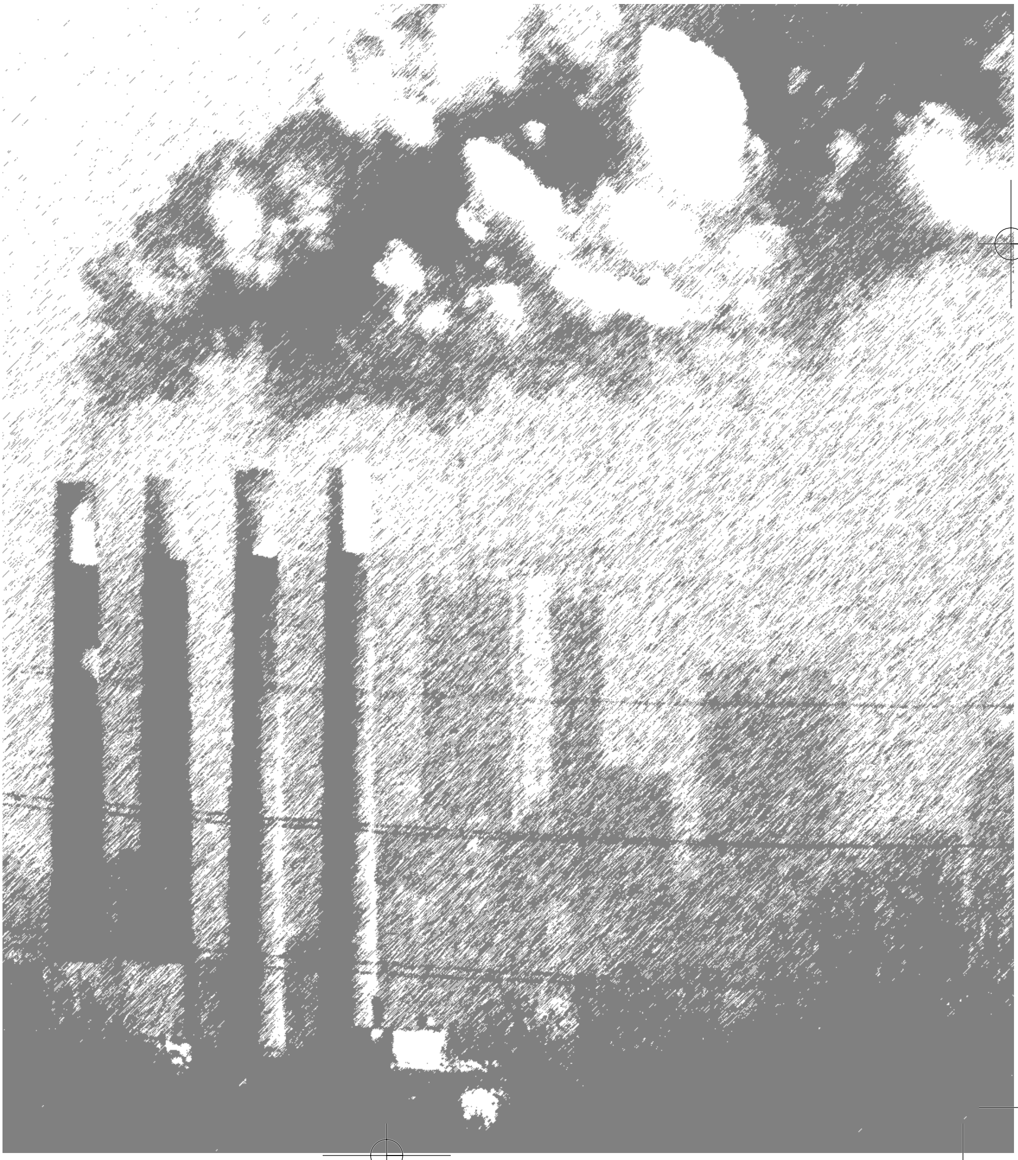
PART I THE POLICY CHALLENGES

CLIMATE CHANGE



CANADIAN POLICIES FOR DEEP GREENHOUSE GAS REDUCTIONS

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THE POLICY CHALLENGE

The litany of potential impacts associated with climate change is becoming familiar to anyone who regularly reads a newspaper or watches the news on television. Global average temperatures are expected to increase by between 2 and 6°C over the coming century. Temperature increases will continue to melt glaciers throughout the world as well as increase the rate of evaporation and precipitation, which will reduce water availability in many areas already facing potable water shortages. Melting glaciers and the thermal expansion of sea water are expected to gradually increase sea levels and potentially damage cities, infrastructure and populations worldwide. Rapid changes in temperature are also expected to significantly affect biological diversity and distribution, with as many as 20 to 50 percent of all species potentially facing extinction. While many species may be negatively impacted, others may thrive as a result of a warming climate; thus, many scientists foresee expansion in the range of tropical diseases like malaria and dengue fever as a result of climate change.

In addition to these and other gradual changes, scientists are particularly worried about abrupt, nonlinear changes resulting from increases in average global temperature. Key among these is the potential for rapid, irreversible melting or collapse of the Greenland and West Antarctic ice sheets. In 2002, part of the Antarctic ice shelf known as Larsen B, an area over half the size of Prince Edward Island and 200 metres thick, collapsed into the ocean, likely as a result of warming temperatures. Although the direct effects of this "small" collapse were limited, a similar collapse of larger parts of the West Antarctic and Greenland ice sheets could catastrophically raise sea levels by over 1 metre this century and up to 12 metres over several centuries. Researchers have also examined the possibility of dramatic changes in ocean circulation as a result of climate change. New evidence suggests that ocean circulation patterns can change very quickly (on the order of decades), and that this can dramatically alter land temperatures.

Although many impacts of climate change are expected to be felt most strongly in low-lying and developing countries, Canada is by no means immune from direct impacts. Temperature changes will likely be most significant at the earth's poles, which are predicted to warm at about double the average rate. A 4°C average global warming, near the central estimate for 2100, would therefore be expected to warm northern Canada by roughly 8°C. Such a change would obviously have dramatic effects on natural systems and on the human inhabitants of Canada's North. Other parts of Canada would probably suffer more prolonged water shortages and extreme weather events. Smog could be exacerbated due to higher temperatures in urban areas, and some pests, like the mountain pine beetle, could become endemic. Over the long term, agricultural and forestry output would likely suffer, even though productivity could actually increase in the short term.

Because of the emissions that have already been released, and because the greenhouse gases (GHG) that cause climate change stay in the atmosphere so long, the planet will be subjected to significant climate warming over the coming century unless technological advances enable us to extract GHGs from the atmosphere. The Intergovernmental Panel on Climate Change (IPCC) reports that to stabilize emissions at 550 parts per million (ppm) — roughly double the earth's pre-industrial concentration, and at the upper end of what most scientists consider acceptable — global GHG emissions have to reach their peak by 2020 to 2030 and decline quickly thereafter (IPCC 2007). With global emissions growing, and with the rate of growth increasing in step with rapid economic growth, particularly in developing countries, the global community will have to make a significant effort to stabilize emissions at 550 ppm. Some economists project that such an effort will impose costs of 1 to 3 percent of gross world product (Stern 2006).

Compounding the technical difficulty and high costs of action are the long time scale and global nature of climate change. While costs of climate change abatement are borne today by whatever party undertakes an action, most benefits of abatement are decades or even centuries away and would be spread throughout the entire world. Seen in this light, climate change is the ultimate public-good problem, which explains the effort that has been invested in coordinating international action and also helps explain negligible progress by national governments in the absence of an effective and truly global agreement (the current Kyoto Protocol to the United Nations Framework Convention on Climate Change [UNFCCC] sets targets for 2008 to 2012 that do not include the developing countries).

Canada produces over 2 percent of global GHG emissions, more than all but six other countries in the world, and it produces more emissions per capita than virtually any other country (UNFCCC 2005; Marland, Boden, and Andres 2006). Canada's emissions are also growing faster than those of most other industrialized countries —

they rose by 27 percent between 1990 and 2004 (Environment Canada 2006), primarily as a result of an expanding population, economic growth and increasing fossil fuel production (Rivers and Jaccard forthcoming). Since these are all expected to increase substantially over the coming decades, Canada's emissions will continue to rise quickly in the absence of strong policies designed to increase energy efficiency, prompt the switch to nonemitting fuels, and encourage the capture and storage of emissions resulting from continued fossil fuel production and use.[1]

The challenge of dramatically changing the course of GHG emissions, given the growth of these factors, is substantial. Politically, Canada is in a difficult situation in that jurisdiction over environmental problems is ambiguously divided between the provinces and the federal government. As an export-driven economy, Canada also faces pressure from business not to adopt environmental regulations that will place its companies at a competitive disadvantage compared with other commodity producers. And because of Canada's cold climate and vast territory, reducing its space-heating and transportation emissions even to current European levels presents a formidable challenge (Bataille et al. 2007).

Despite such challenges, any international agreement designed to tackle climate change will certainly require Canada to make substantial GHG reductions. If rich countries such as Canada do not take action, it will be impossible to convince poorer countries like China and India to do so. In this chapter, we therefore analyze a scenario in which, by 2050, Canada reduces its domestic GHG emissions by about 60 percent from today's level. This reduction is roughly consistent with emissions targets articulated by all of Canada's main political parties; with recent analysis conducted by the National Round Table on the Environment and the Economy; and with national targets set by the United Kingdom, Sweden, the European Union, California and other jurisdictions. The objective of this chapter is to describe a set of appropriate domestic policies for meeting this long-term goal of deep GHG reductions.

WHAT IS THE APPROPRIATE POLICY RESPONSE?

Criteria for choosing climate change policies

Climate change policy must provide strong long-run signals to motivate technological innovators, companies and consumers while avoiding unnecessary economic costs (Jaccard, Nyboer, and Sadownik 2002). The relative emphasis on certain policy tools to achieve this end and the ultimate design of a policy package involves many considerations and trade-offs. For instance, what may be most economically efficient or effective in realizing environmental benefits may be difficult from a standpoint of administrative feasibility or political acceptability.

Policy evaluation criteria have been forwarded in different contexts and by different organizations to assist environmental policy design (Department of Finance Canada 2005; IPCC 2007; Jaccard, Rivers, and Horne 2004). In this chapter, we evaluate policies based on the following criteria, which are common to most evaluative frameworks:

Effectiveness at achieving an environmental target

/ To what extent will the measure deliver its environmental objective? More specifically, how will the measure result in long-term sustainable reductions in GHG emissions by 2050?

/ Does the policy target the generation of GHGs directly, or does it do so indirectly — that is, by improving energy efficiency?

Economic efficiency

/ To what extent, from the perspectives of the government administrator and the firms/households subject to the measure, will emissions reductions be achieved at the lowest economic costs? Does the response to this question include a realistic consideration of consumer preferences (which are often ignored in cost analyses)?

Political acceptability

/ Will politicians find sufficient support to implement a policy?

/ Will Canada maintain the international competitiveness of industries producing goods that are traded in the international marketplace?

Administrative feasibility

/ Is the burden of administration, reporting, monitoring and enforcement acceptable?

In addition to these criteria, there are other important factors that should be considered in the context of GHG policy development in Canada. First, policy development will evolve from the interests and rights of multiple players within the political system and their relative power or influence in shaping policy. In the Canadian context, this is critical because multiple jurisdictions must be involved in enacting climate change policy (Bell et al. 2005). Of particular relevance is provincial jurisdiction over natural resources such as oil and gas, energy, mining, forestry and agriculture. A realistic assessment of policy must involve this dimension, and it should also include consideration of the options available for developing buy-in and of mitigating transitional impacts that may accompany policy implementation.

Second, while the focus of this chapter is on domestic policies, Canadian policies will be more effective if they are consistent with those of other countries and with international coordination mechanisms. The relationship to developments in the US is especially important. While ambitious policies in Canada may be hampered by the absence of such efforts in the US, innovative policy design and careful target setting may reduce the importance of this constraint.

Third, setting GHG policy is a classic case of decision-making with uncertainty, and this reality should be embraced instead of ignored or used as an excuse for inaction. This means that policies should be selected based on how well they perform (their robustness) under highly variable outcomes, and even highly variable reference cases. How might the economy evolve? What kind of international agreement might eventually follow the Kyoto Protocol? What will the US do, and how will its economy be affected? How will the pace and character of technological evolution change? How will our understanding of the costs and benefits of abating climate change evolve? Policies must be well positioned to incorporate unexpected technologies, to adapt to shifting targets, and to anticipate and mesh with international policy instruments. There is a great likelihood that policies developed today will need to be changed sometime in the future to accommodate an unexpected event or development, and they should be designed with this in mind.

Degrees of compulsoriness of environmental policies

Environmental policies should be chosen from the suite of available options based on their ability to satisfy each of these criteria. Policy options can be categorized in different ways. In this chapter, we describe policies in terms of their degree of compulsoriness — an important consideration, because it addresses the extent to which certain behaviour is required by government, which in turn helps to determine the efficiency, effectiveness and political acceptability of a policy. Policies that are noncompulsory involve government providing information or using moral suasion to encourage behaviour changes, while policies that are compulsory involve government mandating a particular choice or outcome, or using fiscal measures to change the market incentives for businesses and consumers. The following survey of policy options starts with the most compulsory and progresses toward less compulsory policies. Each policy is briefly described, and a discussion follows about how it performs relative to the policy evaluation criteria described in the previous section.

Command-and-control regulations are technology or performance standards enforced through stringent financial or legal penalties. This approach dominated environmental policy in the 1970s, and it is still important, although economists critique the regulations on the grounds of economic efficiency (Hausman and Joskow 1982). In particular, command-and-control regulations can be costly when they require identical equipment choices or management practices by firms or individuals whose costs of compliance differ considerably. Also inefficient are regulations that provide no incentive for companies or individuals to achieve emissions reductions beyond the legal requirement (Newell and Stavins 2003; Millman and Prince 1989). This traditional regulatory approach is therefore not ideal for stimulating large emissions reductions throughout the economy. Regulations that eliminate a subset of equipment choices may be justified where information or search costs are particularly high, and research has found that application of this type of regulation can deliver net benefits to consumers and to society in certain situations (Moxnes 2004). Regulations are often used to address market conditions associated with a lack of information; for example, over 50 countries, including Canada, use appliance efficiency standards that are periodically reviewed to account for new technological developments (Nadel 2002).

Market-oriented regulations impose an aggregate regulatory requirement on the entire economy or on a sector of the economy. Unlike traditional command-and-control regulations, however, this policy approach allows individual participants to choose whether they will take action or whether they will pay others to take action on their behalf. This negotiation is conducted through a permit or certificate market, and it can have an economically efficient outcome if the permit market works smoothly. We can distinguish two general types of market-oriented regulation based on the breadth of the policy and the focus of the regulation: emissions cap and permit trading; and obligation and certificate trading.

Emissions cap and permit trading was first proposed as an environmental policy instrument in the 1960s, and it has recently been used in several countries for control of local air pollutants, GHGs and other contaminants (Stavins 2001). An emissions-trading system sets an aggregate cap on emissions from a sector or multiple sectors of the economy and allocates tradable emission permits to all emitters covered by the program. The total number of permits allocated to emitters is equal to the overall cap on emissions. Permits are allocated by government, via either auction or free distribution to emitters.[2] At the end of each period (usually a year), each emitter must remit permits to the government sufficient to cover all the GHG emissions for which it was responsible. Emitters can trade permits (and, in some designs, they can purchase permits from entities outside the covered sectors), which will result in cost-effective emissions reductions if transaction costs are not prohibitively high and the market functions well.

Emissions cap-and-trade schemes are a form of regulation in that the aggregate emissions cap cannot be exceeded, participation is compulsory and penalties for noncompliance are severe. Unlike traditional command-and-control regulations, however, they allow participants to determine their level of emissions and whether they will buy or sell in the emissions permit market. In theory, emissions trading should result in exactly the same cost as a GHG tax for a given level of emissions reduction. In practice, it guarantees a certain amount of emissions, while costs are uncertain — in contrast to a GHG tax, which guarantees a certain maximum cost, while the level of emissions reduction is uncertain. Like a tax, a GHG emissions-trading system that focuses on carbon dioxide (CO_2) emissions from the fossil fuel industry can be applied upstream, on fossil fuel producers according to the carbon in the fuels they produce, or downstream, on CO_2 emissions at the point of end-use technologies.

An obligation and certificate trading system sets an aggregate obligation for a sector of the economy to produce a minimum amount of some desirable good — for example, a low-GHG technology, like a zero-emission vehicle or a process that captures and stores carbon. Certificates are earned by firms for units of the desirable good that are produced in each period. Certificates are tradable between firms, and the system can be designed to allow certificates to be banked for use in a future period or borrowed from a future period for use in the present; a safety valve can also be integrated to allow unlimited certificate purchases from government at a certain price, thereby ensuring an upper limit for the cost of this policy. At the end of each period, each firm must remit enough certificates to government to meet its obligation. This approach to environmental policy is very similar to an emissions cap-and-trade system, except while the latter regulates a maximum amount of an undesirable product (emissions), the obligation and certificate trading system requires a minimum amount of a desirable product or process.

Examples of obligation and certificate trading include the California vehicle emissions standard, which specifies a minimum aggregate level of zero- and low-emission vehicles in the California vehicle fleet but allows vehicle manufacturers to trade certificates among themselves in meeting the targets. Similarly, renewable portfolio standards for electricity, which exist in Australia, many European countries and about half the states in the US, require a minimum market share for certain forms of renewable energy production and allow trading between electricity generators to achieve the aggregate outcome. While both the emissions cap-and-trade system and obligation and certificate trading should cost-effectively meet their goals because of the flexibility resulting from trading provisions, there are notable differences between the two systems. First, while an emissions cap-and-trade system allocates emission permits to emitters at the beginning of each period in correspondence with the emissions cap, no certificates are allocated to firms in an obligation and certificate trading system — certificates are earned by firms when they produce a unit of the desirable good. Consequently, the obligation and certificate system avoids the politically sensitive issue of permit allocation, which can stall the implementation of an emissions cap-and-trade system. However, it also means that revenue is not generated for government through permit auction, which reduces potential government revenue but may improve political acceptability. Second, while the emissions cap-and-trade system necessarily focuses on emissions, the obligation and certificate system can focus on other targets. If the policy objective is emissions reduction, this may be less efficient, but it may also more effectively address market failures and barriers in particular markets.

GHG taxes require domestic emitters to pay a fixed fee per unit of GHG (measured in CO_2) released into the atmosphere. The emitter's response to the tax is to either pay the fee or reduce emissions to avoid it. In this sense, a GHG tax is not as binding as a regulation because it does not specify a particular action: the business or consumer chooses between taking no action to reduce emissions and reducing emissions. In theory, emitters will reduce emissions up to the point where the marginal abatement cost is equal to the tax. Since every emitter covered by the tax faces a uniform fee per tonne of CO_2, a tax system theoretically results in the lowest cost to the economy for a given level of emissions reduction (Baumol and Oates 1988). An emissions tax, unlike emissions trading, does not guarantee a particular level of emissions because emitters have flexibility to pay the tax or to reduce emissions (Weitzman 1974). As a result, it will likely be necessary to adjust the level of the tax to meet a given emissions target. A key economic advantage of GHG taxes is that they limit costs by allowing overall emissions to rise if abatement costs are higher than expected. GHG taxes can be applied upstream (on producers and importers of fossil fuels and other GHGs) or downstream (on final consumers of fossil fuels that produce emissions). GHG taxes raise government revenue, and government can use that revenue to offset other taxes. Alternatively, it could transfer the revenue to other regions or governments, increase spending or pay the revenue back in a lump sum to emitters. If government uses GHG tax revenue to offset other taxes that distort the economy (for example, income taxes or corporate taxes), the economy could benefit while GHGs are reduced. GHG taxes (and other green tax variations, such as environmentally motivated energy taxes) have been instituted in a number of European countries and are considered to have played a role in, for instance, the development of carbon capture and storage technologies in Norway. In practice, tax design has included refunds of taxes to vulnerable industries, differentials in the tax rates applied to industry and households, and exemptions to address equity and competitiveness concerns. Although most economists consider GHG taxes to be the optimal policy for deep GHG reductions in terms of economic efficiency, the Canadian public has to date been reluctant to consider new taxes (although there has been little opportunity for real public debate on GHG taxes). Even propositions to impose a revenue-neutral GHG tax — using the revenue from the GHG tax to offset other taxes — have been successfully portrayed by opponents as a government attempt to increase the overall tax burden (Svendson, Daugbjerg, and Pederson 2001).

Subsidies such as rebates, grants, low-interest loans and tax credits improve financial returns to businesses and consumers who take specified actions to reduce emissions. While this approach appears noncompulsory, governments generally acquire their funds from various types of compulsory taxes. As a result, while subsidies to low-emission technologies can influence the behaviour of consumers and businesses, governments generally lack the financial resources to induce large changes in GHG emissions through this method alone. Also, it is difficult to design subsidy programs to exclude free riders — participants who qualify for the subsidy even though they would have undertaken the action anyway. When free-rider effects are calculated, some subsidy programs prove to be much less effective, and thus much more expensive, than anticipated (Loughran and Kulick 2004). Finally, subsidies do nothing to discourage the development and dissemination of new technologies and products that emit GHGs, so this approach cannot be successful by itself.

Voluntary programs based on labelling and other forms of information provision, moral suasion and voluntary agreement allow individual companies and consumers to determine their own level of effort in the area of environmental protection, and they cast government in the role of information provider, facilitator, role model and award giver. Voluntary programs for GHG reduction and energy efficiency have formed a major part of past policy efforts, with programs directed at public outreach, industry energy efficiency and information provision to consumers and businesses. However, while the use of voluntary programs has been widespread, and while participating industry offers much anecdotal evidence of voluntary actions to improve the environment, it is difficult to estimate the aggregate effect of such programs (IPCC 2007; Harrison 1999). Recent empirical reviews of voluntary programs suggest that both their environmental effectiveness and their economic efficiency are poor (Organisation for Economic Co-operation and Development [OECD] 2003).

Using the criteria to choose policies from the menu

Each of these policies performs differently in relation to the criteria listed earlier. While no policy performs perfectly against all criteria, some do better against the suite of criteria than others. In developing GHG policy for Canada, it is important to choose policies that do not fare badly against any single evaluation criterion. In this vein, voluntary policies in general do not satisfy the environmental effectiveness criterion. Significant research has been conducted to determine the cost of deep GHG reductions, both in Canada and internationally (Energy Information Administration 1998; M.K. Jaccard and Associates 2003). Most peer-reviewed models predict long-run marginal costs of at least C$100 per tonne of CO_2 for deep emissions reductions. The cost is substantial, and so it is extremely unlikely that businesses and consumers will voluntarily reduce emissions on a large scale, even with government-provided information, education or moral suasion (Jaccard and Bataille 2003).

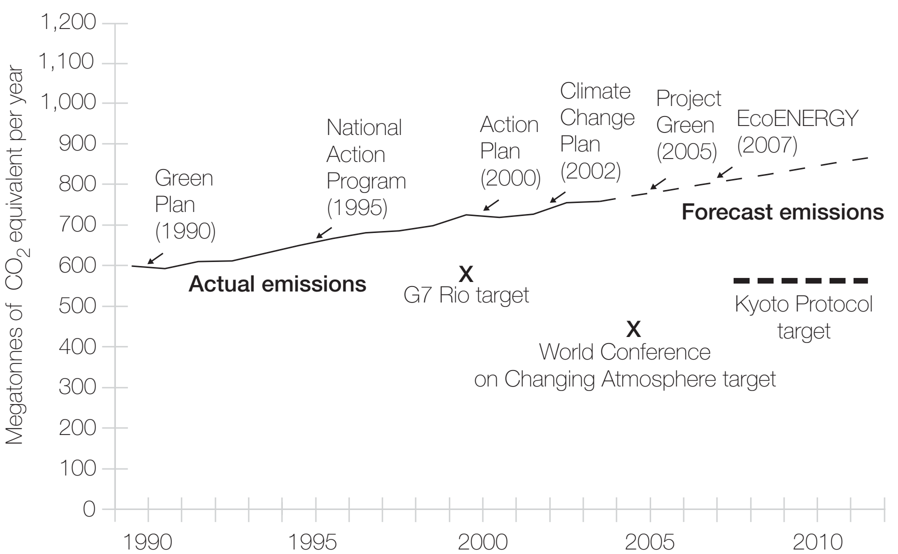
Even for small GHG reductions, we conclude — based on international and Canadian experience — that voluntary policy is relatively ineffective. For example, the Voluntary Challenge and Registry used in Canada in the 1990s to encourage businesses to reduce GHG emissions has been criticized for being ineffective (Bramley 2002; Takahashi et al. 2001). In Europe, the EU negotiated a modest voluntary agreement with automobile manufacturers, but these manufacturers are now falling short of their commitment (OECD 2005).

Like voluntary policies, subsidies are inappropriate for achieving deep GHG reductions. First, it is impossible to exclude free riders from a subsidy program, and they often represent more than 60 percent of total subsidy recipients (Loughran and Kulick 2004). Cost-effectiveness is further compromised by the rebound effect. By making a service cheaper, subsidies encourage increased consumption, which can offset some of the energy-efficiency gains (Greening, Greene and Difiglio 2000). Subsidies to energy efficient or low-emission technologies also fail to curtail the development of new technologies, products and services that produce GHG emissions. New products and services are appearing at an accelerating rate. Finally, a subsidy approach generally places government in the position of having to choose specific technologies to support, and most analysis suggests that government has a poor track record in this.

Canada's GHG policy approach has thus far been dominated by voluntarism and subsidies — an approach that, while politically attractive, has been largely ineffective at stemming fossil fuel exploitation and the consumption of fossil fuel products (natural gas, gasoline, diesel, jet fuel, heating oil) that emit GHGs. Figure 1 matches the evolution of Canada's emissions since 1990 with the voluntary and subsidy policy initiatives launched by a succession of Canadian governments, including the most recent ecoENERGY initiative of the Harper government. Independent research suggests that past policies had little or no effect; the figure clearly shows that they did not lead to declining emissions. The figure also shows the emission levels that Canadian governments were trying to achieve with their policies. An important lesson is that government statements about emissions targets are not credible if they are not accompanied by policies that have a high probability of being effective in reducing emissions — namely, policies that include substantial financial penalties or regulatory constraints on emissions.

In order to assess the likely effect on emissions of a continued reliance on the voluntary approach, we used the CIMS energy-economy model to simulate rising subsidy levels for GHG emissions reduction actions across the Canadian economy. This model uses empirical estimates of how firms and households respond to the financial costs, risks and qualitative attributes of technology options for energy services. Subsidies reduce financial costs of low-emission technologies, which should reduce emissions. But, as noted, there are important countervailing effects. First, a large proportion of the subsidies is captured by free riders. Second, efficient technologies have lower operating costs, which can cause some increase (rebound) in the demand for certain energy services and, more generally, a

FIGURE 1. ACTUAL AND PROJECTED GREENHOUSE GAS EMISSIONS, CANADIAN POLICIES AND INTERNATIONAL TARGETS



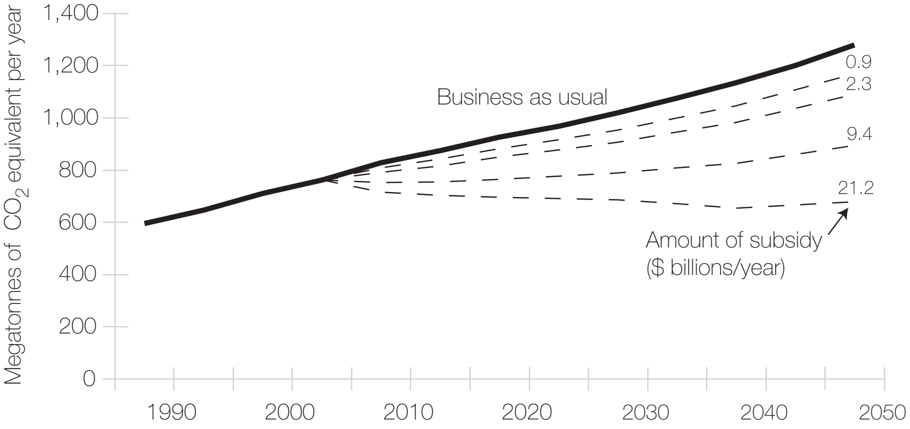
Source: Calculations by the authors using the CIMS energy-economy model.

long-term development of energy-using devices whose proliferation is in part stimulated by the gains in energy productivity from the subsidy programs.

The parameters in the CIMS model are based on 25 years of empirical research into government and energy utility subsidy programs in North America. Figure 2 provides the simulation of ever-higher subsidy levels on GHG emissions in the Canadian economy over the 45-year period 2005 to 2050. The simulation shows that even with a massive annual expenditure of $21.2 billion (1995 Canadian dollars), Canadian emissions are unlikely to fall below their 1990 levels by 2050. Even this level of reduction might not be achieved, since the simulation does not include a full estimate of the development and penetration of new energy-using and GHG-emitting technologies and services — like backyard patio heaters and roof de-icers. Yet this is a likely development in the absence of emissions caps, GHG taxes or regulatory prohibition of these technologies, especially as subsidy programs improve the rate of energy productivity innovations.

In designing our set of three key policies to meet the terms of this policy exercise for the Institute for Research on Public Policy, we therefore exclude voluntary and subsidy policies because they are largely ineffective.[3] We also rely only to a minor extent on traditional command-and-control regulations, as these would prove administratively

FIGURE 2. PROJECTED IMPACT OF SUBSIDIES ON CANADA'S GREENHOUSE GAS EMISSIONS, 1990-2050[1]



Source: Calculations by the authors using the CIMS energy-economy model.

[1] The broken lines show projected GHG emissions corresponding to different levels of government subsidy for emissions reductions. Monetary values are presented in 1995 Canadian dollars and costs are discounted using a social discount rate of 7 percent.

infeasible and economically inefficient when applied to a myriad of technologies across the economy. By imposing particular technologies and processes on all firms and consumers despite significant differences in their costs of abatement and preferences, government imposes disproportionately high costs on some. This can significantly reduce the political acceptability and increase the cost of command-and-control regulations. In addition, specifying regulatory standards for thousands of products throughout the economy is an enormous administrative task. Finally, command-and-control regulations provide little incentive for firms to develop innovative new technologies with dramatically lower GHG emissions, which will be critical in the future.

Although traditional command-and-control regulations are not appropriate to serve as the dominant policy approach for dramatic GHG reductions throughout the economy, some of these regulations can be cost-effective, administratively feasible and politically acceptable when they are used to consolidate gains achieved through other policies (Moxnes 2004). As a result, they play only a minor role in the policy package we describe here.

The policy approaches that perform best in terms of effectiveness and economic efficiency are ones that prohibit or financially penalize technologies and activities that emit GHGs. In other words, the only hope for substantially reducing GHG emissions in a market economy is to ensure that the atmosphere can no longer be treated as a free waste receptacle. The atmosphere must be valued. The policy options of interest, therefore, are either GHG taxes or market-oriented regulations on emissions, technologies and processes that force reductions in GHG-emitting activity.

There are many design options for these policy approaches. A GHG or carbon tax could be applied at the point of emission. GHG emissions from both large and dispersed sources can be accurately estimated based on the amount of fossil fuel consumed, since there is a direct chemical relationship between the amount and type of fuel and the GHG emissions released when it is burned. Instead of the carbon tax, an emissions cap and tradable permit system could be applied to large industries and energy supply facilities like oil refineries, thermal electricity generating stations and natural gas processing plants. This, in effect, is the "large final emitters" policy that Canada's previous, Liberal government tried to negotiate for almost 10 years and that the Conservative government resurrected in 2007 and presented as proposed new emission regulations for industry. Since large final emitters are responsible for about 50 percent of Canadian GHG emissions, the application of a cap-and-trade policy for these industries would raise the question of how to send the equivalent financial or regulatory signal to smaller emitters in light industry, the commercial sector, the residential sector and the transportation sector. One option is a GHG tax for smaller emission sources. Again, it would be fairly easy to link a tax to the carbon content in fuels used in smaller devices. And, possibly, the cap-and-trade system might be extended to all energy-related carbon emissions and perhaps even to other nonenergy GHG emissions. Yet another way to apply the cap-and-trade approach is to place a cap on the carbon content in fuels used and produced by the fossil fuel industry. This is referred to as "upstream cap and trade," since the regulatory constraint is applied to the upstream components of the fossil fuel industry. The advantage of this approach is that the costs of constraining carbon flows are passed down through the economy, so that the cap-and-trade system simultaneously affects large final emitters and all smaller emitters. This means, however, that the price of fossil fuel products would rise, just as they would with the carbon tax, and this would pose a political acceptability challenge.

Although these policies could cover all energy-related GHG emissions in Canada, there is evidence that the political acceptability (and perhaps even the economic efficiency) of such a profound, long-term technological transformation would increase if these economy-wide policies were complemented with sector-specific, market-oriented regulations to support the development of key technologies, energy forms and processes that need to be commercially available as businesses and consumers confront the rising costs of GHG emissions. There is also evidence that even some well-designed command-and-control regulations would improve consumer welfare in some circumstances.

Finally, another objective in policy design is to ensure that the policy does not force the premature retirement of existing infrastructure, buildings and equipment, as this would expose firms and individuals to substantial costs (Jaccard and Rivers 2007). To minimize these costs, policies should be designed to send long-run signals that will stimulate low-GHG innovations and technology adoption without significantly changing the operating costs of buildings and equipment, which, in any case, are likely to be renewed over the coming decades.

OUR POLICY PROPOSALS AND SIMULATIONS OF THEIR IMPACT

While other policy packages could certainly also be effective, we believe that the package we present here best satisfies the criteria we outlined earlier. It involves only three key policies: a carbon management standard that is very similar to the upstream cap-and-trade approach, a vehicle emissions standard and a limited application of appliance and building regulations. We will describe each in some detail and provide simulation of its impact on emissions.

A carbon management standard for fossil fuel producers and importers

The central policy requirement is an economy-wide instrument that imposes on GHG emissions a financial charge (a tax) or a regulatory constraint (a market-oriented regulation). While the options for this have their pros and cons, our position is that it is more important to emphasize the need for at least one of these options than to argue excessively about the relative superiority of one or the other. Canadian policy-makers do not appear to have learned this lesson, in spite of all the evidence of past policy failures. The recent Liberal federal government, the current Liberal opposition and the current Conservative federal government support the imposition of some form of emissions cap-and-trade regulation on large industrial and electricity generation sources, but none of them has considered deploying effective and efficient market-based mechanisms like GHG taxes or cap-and-trade regulation against the remaining 50 percent of emissions in the economy (the proportion not created by the large final emitters). And the cap-and-trade policies have numerous loopholes that allow industries to do something other than reduce emissions.

We believe that a GHG tax is the best policy to promote environmental effectiveness and economic efficiency, so this is our default policy recommendation. However, North American economists have been suggesting GHG taxes for 15 years with absolutely no success — emissions keep rising. If a carbon tax is simply unacceptable for political reasons, then some form of market-oriented regulation should be designed that approximates the environmental and economic effects of a GHG tax. Therefore, this is what we focus on in our proposal.

While major effort has been expended trying to establish a large final emitters cap-and-trade system over the last eight years, an effective market-oriented GHG regulation has yet to be implemented in Canada. In April 2007, the Conservatives proposed yet another version of the large final emitters regulation, but this latest incarnation contains several so-called flexibility mechanisms that allow industries to do something other than reduce their emissions. The policy gives emitters the opportunity to pay into a technology fund (which may or may not succeed in lowering the cost of future emissions reductions); it also subsidizes the efforts of unregulated emitters to reduce their emissions (an offsets program) and subsidizes emissions reductions in other countries using the flexibility mechanisms of the Kyoto Protocol. It is our assessment that the flexibility mechanisms in the initial Liberal version and the subsequent Conservative version of the large final emitters policy will severely limit the emissions reduction that occurs in Canada. Industry will look to emissions reduction actions elsewhere in the economy if these prove to be the cheaper option. However, while these actions may appear cheaper, given that they rely on subsidies (from large final emitters to smaller firms and individuals), they are still subject to the same ineffectiveness challenges that we have already described in relation to subsidy programs.

For these and other reasons, our key policy proposal is a variant of the upstream emissions cap-and-trade policy — with a wrinkle. Our policy borrows from the philosophy of other obligation and certificate trading programs, such as the vehicle emission standard and the renewable portfolio standard. We call this policy a carbon management standard.

Our carbon management standard is a form of market-oriented regulation that would require fossil fuel producers and importers to ensure that a growing fraction of the carbon they extract from the earth's crust does not reach the atmosphere.[4] This obligation would increase over time according to a preset schedule designed to allow the economy enough time to adopt the technologies required to achieve the standard. It would apply to fossil fuel producers and importers, and it would likely be based on measures and estimates from oil, gas and coal extraction activities; it would also apply directly to importers when their fossil-fuel-based product entered Canada.[5] (Fossil fuel exporters could receive partial exemptions from the obligation for exported carbon in order to limit the impact on their international competitiveness.)

The carbon management standard is different from an upstream cap-and-trade system in that it sets an obligation for a growing share of processed carbon to be captured and safely stored; a conventional cap-and-trade system for fossil fuel producers sets a cap on the overall amount of carbon-based fuels producers can sell. Rather than allocating permits to emitters in accordance with the cap, government would collect certificates from firms, and these would have to match the firms' aggregate obligations. At the end of every year, each producer and importer of fossil fuels would be required to remit certificates to the government in accordance with its overall obligation to ensure that a percentage of the carbon it has extracted from the earth is permanently stored. Substantial financial penalties would be levied on firms that failed to comply with the system. Firms participating in the system would be able to trade certificates in an established market. For increased efficiency, the system would allow firms to bank certificates acquired in one period for use in a future period and claim certificates from a future period for use in the present.[6]

By using this obligation and certificate approach rather than the conventional cap and permit approach, government would avoid politically and economically complex negotiations over initial permit allocation. Unlike a carbon tax, the policy would generate no revenue for government, and this would increase its political acceptability. But, like the upstream cap-and-trade system, the policy would cover all carbon flows in the economy. There are no loopholes that would allow regulated entities to subsidize unregulated entities; all carbon emissions in the economy would be covered by the policy.

Table 1 presents the carbon management standard in terms of the percentage of carbon that must be prevented from entering the atmosphere. Expressed in percentages, the carbon management standard functions, in one sense, as an intensity target. Rapid growth of the fossil fuel industry could offset in whole or in part the fact that a growing percentage of the carbon it processes is captured and stored. Only when the standard approaches 100 percent would its effect be closer to that of an absolute cap.

Using the figures in table 1 as an example, consider a coal-mining company that extracts 1,000 tonnes of coal per year. In each year of the period 2011-15, it must remit certificates to the government to indicate that 6 percent of the carbon in the coal it produces will never reach the atmosphere. (If the coal were pure carbon, the certificates would be for 60 tonnes of carbon.) The company could get these certificates by capturing some or all of the carbon as a solid or as CO_2 gas. More likely, it would purchase certificates from a coal-fired electricity plant, which would use coal for thermal purposes, or perhaps, in the future, from a coal-to-hydrogen gasification plant. These latter industrial activities tend to create lower costs for capturing carbon in solid or gaseous form and then permanently storing it. In any case, if the costs of capturing carbon are high relative to energy efficiency and fuel-switching alternatives (to nuclear or renewables), then the coal-mining industry will gradually lose market share over the coming decades. Society will gradually determine that shifting away from fossil fuels is cheaper than using fossil fuels without emissions, but the outcome will vary according to the resource endowments of each particular region.

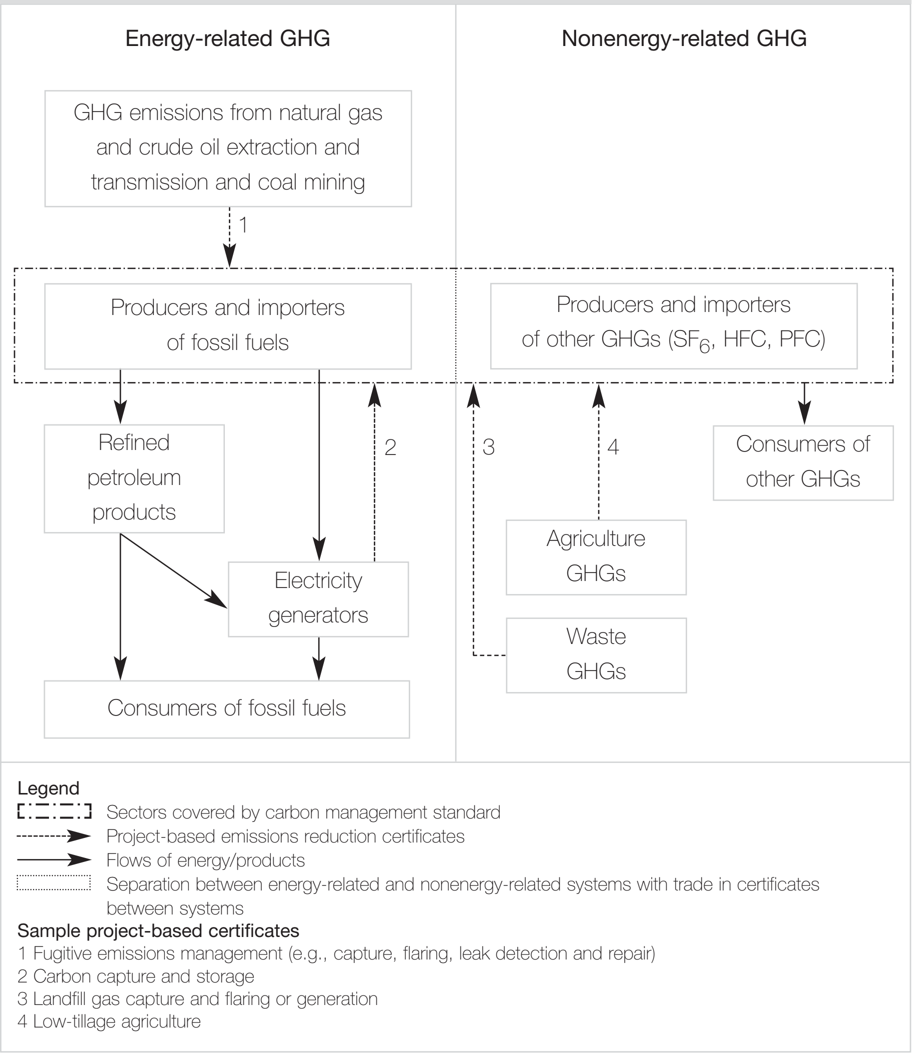
The carbon management standard would cover all carbon contained in fossil fuels, and it could also directly cover emissions of HFC (hydrofluorocarbon), SF_6 (sulphur hexafluoride) and PFC (perfluorocarbon) on the basis of their equivalent global-

TABLE 1. PERCENTAGE OF CARBON THAT MUST BE PREVENTED FROM ENTERING THE ATMOSPHERE UNDER THE CARBON MANAGEMENT STANDARD, 2010-50

2010	2011-15	2016-20	2021-25	2026-30	2031-35	2036-40	2041-45	2046-50
0	6	11	17	25	34	43	52	56

warming potential (the values presented in table 1 would change if these gases were included). The system could also allow noncovered sources to sell project-based certificates to firms directly covered by the carbon management standard. Potential projects would include carbon capture and storage projects throughout the economy, as well as projects to reduce fugitive emissions from oil and gas wells and to reduce methane emissions from the coal-mining and agricultural sectors. Projects would need to be certified through government or third-party audits, and certificates could be

FIGURE 3. DESIGN OF THE CARBON MANAGEMENT STANDARD



marketed through a central emissions exchange. Figure 3 shows the basic design features of the carbon management standard.

Careful design of the carbon management standard, including incorporation of a safety valve, monitoring, and certificate banking and borrowing, is critical if the policy is to function effectively and efficiently.[7] We do not address these issues in detail, but significant experience with design issues for economy-wide market-oriented regulations is available to draw upon through, among many other sources, the Emissions Trading Scheme of the European Union, the sulphur dioxide (SO_2) trading provisions under the US *Clean Air Act*, the California RECLAIM program for nitrogen oxides and SO_2 emissions, and the phase-out of lead from gasoline. In addition, there is a large theoretical and applied treatment of emissions-trading programs in the economics literature. As discussed earlier, the carbon management standard and emissions cap-and-trade systems applied to fossil fuel producers have many similarities.

A zero-emission vehicle standard for vehicle manufacturers

A vehicle emission standard (VES) is an obligation and certificate trading system that requires vehicle manufacturers and importers to sell a minimum number of zero-emission vehicles by a target date as a percentage of total vehicle sales. This market share percentage grows over time, thus creating and expanding an artificial niche market for low- or zero-emission vehicles. The goal is to reach a critical threshold at which the cost of producing the vehicles falls significantly and consumer acceptance becomes widespread. A VES, therefore, accelerates the process of developing, commercializing and disseminating low-emission vehicles, while letting industry pick technologies to meet the emissions criteria that are in accord with customer preferences. A per-vehicle penalty is charged to manufacturers who do not sell the required number of zero-emission vehicles, but manufacturers can trade among themselves to meet the overall target. A VES is therefore designed to give manufacturers significant flexibility in meeting the aggregate market outcome while bringing down the cost of innovative low-emission vehicles.

The development of zero-emission vehicles is critical for generating deep GHG reductions over a long period. Incremental price signals, as generated by the carbon management standard, are unlikely to quickly stimulate demand for zero-emission vehicles. The VES policy is designed to create a market for zero-emission secondary sources of energy in the transportation sector — namely, electricity and hydrogen, as well as biofuels like ethanol, methanol and biodiesel. The VES ensures that vehicles with engine platforms that use these sources of energy become available to consumers, as a policy like the carbon management standard gradually increases the cost of using fossil-fuel-based energy sources, like gasoline and diesel, to power vehicles.

California has had a VES in place since 1990 — the Zero-Emission Vehicle (ZEV) program. As part of the state's larger Low-Emission Vehicle (LEV and LEV II) programs to reduce smog-causing emissions, the ZEV program has aimed to commercialize vehicles with zero exhaust emissions under all operating conditions (a vehicle with zero local air emissions would also have zero GHG emissions at the point of end use). Although the California program has been amended several times and has faced legal challenges from vehicle manufacturers, the ZEV requirements still exist. In fact, they have been increased: by 2018, zero-emission vehicles must account for 16 percent of new vehicle sales (California Air Resources Board 2003, sec. 1962, title 13). Because a VES is already in place in California, and in a number of northeastern US states that automatically adopt California's regulations, the introduction of a Canadian VES should not cause competitiveness problems with the US. California, New York, Massachusetts and Vermont alone represented 18 percent of the US auto market in 2000, and vehicle manufacturers are already required to produce low- and zero-emission vehicles to meet the VES in those states (Larrue 2003).

Based on our simulations with the CIMS model, we present a schedule for specific requirements under the VES in table 2. For the policy simulated here, an aggregate target was set for vehicle manufacturers; in practice, government may distinguish between classes of vehicles (for example, cars and light trucks) in setting the standard. The VES could also be designed to allow manufacturers of low-emission vehicles to qualify for partial ZEV credits. This is done in California, where exceedances of the Ultra-Low-Emission Vehicle (ULEV) requirements are granted partial VES credit. The VES we design and model in this chapter applies only to passenger transportation, because experience exists with passenger transport VES in the US; in a comprehensive policy approach, the standard should also be applied to freight transportation, especially since zero-emission freight transportation vehicles may be more easily achieved in the medium term (Keith and Farrell 2003).

TABLE 2. SALES OF ZERO-EMISSION VEHICLES AS PERCENTAGE OF NEW VEHICLE SALES UNDER THE ZERO-EMISSION VEHICLE STANDARD, 2010-50

2010	2015	2020	2025	2030	2035	2040	2045	2050
0	1	5	10	20	35	50	65	80

Residential and commercial building codes and appliance and equipment standards

The application of the carbon management standard will result in relative price increases for carbon-intensive energy forms, which in turn will motivate more efficient buildings and equipment, as well as a switch to cleaner fuels for end uses in the residential and commercial sectors. However, the existence of an incentive split in residential and commercial rental and leasing (a split between those who would pay the investment costs of efficiency improvements and those who would receive the operating cost benefits via lower energy bills), as well as incomplete information on consumer decision-making, provides the rationale for a more targeted approach to improving energy efficiency and reducing emissions.

The most cost-effective way to lower GHG emissions in the building stock (through energy efficiency and fuel choice) is by means of design and construction, which strongly influence energy use in space heating, lighting, cooling, ventilation and water heating during the life of a building. Currently, Canadian provinces have a diversity of energy-related requirements in their building codes, but some of these are quite lax.

In our policy proposal, new buildings are required to meet strengthened performance standards, in terms of either energy efficiency or GHG emissions (table 3). Both could be related to other "green" building requirements.[8] Standards would either eliminate the least energy-efficient (or GHG-intense) new buildings or encourage a shift across the entire market. Flexibility mechanisms could also be used to set average sales standards for developers or to specify shares of sales that must meet a desired performance level, with trading between developers permitted to meet the requirement.

TABLE 3. REDUCTION IN ENERGY USE REQUIRED BY STRENGTHENED RESIDENTIAL AND COMMERCIAL BUILDING CODES

Building type	Energy reduction by 2050 relative to current building practices (percent)
Residential buildings	
Apartments and attached buildings	40
Single-family detached buildings	35
Commercial and institutional buildings	55

The federal government stipulates minimum energy performance standards under the *Energy Efficiency Act* for more than 30 products. Because standards restrict consumer choices, an important consideration in policy development is whether given standards lower consumer utility. However, if research indicates that consumers would make different decisions if they had additional information, there can be a social benefit to eliminating the least energy-efficient products (Moxnes 2004).

Canada has relatively strong efficiency standards for some equipment — for instance, cooking appliances, commercial cooling equipment, refrigerators and freezers. However, we see from the examples of the European Union and Australia that there is substantial opportunity to achieve stronger standards in washing machines, dishwashers and commercial lighting while still achieving political acceptance. No mandatory standards have been introduced in relation to domestic electronic equipment and lighting. Energy consumption related to the former has grown considerably in Canada (and other countries), and there is some momentum internationally to develop limits for standby power use in small appliances. Table 4 shows the representative appliance and equipment efficiency standards that we propose for adoption over the coming decades. The standards as presented will not drive

TABLE 4. MINIMUM EFFICIENCY REQUIRED UNDER ENHANCED EQUIPMENT AND APPLIANCE STANDARDS

Equipment and appliances	Minimum efficiency by 2050
Furnaces (annual fuel utilization efficiency)	92
Gas water heaters (energy factor)	0.86
Water fixtures	Low flow
Air-conditioning systems	
Central (seasonal energy efficiency rating)	15.5
Room (energy efficiency rating)	10.8
Clothes washers (modified energy factor)	46
Freezers (efficiency improvement)	
Upright	10%
Chest	50%
Minor appliances	1 kW standby loss
Lighting (overall luminous efficiency)[1]	6%

[1] "Luminous efficiency" refers to the percentage of lighting flux in total power (incandescent lighting is typically about 2 to 3 percent; compact fluorescent lamps, 7 to 9 percent; and prototype LEDs, 25 percent).

technological changes, since regulations are inefficient in that role, but they will follow and consolidate changes pushed by market conditions.

We used the CIMS energy-economy model to quantitatively estimate the effects of the policy package because it integrates three key dynamics: it makes technologies compete to provide end-use services based on realistic consumer and company decision-making; it integrates the energy demand and supply sides of the economy; and it estimates changes in the demand for final goods and services based on changes in energy prices and production costs (Bataille et al. 2007; Nyboer 1997). CIMS also allows modelling of sector- and technology-specific policies, unlike more aggregated models.

In a business-as-usual simulation, CIMS projects that energy-related GHG emissions will rise from over 700 million tonnes in 2010 to almost 1,200 tonnes in 2050 — an increase of 65 percent (see table 5).[9] Much of the increase comes from the oil and gas industry and is especially due to surging exports of crude oil from the oil sands. The transportation sector is also expected to grow significantly by 2050, primarily as a result of increased population and demand for mobility.

Table 5 also shows projected emissions in Canada in 2050 based on the implementation of our policy package. A few sectors make major contributions to the 60

TABLE 5. ENERGY-RELATED GREENHOUSE GAS EMISSIONS, BY SECTOR, BUSINESS AS USUAL AND POLICY SIMULATION, 2010 AND 2050 (MEGATONNES OF CO_2 EQUIVALENT)[1]

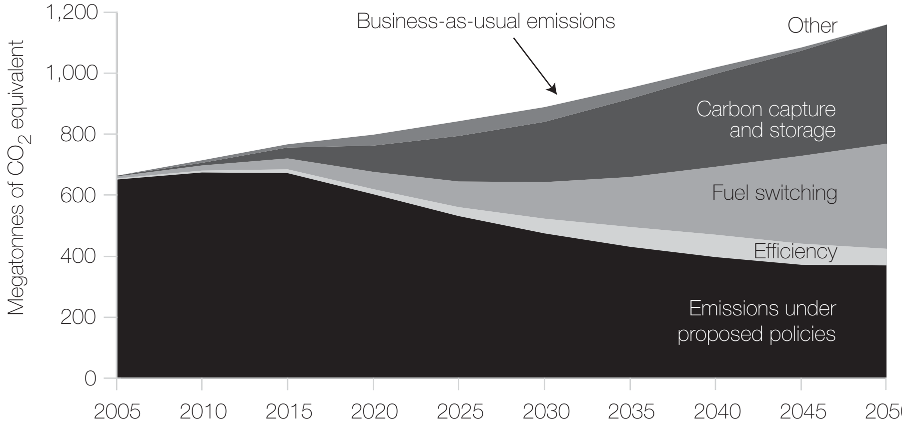
Sector	Business as usual		Policy simulation
	2010	2050	2050
Electricity generation	127	178	23
Oil and gas production	176	325	117
Energy-intensive industry	112	194	59
Non-energy-intensive industry	23	66	22
Residential	41	19	7
Transportation	193	272	95
Services	42	102	33
Total	**713**	**1,157**	**357**

Source: Calculations by the authors using the CIMS energy-economy model.
[1] Only energy-related GHG emissions are included; total GHG emissions are about 20 to 25 percent higher.

percent reduction in GHG emissions from 2010 levels. The electricity sector is highly responsive to GHG policy over the long term; CIMS projects an emissions reduction of almost 90 percent from 2010 levels. This conclusion is similar to those of other analyses, and it reflects the relatively low-cost opportunities for dramatic GHG reductions in the electricity sector. Oil and gas production is also quite responsive to aggressive GHG policy over the long term; emissions fall by about two-thirds compared with business as usual. Other sectors reduce emissions to a relatively lesser degree, because the cost of doing so for them is somewhat higher.

Figure 4 presents the results, in the form of wedges, of emissions reduction actions that would occur under the policies but not under business as usual. There are many actions, but they can be assembled into three main categories and a catch-all category. GHG emissions will fall for these reasons only: using less energy (efficiency and conservation) where fossil fuel use is substantial (as it is in most locations); switching from fossil fuels to renewables and nuclear power; and preventing emissions from the use of fossil fuels by implementing carbon capture and storage. The fourth action

FIGURE 4. PROJECTED CANADIAN GREENHOUSE GAS EMISSIONS UNDER THE BUSINESS-AS-USUAL AND THE PROPOSED EMISSIONS REDUCTION POLICIES,2005-50



Source: Calculation by authors using the CIMS energy-economy model.
Note: The upper line shows projected business-as-usual GHG emissions (in the absence of policies specifically designed to control them). The bottom line shows projected GHG emissions with application of the proposed carbon management standard, the vehicle emission standard and the appliance and equipment standards. The wedges between the two lines show the emissions reductions that would occur as a result of actions under the policy proposals. Only energy-related emissions are shown.

category includes things like methane capture and use from landfills. Because the modelling conducted for this chapter covers only energy-related GHG emissions, actions related to afforestation and waste management are not included in the figure.

It may seem surprising that the contribution of energy efficiency is small compared with those of fuel switching and carbon capture and storage. There are two reasons. First, when risk and consumer preferences are accounted for, energy efficiency can be more expensive than its advocates suggest, so its contribution is diminished in comparison with the other main options. Second, the figure shows net energy efficiency. Expanded use of oil sands and coal, on the one hand, and the extra energy needed for carbon capture and storage, on the other, will tend to increase energy use in the economy. The net effect is that much of the improvement in end-use energy efficiency is offset by declining energy efficiency in the energy supply industry.

Implementation of our three major GHG reduction policies would impose costs on the Canadian economy. Cost increases would be highest by far in the industrial minerals sector, whose significant process-related GHG emissions are hard to reduce. The pulp and paper sector and the chemicals sector, both of which are energy-intensive, would also face increases in the cost of production. Other industrial sectors would face fairly minor cost increases.

The ability of firms to pass these cost increases on to consumers would depend heavily on how exposed the sector is to international competition and whether other countries impose policies to curtail GHG emissions on a scale similar to that of the policies proposed here. In a sector that faces large cost increases because emissions controls are expensive or impractical and that is exposed to competition from other countries (for example, the industrial minerals sector), leakage of firms to other countries would be likely if Canada's GHG policy were much more aggressive than those of other countries and offered the sector no partial exemptions. If, however, Canada's trading partners impose GHG policies of similar stringency, costs would likely be passed through to final consumers, and leakage of industrial activity to other countries would likely be minimal.

The economic impacts are also not distributed evenly by region. Although this is certainly not a prerequisite for cost-effective emissions reduction, the federal government has made it a priority throughout the process of developing climate change policy that no region should bear a disproportionate share of the cost of reducing emissions. To satisfy this self-imposed requirement, the federal government would have to design compensatory mechanisms to at least partially share nationally the cost burden of GHG emissions reduction.

CONCLUSIONS

Climate change policy in Canada to date has failed because it has relied primarily on voluntary and subsidy policies, which, although politically acceptable, are ineffective in producing substantial emissions reductions (Jaccard, Rivers, and Horne 2004). In the absence of a dramatic shift in approach, it is very likely that GHG emissions in Canada will continue to increase quickly, especially as a result of the combined effect of population growth, economic growth and growth in production of crude oil from Alberta's oil sands (Rivers and Jaccard forthcoming).

This chapter outlines three policies that could reverse the trend of increasing GHG emissions in Canada. The main policy proposed is an economy-wide market-oriented regulation, which we call a carbon management standard. It sets an obligation for the fossil fuel industry to prevent a growing percentage of the carbon it processes from reaching the atmosphere, eventually leading to intensified production of zero-emission forms of energy, such as electricity and hydrogen. This policy is supplemented with a zero-emission vehicle standard, which requires vehicle manufacturers to produce a minimum number of zero-emission vehicles to account for a percentage of total sales; the policy will eventually be applied to other forms of transportation as well. The carbon management standard is also supplemented with building and equipment standards, which require improvements in energy efficiency and emissions reductions in buildings throughout the economy.

We estimate that implementation of these three policies over a 45-year time frame would reduce energy-related GHG emissions to roughly 60 percent below current levels by 2050, a rate of reduction that may be required of industrialized countries such as Canada if humanity is to avoid dangerous anthropogenic interference with the climate system. Along with substantial GHG reductions, these policies are certain to have economic impacts; they will result in higher energy services costs to households and firms, and some loss of industrial output if Canadian firms are hit harder than their international competitors. But careful policy design can reduce these impacts significantly.

One of the key attributes of the policy package is that it explicitly targets the penetration of zero-emission technologies through the creation of artificial niche markets for these technologies (for example, zero-emission vehicles and zero-emission fossil fuels) rather than just seeking incremental improvement in current practices. As a result, industry and consumers gain experience with these revolutionary technologies while avoiding large cost increases in the near term. This experience is expected to drive down costs in the longer term, easing the pursuit of the dual goals of economic growth and environmental protection.

NOTES

1 Changing agricultural, forestry and land-use practices could also help to reduce emissions, but we do not address these here.

2 Economists who study emissions-trading systems generally favour distribution of at least some of the permits by auction as opposed to 100 percent free allocation, since an auction system reduces windfall profits to particular firms, barriers to entry and opportunities for gaming (Grubb and Neuhoff 2006).

3 Subsidies could be used, to a limited extent, as a complementary measure to help fund key public infrastructure, for building retrofits (particularly for low-income households) and possibly for research and development. Because of the scope of this chapter, we do not provide a discussion of these policies, which are less important to GHG emissions than the ones we do cover.

4 Other GHGs could also be covered by the carbon management standard — including HFCs (hydrofluorocarbons), PFCs (perfluorocarbons) and SF_6 (sulphur hexafluoride) — by using a project-based approach: projects proving emissions reductions would be given government-allocated certificates that could be sold in the certificate market. In total, 80 to 90 percent of Canadian GHG emissions would be covered by the carbon management standard, depending on how effectively fugitive emissions from the upstream oil and gas sector and other key sectors were addressed.

5 Applying the carbon management standard at bulk collection and shipment points would be less economically desirable than applying it at the wellhead, since a significant and rising amount of fugitive emissions (about 70 tonnes in 2004) is released at wellhead and would be outside the scope of the system. However, because of the large number of oil and gas wells in Canada (over 100,000 and counting) and because of the difficulty in measuring fugitive emissions, it would be administratively more feasible to apply the system at bulk collection and transshipment points. Firms undertaking verified emissions reduction upstream from the carbon management standard certificate requirement points could be given certificates that they could sell to firms directly regulated by the carbon management standard. For a discussion of the point of application of an upstream system in Canada, see National Roundtable on the Environment and Economy (1999).

6 The borrowing of permits or certificates is contentious, and a credible institutional arrangement is required to ensure that future permit or certificate deficits are not forgiven by the regulator. However, certificate borrowing is likely to significantly lower compliance costs (Richels and Edmonds 1995).

7 The safety valve is a guarantee by government to sell an unlimited number of permits or certificates at a predetermined price and to ensure that market prices for permits or certificates never exceed that price. It can be used in a cap-and-trade system or an obligation and certificate system to limit the exposure of sectors affected by the policy to very high abatement costs.

8 In this regard, interest has grown in the LEED (Leadership in Energy and Environmental Design) rating system, which ranks a building's environmental performance in different categories and awards points for achieving specific goals.

9 This chapter considers only energy-related emissions, thereby excluding emissions associated with agriculture, various kinds of urban and industrial waste, and certain chemicals. Energy-related emissions represent just over 80 percent of total Canadian emissions.

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