidelines have been in the form of negotiated licences between the government and specific polluters. Air-pollution regulation covers emissions from all sources. Since 1983, the province has been revising its regulations. It is moving from point of impingement standards based on scientific and health studies to BATEA standards, analogous to those planned under MISA. Draft regulations were released in 1990.

Ontario, Newfoundland and Labrador, and Manitoba are the only provinces that use or have used point of impingement concentrations for their air-quality regulations. Saskatchewan sets ambient standards that specify maximum concentration levels for pollutants such as particulates, oxidants, and nitrogen dioxide. If there are multiple sources of a pollutant, the aggregate discharge from all sources must not exceed the ambient standards. These standards are thus analogous to point-of-impingement regulations. British Columbia and Nova Scotia have air-quality objectives. Alberta, Quebec, and New Brunswick have imposed regulations. These objectives and regulations are based primarily on the NAAQOs. Alberta, for example, sets emission limits for visible emissions, particulates, lead from secondary smelters, and vinyl chloride. There are guidelines for the fertilizer industry, asphalt plants, and ammonia storage. The guidelines and standards are based on BPT—best practicable technology. Before continuing the discussion of Canadian air-pollution policy, we will consider some issues that challenge policy-makers.

POLICY ISSUE #1: How do we protect areas that have higher air quality than the maximum acceptable level (the non-degradation dilemma)?

The three levels of NAAQOs take into account the existing level of pollution in a region. The maximum desirable level is supposed to guard against having a region’s air quality degrade to the maximum acceptable level. Canada’s ambient emission guidelines are basically weaker versions of the U.S. ambient standards in that they are not binding and do not address the problem of how to prevent degradation of areas with air quality better than the national standards. This is the non-degradation dilemma. In the U.S., there was widespread concern that cities in areas with air quality already better than the national ambient standard could compete unfairly for new industrial development. New firms might be attracted to these areas by the promise of less strict emissions controls than firms would face in areas where air quality was already worse than the standards. In 1977, amendments to the U.S. Clean Air Act differentiated PSD areas (PSD stands for “prevention of serious deterioration”), and non-attainment areas. Non-attainment areas have lower air quality than required by the NAAQOs. Stricter technology-based effluent standards would apply to PSD regions, where air quality was already better than the standard, than to non-attainment regions.

The PSD policies can give existing firms a significant competitive advantage compared to a new entrant to an industry. The new entrant is likely to face significantly higher MACs because it has to meet a tougher standard than existing firms in its industry. If new entry does not occur, this can make consumer prices higher than they otherwise would be. Secondly, is it really cost-effective to have a PSD (non-degradation) policy? A cost-effective policy has the MACs of all polluters equal on the margin. A non-degradation policy could, in principle, be chosen so as to have the MACs equal, acting like an individual standard. But, as shown in Chapter 11, it would take a tremendous amount of information for governments to choose the “correct” individual standards. Market-based policies such as emission markets/TEPTEPs and taxes might be alternative policy choices.

POLICY ISSUE #2: Should old plants be treated differently than new plants?

Federal standards in the U.S. are often less stringent for older plants than for new plants in any location. For example, the U.S. regulates emissions from stationary sources of air pollution with technology-based standards (TBS) that can differ between existing and new sources. New sources, or existing sources that are modified in some major way, are usually held to stricter standards than existing, established sources. This is called a new-source bias.

The case for holding new sources to stricter standards than those applied to existing sources is usually made on the basis of cost; it normally costs more to retrofit existing plants with pollution-control equipment than to incorporate the equipment into new plants when they are being built. In effect, the argument is that the marginal abatement costs of existing plants are normally higher than those of new plants, so cost-effectiveness justifies more restrictive emission standards for the former than for the latter.
To a large extent, this is probably an economic argument being used to justify a course of action that is politically expedient. It is easier to put stricter limits on new sources than on existing ones because, by definition, the former will have less political clout than the latter. And existing firms may not be so opposed to applying stricter controls that make it relatively costly for new competitors to get into business.

From an administrative standpoint a new-source bias is also easy to understand. In any given year there are many times more existing sources than there are new or modified sources, so more administrative resources may be concentrated on the latter. A focus on new sources also implies a gradualist approach, since it means that stricter standards will gradually spread through the various industries as old capital is replaced with new.\footnote{In the United States, the states have the primary responsibility to set TBSs. Because of this, there was some fear among federal policy-makers that economic competition among them would motivate some to set less-restrictive standards to attract business. Thus, the EPA is empowered to set a floor level for standards applying to new or modified stationary sources. These are called new-source performance standards (NSPSs).}

However, there may be problems associated with this policy principle. A new-source bias creates incentives to hold on to existing plants because they will be subject to less strict environmental standards than new or modernized plants. In trying to ease the transition to lower pollution levels through a new-source bias, governments may inadvertently slow up the rate of adoption of new pollution-abatement technologies. If so, this can mean that MAC curves will shift down more slowly than would be the case without the more restrictive standards for new sources. Not only does this increase total costs of meeting a given target, it also impedes reaching targets with lower levels of emissions/higher environmental quality. Old, more costly technologies will have a MAC curve that intersects the MD at a higher emission level than could be the case with new technologies. This no doubt is an important reason why so many urban regions of the United States continue to suffer from substantial air-pollution problems many years after the beginning of the federal program.

**POLICY ISSUE #3: Uniformity of standards**

The NAAQOs are an example of a uniform target. New standards (see the section below on Canada-wide standards) are also to be uniform. This creates a policy problem. From the theory chapters, we know that unless marginal damage and marginal abatement costs happen to be the same in all regions, uniform national standards will not be efficient. They will be overly stringent where marginal damages are relatively low and/or marginal abatement costs relatively high; or not stringent enough where marginal damages are relatively high and/or marginal abatement costs are relatively low. Thus, standards cannot in general be efficient unless they are established with an eye toward both marginal benefits and marginal control costs. Standards that take into account differences in MACs and MDs across regions may be cost-efficient. They will, however, be much more complex to define and administer. Again, governments might do better by considering market-based policies such as TEPs and taxes.

\footnote{Canada–United States Ozone Annex: [www.ec.gc.ca/press/001207_b_e.htm](http://www.ec.gc.ca/press/001207_b_e.htm)
CCME Canada-Wide Standards: [www.ccme.ca/initiatives/standards.html](http://www.ccme.ca/initiatives/standards.html)

As noted in Chapter 15, a major initiative for Canadian air-quality regulation in the early 1990s was under the now-defunct Green Plan. Management plans to reduce ground-level ozone by setting more stringent objectives for NOx and VOCs were put in place. Various airsheds such as the Hamilton to Quebec City corridor and the lower Fraser River Valley in B.C. were the subjects of pilot studies on various policy options. However, few substantive policies have come from these plans. Slow progress continues at the federal level, two policies coming into force since 2000 are highlighted: the Ozone Annex and the Canada-Wide Standards (CWS).

**Ozone Annex to the 1991 Canada–U.S. Air Quality Agreement**


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In December 2000, Canada signed the Ozone Annex, an agreement with the United States to reduce transboundary smog. The overall target is to reduce NOx by 44 percent in the transboundary region by 2010. The Annex commits Canada to

- reduce emissions of NOx in Ontario and Quebec. An annual cap of 39 kilotons of NOx (as NO$_2$) is to be reached by 2007 for central and southern Ontario, while a cap of 5 kilotons is set for Quebec. The federal government has allocated funds to help the fossil-fuel electricity generators meet these targets.
- improve air pollution monitoring.
- ensure that Canadian fuels and vehicle emissions are in line with U.S. standards. As noted in Chapter 1, Canadian vehicle emission guidelines now align with those in the U.S.

These commitments suggest that Canada will continue to rely on command-and-control policies to reach environmental targets. While the policies will help reach environmental targets, a key policy question is whether they are the most cost-effective policies that could be used.

Canada-Wide “Standards” for Air Quality: Reinventing the Wheel?

In 1998, the federal government and all provinces except Quebec signed the Sub-Agreement to the Canada-Wide Standards for the Environment$^4$ (see Chapter 15). The goal of the sub-agreement is to set:

1. numeric limits for pollutants,
2. a timetable for attainment, and
3. a framework for monitoring progress and reporting to the public.

Notice that there is nothing said about the use of particular policy instruments or how the numeric limits will be attained. The Canadian Council of Ministers of the Environment (CCME) is charged with the task of coordinating and developing national air-quality standards to meet the first objective. The term “standard” is a bit misleading, as these are still to be non-binding targets. There is no penalty for violations of the standards, no consistent set of monitoring and enforcement across the country. These “standards” are better thought of as air-quality guidelines or objectives—the same concept as the NAAQOs.

Canadian Council of Ministers of the Environment: www.ccme.ca

To date, the provinces have ratified an agreement covering the following contaminants: fine particulate matter, ground-level ozone, benzene, and mercury from incineration and metal smelting. The Canada Wide Standards for particulate matter (PM$_{2.5}$) and ozone have been set as follows:

- Ozone: 65 ppb over an 8-hour average;
- PM$_{2.5}$: 30µg/m$^3$ over a 24-hour average.

A review in 2005 determined that these levels should remain in effect until 2015 while additional studies on the impact of these CACs on health and the environment continue.

The CCME approved in principle targets for dioxins and furans from waste incineration and pulp and paper boilers. Other sources of dioxins, furans, mercury, and benzene are under investigation for future standards. The federal government regulates sulphur content in transport fuels. For gasoline, the limit was 150 parts per million (ppm) from 2002 through 2004, then fell to 30 ppm on January 1, 2005 (but never to exceed 80 ppm). That level remains in effect today. Sulphur in diesel fuel was regulated beginning in 1998 with a limit of 500 ppm. The limit became 15 ppm starting June 1, 2006.
Did you know? Research done by the U.S. EPA found that burning trash in backyard barrels (something that is legal in many rural areas) releases more dioxins and furans than a municipal waste incinerator serving tens of thousands of residents. This is because the backyard burners cannot reach a temperature high enough to properly burn the wastes. They also have no pollution-abatement equipment attached to trap waste gases. Think about this when considering how Canada should regulate airborne dioxins and furans.

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The signing governments agreed to develop implementation plans, look for methods of pollution prevention in conjunction with industry, and work to prevent degradation of areas with air quality already cleaner than the standards. They will work together to avoid overlap and duplication, share expertise, promote consistency across the country, and seek cost-effective mechanisms to reach the targets. The new standards take effect by 2010. Provinces have agreed to report to the public on progress toward meeting the targets and produce yearly reports each September beginning in 2011.

What sort of policy is this? Some key points are as follows:

- Provinces can design their own policy instruments to reach the targets. This may make sense in the context of air pollutants. There are pros and cons of provincial control over policy instruments. A pro is flexibility in adapting the policy instrument to the particular needs of the region—its sources of emissions, geography, and so on. For example, Ontario has introduced a tradable emission scheme to reduce sulphur and nitrogen oxide emissions from electricity generating plants. A con is that a polluting company that operates in more than one province could face 10 different sorts of policies that govern its operations. Using the discussion in the preceding chapters in Section 5, think about other arguments for and against provincial design of policies.

- The accord emphasizes the use of command-and-control policies. Studies done in the U.S. suggest that while these policies may achieve their targets they are not cost-effective. These findings are illustrated in policy issue #4.

POLICY ISSUE #4: Inefficiency of command-and-control (CAC) policies

Environmental economists have estimated the excess costs of the command-and-control (CAC) approach to air pollution control inherent in technology-based standards. The analyses involve complex models that incorporate economic factors, such as control costs at each source, with emission and meteorological factors that show how ambient air quality is affected by various patterns of emissions. The models are used to simulate a least-cost approach to achieve a given environmental target and compare that to TBSs under CAC policies. A multitude of studies done in the United States find that CAC programs cost more than market-based approaches to achieve a specific level of improvement in air quality. Ratios of CAC costs to a least-cost program range from 1.07 to 22.0. The problem with not being cost-effective is not just that society is paying much more than is necessary to get the improvements in air quality, though this is certainly a serious shortcoming. The real problem is that the actual control programs are so much more costly than they need be. This creates an aggregate marginal abatement cost function that is much higher than it need be, and means that society is probably settling for smaller improvements in ambient quality than might be achieved if control programs were fully cost-effective.

- Canadian governments could use a number of incentive-based policies to meet their targets. These could include taxes on the pollution content of fuels that in combustion produce the criteria pollutants, or an increase in existing federal and provincial excise taxes on fuels. Governments might use the concept of environmental tax shifting as noted in Chapter 1 to help the public and corporations accept any new taxes that might be introduced. Tax shifting involves the introduction of an environmental tax that corrects an economic distortion and the recycling of the tax revenue received back to the economy in the form of lower taxes on income, savings, investment, and so on. The important point is that the environmental taxes introduce a price for pollution, while the tax shifting ensures that the overall tax burden for society does not rise. Alternatively, a transferable
discharge permit might be introduced for various pollutants. This option is examined later in the chapter. Or, the governments could continue to follow their path of using standards for things such as the sulphur content of fuels. Think about which of these policies is likely to best achieve the targets in a cost-effective way.

In summary, while the accord may lead to a new wave of environmental policies to help address regional and local air pollution, some skepticism is warranted. The federal government and the provinces agreed in 1990 to jointly cut air pollution. No significant policy initiatives occurred.

**Motor Vehicle Emissions**

The federal government regulates emissions from new motor vehicles under the *Motor Vehicle Safety Act*, which is now administered by Environment Canada under CEPA.\(^8\) These are called the corporate average fuel standards (CAF).\(^9\) As we saw in Chapter 1, there are specific standards for nitrogen oxides, hydrocarbons, and carbon monoxide. One question you may have had in Chapter 1 is, Why does the regulation cover only new vehicles? This stems from the federal government’s constitutional powers regarding trade and commerce. As we saw in Chapter 15, the federal government can regulate only interprovincial or international trade and commerce. Therefore, once a car leaves the assembly line, the provinces are responsible for any air-pollution regulations that apply.

8. Transport Canada administered these policies until the early 1990s.

9. The Canadian standards are harmonized with those in the United States. The North American automobile industry is so integrated across the countries that it would be very costly for producers to meet different standards in different countries, provinces, or states.

Most provinces have not regulated emissions of vehicles once in use. However, starting in 1992, in its AirCare program British Columbia introduced mandatory testing of all light-duty vehicles registered in the Lower Mainland that were more than a few years old. Emission standards for these vehicles have been imposed. Vehicles not meeting the standards must be repaired or will not be granted a licence to operate. The B.C. government offers owners of old vehicles that fail the tests a voucher that can be used toward the purchase of a fuel-efficient vehicle or a transit pass if they dispose of the old vehicle. Ontario implemented its Drive Clean mandatory testing program in 1999 for the Greater Toronto Area, and has extended the program to other areas of the province. There is continued debate about the effectiveness of vehicle monitoring programs. While the AirCare program claims to have reduced air pollution by substantial amounts, it is not clear how much the program has contributed compared to other policies in place or to non-regulatory factors such as higher prices of gasoline leading to fewer kilometres travelled. Moreover, are these programs cost-effective? Some points will illustrate that they may not be. Mandatory testing can be an expensive method of ensuring people maintain their vehicles if only a small proportion of the total number of vehicles tested actually exceed the emission standards. The program could then be scaled down so only older vehicles or specific models (with maintenance problems) are tested. Annual testing also does not ensure compliance with standards every day. Remote sensing could also be used to detect high-pollution vehicles, and other forms of monetary incentives such as expanded buy-back programs for old vehicles (or higher fuel taxes) might be more cost-effective.

As suggested in Chapter 1, there is a fundamental problem with all the regulations currently in place. They are based on the emissions per kilometre travelled; there is no control for the total number of kilometres driven. Pollution may therefore initially decrease as emissions per car fall, but if there is an increase in the number of cars driven each year, and/or an increase in the number of kilometres driven, emissions may start rising again. In the U.S., for example, NOx emissions have stayed relatively constant despite fuel efficiency standards, due to an increase in the number of vehicles on the road and total miles driven.\(^12\) Recall the formula given in Chapter 1:

\[
\text{Total quantity of emissions} = \text{Number of vehicles} \times \text{Average kilometres travelled} \times \text{Emissions per kilometre}
\]

In devising a cost-effective way of reducing the total quantity of emissions, one would want to balance the three factors on the right side of this equation according to the equimarginal principle. In fact, the federal motor vehicle emission standards focus only on the last of these factors. Air pollution continues to be a serious problem in many regions because the first two factors in the equation have continued to grow. There has also been a shift in consumer taste to more pollution-intensive sport-utility vehicles (SUVs), light duty trucks, and minivans. As these vehicles replace smaller cars, emissions rise because these vehicles release more emissions per kilometre. The average fuel consumption of passenger cars in Canada fell from approximately 12.8 litres per 100 kilometres in 1977 to 7.4 litres per 100 km in 2003. However, if one includes light-duty trucks, fuel efficiency of all vehicles has not increased as much because the light-duty trucks make up a larger share of the market today than they did in the late 1970s and their fuel efficiency in 2003 was approximately 10.6 litres per 100 km. Estimates by Natural Resources Canada for 2005 show the average over all passenger vehicles ranges from 9.9 litres per 100 kilometres in Nova Scotia to 11.9 in Saskatchewan.

Another problem is with the maintenance of motor vehicles. As a car ages and accumulates kilometres, emissions can increase unless the equipment is properly maintained. Policies that increase the costs of new cars (such as the CAF standards) increase the average age of vehicles on the road, thus increasing the likelihood of improper maintenance.¹³

Vehicle emission policies in Canada and the United States rely on technological fixes to solve a massive air-pollution problem. The CAF standards of Canada are largely invisible to the public and may give the illusion that the technology will solve urban air-pollution problems. Without incentives to reduce kilometres travelled or the total number of vehicles, total emissions may not fall and society may be paying more than is necessary to reach targets.

What about other technologies to power motor vehicles? Electric cars generate no criteria pollutants, but where does the electricity come from to recharge the vehicles? If it is generated by power plants burning fossil fuels, we will simply shift the source of emissions but not their presence in the atmosphere. Hybrid vehicles are becoming more cost competitive, and changes in vehicle and engine construction are further reducing fuel consumption. Technologies such as fuel cells may become viable for mass production and fall in price. These other technologies also have no impact on the number of vehicles, so urban congestion would remain a significant problem.

This argues for more direct incentive-based approaches to mobile-source emissions. One approach that has been suggested is to levy a significantly higher tax on motor-vehicle fuels. With these fuels being more expensive, motorists would have the incentive to think more about their driving habits, organize their driving more coherently, reduce total kilometres travelled, shift to more fuel-efficient vehicles, use mass transit to a greater extent, and so on. The effects of the higher fuel price would filter throughout the transportation system and lead people to shift their behaviour in places where the marginal costs of doing so are lowest, much as they have done when fuel prices rise substantially.

Another suggestion is to place a tax directly on vehicle emissions. As part of each province’s annual vehicle licensing, the total kilometres that a vehicle had been driven could be recorded. This total could be multiplied by the emissions per kilometre, also measured at the time of licensing, to yield an estimate of total emissions in the preceding year. A tax could then be levied on these emissions. Unlike a fuel tax, which would have no direct incentive for drivers to worry about emissions, a tax on emissions would create an incentive to look at all the ways of lowering them, including reducing total kilometres driven, driving low-polluting vehicles, and so on. One attractive aspect of this approach is that the tax could be varied among regions to match the severity of regional air-quality problems.¹⁷

There is, however, a concern that this sort of tax would provide an incentive for people to tamper with their car’s odometer requiring methods of ensuring this does not occur.

How well would these policies work? Could we predict the total quantity of emissions? Economists can use information on elasticities to predict changes in a target variable. Table 17-2 presents elasticity estimates that might be helpful in choosing a policy to reduce vehicle emissions. Suppose for example that we want to see how demand for new cars that are “gas guzzlers” will decrease if we introduce a new tax on them. The elasticity estimate says that
for, say, a 10-percent increase in the price of the car, the quantity demanded will fall by 6 to 8.7 percent. How about a rise in fuel taxes? Here, a 10-percent increase in the tax will lead to a 1.8- to 10-percent fall in fuel consumed. Why such a big gap? The difference no doubt reflects the short-run versus long-run price elasticity of demand. With sufficient time, consumers can more readily change their behaviour in response to the price change. These sorts of elasticity estimates are key to undertaking benefit–cost studies of alternative policy instruments. What is clear to economists is that innovative approaches that go beyond technology standards will be required to meet air-pollution problems from mobile sources.

An example of an innovative policy used in Canada was the tax on leaded fuel. The federal government regulates the lead content in gasoline. By the 1970s airborne lead was recognized as a serious health threat, especially to children. In 1976, the lead content in gasoline was limited to 0.77 grams per litre. In 1990, this was reduced to 0.26 grams per litre. That limit, combined with federal taxation of gasoline, effectively eliminated lead as a fuel additive for automobiles. Some lead is still used in fuel for farm equipment, trucks, and fishing boats. The innovative part of the federal government’s policy with respect to lead in gasoline was that it used an excise tax to speed the switching by motorists to unleaded fuel. When unleaded gasoline first appeared on the market, it was more expensive than leaded. motorists whose vehicles were supposed to burn unleaded fuel had an incentive to “misfuel” by buying leaded fuel instead. Many did. In 1989, the federal government announced an additional excise tax on leaded gasoline of 1 cent per litre. Six provinces followed suit by increasing their own taxes on leaded gasoline. The tax differential between leaded and unleaded gasoline ranged from 1.5 to 3 cents per litre. Not only did misfuelling disappear, but most motorists switched to the now-cheaper unleaded gasoline. By 1992, leaded gasoline had disappeared from the retail market.\footnote{In the U.S., a lead-trading system was used for refineries in their transition from leaded to unleaded gasolines. It should also be noted that eliminating lead as an additive to gasoline may reduce one environmental problem while creating others. Benzene, toluene, and xylenes are added to motor vehicle fuels to help engine performance. Each of these are known carcinogens and also increase emissions of VOCs.}

### Acid Rain: A Transboundary Pollution Problem

Sulphur dioxide is a transboundary pollutant in North America. The most serious problems occur in the eastern parts of Canada and the United States. In these regions, sulphur dioxide is responsible for the acidic precipitation that lowers the pH of susceptible lakes, damages forests and buildings, and may also contribute to health problems of susceptible individuals. The flow of sulphur dioxide both ways across the Canada–U.S. border has been the source of a political struggle between the two countries. There are barriers to an efficient solution to this cross-border pollution problem. Many levels of government are involved. The distribution of benefits and costs of reducing sulphur dioxide emissions are unequal across and within the jurisdictions. Scientific information about damages took time to be established, and was debated by the various interest groups.

In Canada, the major sources of sulphur emissions are metal smelting companies in Sudbury, Ontario and coal-fired electric power plants operated by Ontario Hydro (now Hydro One). While the Ontario government began

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<th>Table 17-2: Elasticity Estimates for Policy Options to Reduce Air Pollution Emissions from Motor Vehicles</th>
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<td><strong>Elasticity of</strong></td>
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<td>Vehicle travel with respect to fuel price</td>
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regulating the metal companies in the early 1900s, it wasn’t until the 1970s that acid rain became a topical issue in Canada. The major contributor to sulphur dioxide emissions in Ontario was from Inco, Ltd., the major producer of nickel in the world. The area around Inco’s smelter in Sudbury was largely barren due to sulphur dioxide emissions. The Ontario provincial government responded by requiring Inco to lengthen the height of the stack on its smelter. This regulation reflected thinking at the time that “the solution to pollution was dilution.” The “super stack,” as it was called, did result in fairly rapid improvement in Sudbury’s air quality. Scientists then began discovering that lakes in the Canadian Shield downwind of the superstack were becoming acidified and fish stocks were threatened. These lakes were susceptible because they lacked buffering capacity. The Great Lakes, for example, are not susceptible to acidification because their bedrock is mostly limestone, a highly alkaline mineral that neutralizes the sulphuric acid created by the sulphur dioxide emissions.


Canada saw acid rain as a bilateral issue because it “imports” substantial quantities of sulphur dioxide from the United States. The coal-fired power plants in the midwestern states, primarily along the Ohio Valley, have been the major sources of these transboundary flows of pollution. Until the 1990 amendments to the U.S. Clean Air Act (discussed below), Canada took the position that the United States was not “doing its share” in regulatory actions to protect the environment from acid rain. Even though this was a bilateral problem, U.S. “exports” of sulphur dioxide to Canada exceed Canadian exports to the U.S. Canada’s position was that the ambient air quality standards in the U.S. weren’t strong enough. One reason for this was that certain states were not implementing the national standards—specifically, those in the U.S. midwest that were heavily dependent on coal as the feedstock for their electricity-generating power plants. Another problem was the very slow phase-in of technology standards for existing plants. By the early 1980s, it was clear that strong actions from the U.S. were unlikely. This position reflected in part the fact that Canada would benefit more than the U.S. from sulphur dioxide controls, while the U.S. would bear the largest proportion of control costs. The official view of the U.S. federal administration at the time was that not enough was known about the problem and additional scientific research was needed before more stringent regulations would be passed.

20 Note in Table 17-1 that the U.S. ambient air quality standards for sulphur dioxide remain more lenient than Canada’s ambient guidelines.

21 And certain regions of the U.S. would bear some of the highest costs, namely the high-sulphur coal-producing region of Appalachia (e.g., states of Kentucky and West Virginia). These regional inequities and the political fallout were a factor the U.S. had to contend with.

22 This argument is used frequently by regulators in Canada as well as the United States. Canada has many examples of inaction on environmental policies because it is necessary to further study a problem. See the discussion on greenhouse gases in Chapter 20.

In Ontario, acid rain was a major issue. Many environmental groups took part under the umbrella of an organization called the Canadian Coalition on Acid Rain (CCAR). The CCAR began a massive lobbying effort in Canada and the U.S. that ultimately succeeded in accomplishing the regulatory targets it had established. Its efforts were supported by the federal and Ontario governments, who were happy to keep attention focused on the United States as the main culprit. Canada became increasingly frustrated with the lack of action in the United States and began taking unilateral action while continuing scientific studies to document damages. Ontario imposed increasingly strict emission limits on Inco and Ontario Hydro. In 1982, the federal government announced a federal–provincial agreement (for all provinces east of Saskatchewan) to cut sulphur dioxide emissions by 50 percent of the 1980 levels by 1990. This plan was to be contingent on the U.S. following suit. The U.S. federal government rejected the plan and nothing was done until 1985, when Canada adopted the plan unilaterally. As part of the plan, the federal government was to contribute $150-million to assist the mining industry in complying. Provincial subsidies were also forthcoming. The government in Ontario also extended its acid rain commitments to include all major sources of SO₂, and brought in regulations that would reduce emissions by 67 percent of their 1980 levels by 1994. The other eastern provinces implemented regulations over the next few years.
The Canadian program has succeeded in significantly reducing emissions and meeting the targets. The CCME reports every two years on the progress toward goals as part of the Canada-Wide Acid Rain Strategy for Post-2000. SO\textsubscript{2} emissions fell by 38 percent overall from 1990 to 2006, while NO\textsubscript{X} fell by 7.6 percent. Figure 17-1 illustrates the major reduction in SO\textsubscript{2}, with less success for NO\textsubscript{X} to 2006, and provides projections to 2015. Some lakes are beginning to recover, but not as quickly as scientists had hoped. Studies are underway to see if further reductions in SO\textsubscript{2} emissions are needed. The Canada-Wide Acid Rain Strategy for Post-2000 calls for

- new emissions targets in eastern Canada,
- pursuing emissions reduction commitments from the United States,
- ensuring the adequacy of acid rain science and monitoring, and
- minimizing growth in areas that currently have low emissions levels (a non-degradation objective).

**Figure 17-1**: Emissions of Sulphur Dioxide (SO\textsubscript{2}) and Nitrogen Oxides (NO\textsubscript{X}) in Canada

A very significant policy change that has dramatically reduced SO\textsubscript{2} emissions in the U.S. occurred with the passage of the 1990 Clean Air Act Amendments.\textsuperscript{23} This is the Act that established a TEP market in the U.S. for sulphur dioxide—the next topic.

Another factor that contributed to reductions in SO\textsubscript{2} emissions in the U.S. was the substitution of coal from the western United States that had a lower sulphur content for eastern, high-sulphur coal as a fuel in power plants.

TEPs for Sulphur Dioxide

In the mid-1970s the EPA began to experiment with limited forms of trading pollution rights.\textsuperscript{24} These plans were, and are, meant to be strictly secondary to the primary approach based on technology-based standards. The 1990 Clean Air Act Amendments established an innovative new permit-trading scheme for the control of airborne SO\textsubscript{2} emissions.

\textsuperscript{24}See Chapter 15 in B. Field, Environmental Economics, 2nd ed. (Boston, MA: Irwin McGraw-Hill, 1997) for details on these policies.

The simple outline of the TEP system is as follows. The EPA issues a quantity of emission permits to designated power plants. Each permit will allow the release of 1 ton of sulphur dioxide from that plant; if, for example, operators of a particular plant have 20,000 permits, this plant would be allowed to emit a maximum of 20,000 tons of sulphur per year. The permits may be traded at prices agreed upon between buyer and seller. The purpose of a TEP program like this is to achieve a reduction in total SO\textsubscript{2} emissions at much lower cost than if all plants were required to meet the same proportionate reductions or if all firms were held to the same TBSs. The law calls initially for a reduction of approximately 20 percent from estimated total sulphur emissions of 1980, and a further 20-percent reduction in later years. The program represents a very substantial departure from the command-and-control approaches of the past. If it works according to expectations—at least, the expectations of many environmental economists—it should save considerable amounts of money and give a big boost to the application of incentive-type measures to other environmental problems.

Initial Permit Distribution

The program has two phases. The first ran from 1995 to 2000 and was limited to 110 electric utility plants located in 21 Eastern and Midwestern states. The plants involved were large coal-burning plants that currently emit more than 2.5 pounds of SO\textsubscript{2} per Btu of fuel used. Each of these plants will be allocated a prescribed number of permits (or “allowances,” as they are called by the EPA). These allocations were calculated with the following formula:

\[
\text{Number of permits} = \frac{\text{Average Btus of fuel used (in millions) from 1985–1987} \times 2.5 \text{ pounds of SO}_2 \text{ per million Btus}}{2500 \text{ Btus}}
\]

The formula gives more permits to larger plants, as measured by the average quantity of fuel used during the base period 1985–1987. It is not exactly an equiproportionate system, but it moves in that direction by using a common sulphur conversion factor—2.5 pounds of SO\textsubscript{2} per million Btus of fuel—to calculate initial allowances. Two plants burning the same amount of fuel end up with the same permit allocation, even though one of them may have put more effort than the other into reducing SO\textsubscript{2} emissions. But since the plants are all large coal-burning plants, the formula in effect treats them roughly the same.

The initial allocation totalled 5,489,335 permits. About 57 percent of these went to power plants in five states: Ohio, Indiana, Georgia, Pennsylvania, and West Virginia. In a special Phase I allocation, additional permits were given to power plants in Illinois, Ohio, and Indiana.\textsuperscript{25} The EPA also held back large quantities of permits. It has a “bonus reserve” of up to 3.5 million permits, which can be used to allow certain states to accommodate growth in their electricity-producing sectors or to provide temporary delays to power plants that wish to install scrubbers\textsuperscript{26} to reduce SO\textsubscript{2} emissions. It also may auction off a number of permits, as well as sell a certain number at a fixed (real) price of $1,500 per permit. The EPA will have an additional reserve of permits that it may allocate to utility firms that undertake approved programs in energy conservation or renewable energy development.

\textsuperscript{25}The initial allocation of permits was probably the most controversial issue when the law was being hammered out because it determines how the overall cost burden of SO\textsubscript{2} reduction will be distributed among plants, states, and
regions. The extra allocation to the three Midwestern states was simply a way to help get their political support for the program.

26 A scrubber is a device for treating stack gases; it can remove up to 95 percent of the sulphur in the gas.

Phase II, started in 2000, extended the program to cover power plants throughout the country with capacity of 25 megawatts (MW) or larger. This adds approximately 1,000 power plants burning coal, oil, or natural gas. The formula for allocating permits will be much the same as in Phase I except that the SO$_2$ index will be lowered to 1.2 pounds of SO$_2$ per million Btus of fuel used. Furthermore, Phase II requires an overall cap of 8.95 million permits given out by the EPA. The program has been a resounding success in terms of reductions in emissions. Total U.S. emissions fell from 11.8 million tons (U.S. short tons) in 1995 to 5.7 million tons in 2009. The price of allowances were somewhat volatile as the participants learned how the market operated, but settled down to a level of about $150 to $200 per ton until 2003. In 2003, the EPA announced the Clean Air Interstate Rule (CAIR) that required utilities in the eastern United States to reduce their emissions beginning in 2005, with significant reductions to occur by 2010. The reason for this rule is that emissions in the eastern part of the US have a much larger adverse impact on environmental quality and health than emissions in other parts of the US. These are the emissions that flow into Ontario and Quebec as well as New England. The rule called for reductions of 60 to 70 percent below the 2003 levels. The immediate impact was a large spike in the price of allowances, rising to $1600 per ton in 2005. A legal challenge to the CAIR was launched by some utilities and the state of North Carolina, arguing CAIR violated the Clean Air Act and that the EPA overstepped its authority. The U.S. Court of Appeals agreed and required the EPA to develop new regulations. The allowance market was allowed to operate while the new rules were under development. The price of permits began to fall precipitously as utilities were uncertain about their future demand. In July 2010, the EPA announced new regulations that would significantly limit the use of the market and instead focus on emission reductions mandated at the plant level. These regulations sound much like individual technology-based standards. Not surprisingly, the value of allowances is approaching zero. It appears that the experiment with a cap and trade system for sulphur dioxide may be over. Time will tell if the market can be revived with further regulatory changes or new court challenges.

EPA'S Airmarket Fact Sheet: http://www.epa.gov/airmarkets/trading/factsheet.html.

**Did It Work? Is the Sulphur Dioxide TEP System Cost-Effective?**

Before changes in the regulatory environment in 2010, many economists examined the effectiveness of the TEP system for sulphur dioxide in the United States. A key question was: does the program run smoothly and produce reductions in SO$_2$ emissions at a substantial cost savings over a CAC-type program? The answer was yes for the following reasons.

1. TEP markets work best if utilities are allowed to use whatever means they find the cheapest (within reason) to reduce SO$_2$ emissions and then take advantage of this flexibility by buying or selling emission permits. This appears to have happened.

2. Prior to 2010, the EPA did not dictate technology choices made by utilities to reduce their SO$_2$ emissions. Control over technology will inhibit the market.

3. The move to greater competition in supplying electricity to consumers (though not without many problems in the U.S.) probably aided the efficiency of the market by increasing the number of buyers and sellers.

4. Provisions for banking permits allows utilities to hedge against future changes in their emissions due to demand for electricity or if sources expect more stringent government policy in the future as was the case with the introduction of the CAIR. Banking may inhibit the competitiveness of the market and lead to large price swings. The price volatility may decrease the effectiveness of the market. Banking can change the dynamics of the market in the short term and over time. Permits withheld from the market in a given year by banking may reduce the number of permits traded, thus shifting the supply curve to the left and leading to a higher price. The
holder has to reduce emissions accordingly. These permits may be later used by the holder or sold. If sold, there will be a higher supply of permits in that period, leading to lower prices, other things equal.

5. The increasing stringency of the regulations signaled increasing permit scarcity. As prices increase, producers have an incentive to look for cheaper ways of lowering emissions, thus reducing the number of permits they need. They are no longer constrained to use a prescribed TBS. Consider Figure 17-2.

The utility is initially operating with MAC\(_1\) and given \(E_1\) permits. Suppose the market price of a permit is \(P_0\). At this price, the utility could buy \((E_2 - E_1)\) permits at a total cost of \((a + b)\). It would save in total abatement costs (TAC) area \((a + b + c)\), for a net gain of area \(c\). Alternatively, suppose there is a new technology that reduces its MAC to MAC\(_2\). If it purchases the new technology, the utility can stay at emission level \(E_1\) and save area \((b + c + d)\) in TACs. Alternatively, the utility could control even more of its emissions and sell unused permits. At the permit price of \(P_0\), under the new technology the utility can sell \((E_1 - E_3)\) permits, earning total revenues equal to area \((f + g)\), and incur abatement costs equal to area \((a + e + f)\) for a net gain of areas \((g + b + c + d - e)\). What actually happens depends on the relative cost saving of trading versus buying the new technology under the different scenarios \((E_2\) versus \(E_1\) or \(E_3\)). Apparently, an equilibrium at \(E_1\) with MAC\(_2\) happened during the early years of the TEP system. There were relatively few permits traded but substantial reductions in abatement costs.\(^{29}\)


**Figure 17-2: Incentive to Invest in New Technology Rather Than Trade Permits**

![Image of Figure 17-2](attachment:figure172.png)

An electric utility may choose to invest in a new technology for controlling emissions rather than engage in permit trades. If MAC\(_2\) represents the new technology, the polluter will save area \((b + c + d)\) compared to staying on its initial MAC\(_1\). This may be a higher return than trading in a permit market. If the utility was initially allocated \(E_1\) permits, it can gain area \(c\) by buying \((E_2 - E_1)\) permits at a total cost of area \((a + b)\) and increasing its emissions to \(E_2\). If the amortized cost of the new technology is less than area \((b + d)\) each year, the utility will purchase the technology and not trade in the TEP market.
A study of the cost-effectiveness of the TEP system in its early years confirms that MAC curves declined considerably since the introduction of the program. This is due to technological changes that allow plants to operate more efficiently. The study estimates that this has lowered MACs by $50 per ton of SO2 released over the period 1990 to 2000. The second factor is lower coal prices. They are estimated to have decreased MACs by about $200 per ton of SO2. The graph above is thus representative of the sorts of changes going on and helps explain why in the early years of the TEP program there were fewer trades and at lower prices than expected. However, this is not to say that the TEP program was not effective. Quite the contrary! The TEP policy allowed polluters to find the most cost-effective way of meeting SO2 standards. They were no longer restricted to a mandatory TBE. Cost savings resulted.


This same study also considered whether or not the TEP system was cost-effective compared to a uniform emission standard and the least-cost solution (a perfectly functioning TEP system or efficient tax). They found that an efficient TEP system would incur total compliance costs of $552-million in 1995 (the first year of operation), compared to $802-million for the uniform standard. The efficient permit price would be $101 per permit. Actual compliance costs for that year were $832-million. In 1996, actual compliance costs were $910-million, compared to $751-million for the efficient market and $777-million for the uniform standard. The actual TEP system was therefore not cost-effective during its first two years. The authors caution that this result should not be extended to later years because all new policies have start-up costs (e.g., learning and administrative costs). Over time, they expect greater efficiency. However, the study cautions that an incentive-based system is not necessarily superior to all command-and-control policies.

A study using the MAC estimates from above undertakes a benefit-cost analysis of the TEP program and concludes that the program is an "environmental success." Not only is there 100-percent "environmental compliance," meaning that the emission targets are met, there was over-compliance in Phase I of the program—that is, utilities released less SO2 than the target level. Costs of the program were one-quarter to one-half of what was originally expected, due in large part to the flexibility given to firms to seek their cost-minimizing actions. The benefits of reducing SO2, the author argues, far outweigh the costs.


The TEP program represented a considerable innovation in U.S. pollution-control policies. It is the first large-scale example of a system of transferable discharge permits tried in the United States; in that sense, it represents a kind of laboratory for environmental economists, who have been talking for many years about the advantages of moving to economic incentive programs to combat pollution. Time will tell whether the system will recover from the recent court challenge and regulatory change that looks like the EPA is returning to a form of individual emission or technology-based standards. Canada can learn much from the U.S. experience—how to design regulations and use the market.

**SUMMARY**

Air-pollution control in Canada, like water-pollution control, is primarily a provincial responsibility. However, due to the transboundary nature of many air pollutants, the federal government has played a larger role than in the case of water pollution. The federal government provided a strong advisory role with the creation of the NAAQOs—national ambient air quality objectives for criteria pollutants. These are being followed by guidelines for other air pollutants under the Canada-Wide Standards program. These pollution targets are not binding on any province or polluter. It is up to each province to enact its own regulations. Most provinces have chosen to use the federal objectives as the basis for their guidelines and standards.

Policy problems associated with non-degradation and differential standards versus uniform standards were discussed. Canada and the U.S. still rely heavily on TBSs for air pollution regulation. Most economic studies of
these TBSs in air-pollution control show that for the total amount of money spent on pollution control they achieve only a fraction of the emission reduction that a fully cost-effective program would attain.

Vehicle emissions from new cars are controlled by federal design standards. Provinces have the authority to regulate emissions from mobile sources of air pollution. The largest urban areas in British Columbia and Ontario now have an annual system of vehicle exhaust inspections as part of vehicle licensing requirements. Little attention has been given to the important problem of reducing total vehicle kilometres in urban areas with seriously degraded air quality. The federal and some provincial governments used an incentive-based policy, an excise tax on leaded gasoline, in combination with a standard to eliminate the use of leaded gasoline in Canada.

The bilateral problem of acid rain led to unilateral command-and-control actions by Canada in the 1980s to reduce domestic emissions of sulphur dioxide. The U.S. finally agreed in 1990 to significant reductions in its emissions and introduced an innovative national TEP program that covers more than 1,000 power plants and other sources of SO₂. Canada can learn much from the U.S. experience and perhaps begin its own experiments with market-based environmental policies.

**KEY TERMS**

Banked permits, 338  
Elasticities, 333  
Environmental tax shifting, 331  
Maximum acceptable level, 323  
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Maximum tolerable level, 323  
New-source bias, 326  
Non-attainment, 325  
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**DISCUSSION QUESTIONS**

1. The federal regulation of emissions from new automobiles and light trucks means that those vehicles sold in rural regions meet the same emissions standards as vehicles sold in urban areas. Since there are a lot fewer vehicles in rural areas, this means that air quality will be a lot better in rural areas than in the cities. Is this efficient? Is it equitable?

2. What are the advantages and disadvantages of a new-source bias in stationary-source air-pollution control? Consider especially its impacts on the incentives of the operators of existing sources.

3. The U.S. utilities covered in the SO₂ TEP program may not be acting as competitive firms. Suppose they can pass along the permit costs to their customers in the form of electricity-rate price increases. How might this affect the TEP market? Could it still be an efficient market?

4. What are the regulatory problems governments might encounter in trying to reduce a transboundary pollutant? Is any one policy instrument better than another to deal with the intergovernmental issues?

5. Why do you think sulphur levels in diesel fuel are allowed to be much higher than sulphur levels in gasoline? Does this make economic sense?

6. Using the elasticity data from Table 17-2, choose one policy to reduce air pollutants from motor vehicles and show how effective it would be. Use economic arguments to support your answer.
7. Compare the NAAQOs in Table 17-1 with the data on ambient air quality in Figure 2-4. What conclusions can you draw about the impact of Canadian air-pollution regulations?

8. Using Figure 17-2, explain how the size of the reduction in MACs due to a new pollution-abatement technology influences a TEP holder’s decision whether to buy or sell permits in the market.