Chapter 20

Global Environmental Problems

People all around the world are struggling to come to grips with local environmental problems and improve their immediate surroundings. But over the last few decades, the outlook has been broadened because of the recognition that many environmental issues are global in nature. For all of history, one of the ways humans have reacted to local environmental destruction is migration. But at the planetary level this option is not available. There is no escape if we degrade our natural environment to make the planet less habitable.

Political and economic reality makes it extremely difficult for the world's nations to act collectively. Nations are still accumulating scientific data that help us understand the factors giving rise to global changes. While there are growing efforts to develop international institutions and perspectives that will make concerted action possible, the world is far from agreement on how to combat the potential changes scientists warn of.

In this chapter the focus is on global environmental problems and Canada's policy initiatives to address these problems. The topics covered are: the response of Canadian governments to climate change, depletion of stratospheric ozone, and Canada's actions on international treaties such as measures to protect the oceans, endangered species, and biological diversity.

Global Climate Change

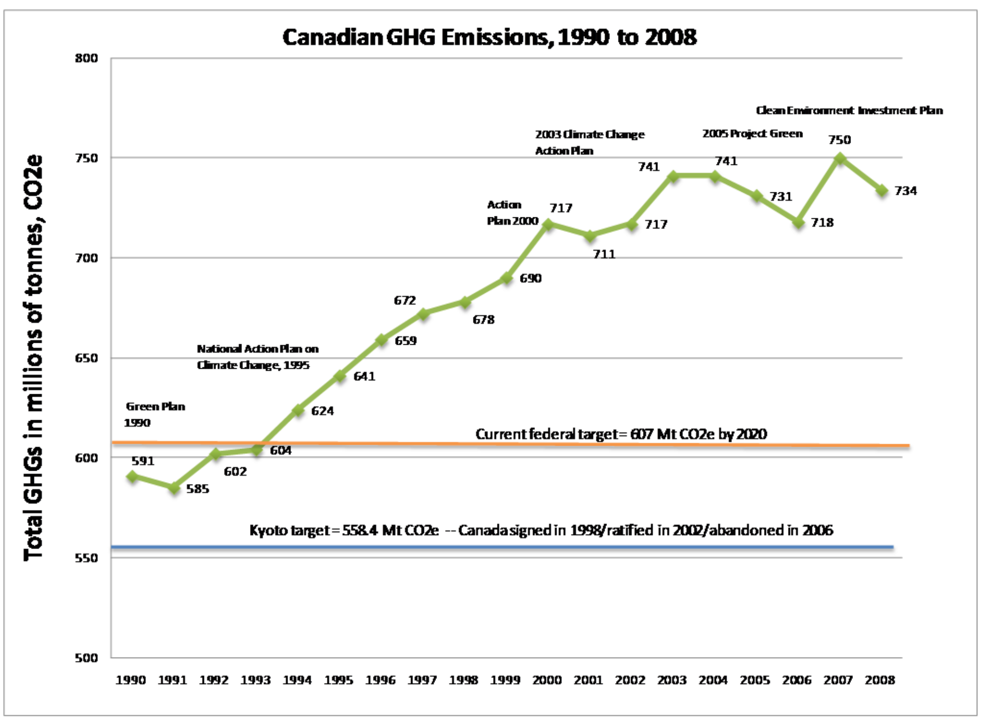
Chapter 1 illustrated how human releases (anthropogenic sources) of greenhouse gases (GHGs) are contributing to massive changes in the globe's climate and briefly noted what sort of policy actions are possible. This chapter briefly examines Canada's responses to the challenge of reducing GHG emissions and explores the policies that Canadian governments – the provinces and federal government – have implemented to meet the daunting challenge of reducing Canada's GHG emissions.

Greenhouse Gas Policy in Canada

Federal Policy

Canada has been largely a passive player in the world's efforts to limit emissions of GHGs. As discussed in Chapter 15, responsibility for international agreements concerning the environment lies with the federal government. Over the past 20 plus years, successive Canadian federal governments have failed to deliver meaningful policy to reduce Canada's GHGs. Figure 20-1 shows the inexorable rise in our GHG emissions since 1990, along with the myriad of federal policies designed to slow their growth. The picture says it all: Canadian federal policy has failed to effectively tackle our GHG emissions. This section looks briefly at the evolution of international agreements and Canada's commitments, then explains the federal policies noted on Figure 20-1, followed by a look at what our provincial governments are doing. Leadership and concrete action on the climate file is coming from Canadian provincial governments.

Figure 20-1 Canadian GHG Emissions and Federal Policies Addressing Climate Change



Source: Figure updated and adapted from Mark Jaccard et al. "Burning our Money to Warm the Planet, Canada's Ineffective Efforts to Reduce Greenhouse Gas Emissions", C.D. Howe Institute Commentary No. 234, (May 2006).

Canada was one of the early signatories to the Framework Agreement on Climate Change, referred to as the Kyoto Protocol, signing in 1997, and ratified by Parliament in 2002. Each signatory to the Kyoto Protocol set its own target for reductions in GHGs to be met by 2008 to 2012. Each country decides what policies to use to meet the targets. The Protocol is not binding on any country—there is no way to enforce these targets. Canada announced at the Kyoto Convention that it would reduce its emissions by 6 percent from their 1990 level no later than 2012, to 558 Mt. The United States made a similar commitment (5 percent reduction), but did not ratified the treaty. The lack of action by the U.S. has repeatedly been used as a rationale for why Canada could not act to significantly reduce its emissions. The argument is that Canadian businesses would be put at a competitive disadvantage relative to their U.S. counterparts. While many western European countries have introduced specific policies to mitigate GHGs, as we discuss below, the majority of the world's countries, including Canada, have made little progress toward meeting their Kyoto targets. The trend in Canada's GHG emissions is upward, rising 24 percent since 1990, as Figure 20-1 indicates. Successive Canadian federal governments have failed to introduce policies that have stemmed the rise in emission. These policies have typically been focused on:

- subsidies to renewable energy, ethanol;
- technological incentives to find ways to sequester carbon dioxide (e.g., carbon capture and storage);
- moral suasion to induce people to reduce their emissions (the campaign using comedian Rick Mercer that asked Canadians to meet the "One Tonne Challenge" – to reduce their annual CO_2 emissions by one tonne);
- voluntary agreements with industry to reduces their GHG emissions;
- incentives to increase energy efficiency (e.g., increase vehicle fuel efficiency).

Why economists are leery of mandated fuel content rules. Canada's Bill C-33 requires gasoline sold in Canada to contain 5 percent renewable fuel content as of 2010. On the surface, this policy sounds like it will help reduce GHG emissions, it is possible emissions could rise. One has to look at the life cycle of production of the renewable fuels to estimate net impact on GHGs. Ethanol production requires plant matter. In Canada much of this has come from corn, an energy-intensive crop that uses considerable amounts of fertilizer. The production of the fertilizer requires energy that typically comes from fossil fuels. The corn then has to be refined into ethanol. At least one ethanol refinery in Canada burned coal to process its ethanol. Coal is one of the highest producers of GHGs per unit of energy (Gigajoule). The U.S. EPA estimates that ethanol produced from corn using coal as an energy source will increase GHGs by 13 to 34 percent (depending on the time horizon and discount rate used). By comparison, biodiesel produced from waste grease reduces GHGs by 80 percent. Thus, regulations that specify fuel content, but don't look at life cycle GHGs, may be counterproductive.

See EPA "Lifecycle Analysis of Greenhouse Gas Emissions from Renewable Fuels", EPA 420-F-09-024, May 2009, at http://www.epa.gov/oms/renewablefuels/420f09024.htm, accessed 15 October 2010.

The plans listed on Figure 20-1 have combinations of the above policies. Note that there were no binding regulations in the form of emission standards, nor any form of emission tax imposed. The federal election in October 2008 was fought in part over Stefan Dion's platform that included a carbon tax that would return the revenue collected by cutting taxes and providing more incentives for energy efficiency and renewable energy. This was called the "Green Shift" to denote the principle of tax shifting that was behind the policy. The Conservatives ran against the carbon tax as did the NDP. Much damage was done to the notion of a carbon tax with the campaign rhetoric and mis-representations of the role of carbon taxes versus a cap and trade system propagated. Economists across Canada were incensed with the level of debate and worked together to produce an "economists letter" that was signed by over 250 economists and is reprinted in the box below.

Comment [NO1]: Put this into a box, please. The 'letter' has a number of important points that will serve as a reminder to students about policy principles. It can be edited down more.

An Open Letter to the Leaders of Canada's Federal Political Parties

A letter, signed by 255 economists, was released during the federal election campaign of October 2008. Further details are available at the following site: http://www.econ-environment.ca. This is an abridged version of the letter.

One of the few issues on which most economists agree is the need for public policy to protect the environment. Why so much agreement? Because in the absence of policy, individuals generally don't take the environmental consequences of their actions into account, and the result is "market failure" and excessive levels of pollution. Environmental degradation diminishes the quality of life for all of us. And without a healthy environment, we can't sustain a healthy economy. We, the undersigned, have therefore joined together to express our shared views on effective policies to address climate change.

What Needs to be Done

While Canada clearly cannot solve the climate change problem on its own, we need to do our part, and this requires immediate and substantive action by our federal government. We bear the costs of our lack of action on carbon reduction on a daily basis, and within a few decades the impacts of climate change could be truly catastrophic—unless we take action now. Even those who are not quite convinced by today's scientific evidence need to consider the costs of not acting now. If they turn out to be wrong, and we wait for complete certainty, it will be too late.

All the major political parties have stated that they understand the need to act on carbon emissions. The question then becomes what action to take. Any action (including inaction) will have substantial economic consequences and, thus, economics lies at the heart of the debate on climate change.

With this letter, we hope to help put the debate on a more solid economic foundation by offering the following set of principles upon which we believe climate change policy should be founded.

1) **Canada needs to act on climate change now.**

2) **Any substantive action will involve economic costs**. Any effective carbon-reduction policy will necessarily entail changing the way we live and do business. All forms of regulation, taxes, or markets for the exchange of emission permits that have a significant impact on greenhouse gas emissions will affect the prices of carbon-intensive goods.

3) **These economic impacts cannot be an excuse for inaction**. Climate scientists are clear on the costs of inaction, and that these costs will accumulate well beyond the current business cycle, possibly at an accelerating rate. Active and effective climate change policy should be seen as an investment that will yield pay-offs for ourselves, our children and our grandchildren. Given the need to act, the question then becomes which policies would obtain the carbon reduction goals we establish with the lowest cost and greatest level of fairness.

4) **Pricing carbon is the best approach from an economic perspective**. Approaches to reaching any particular climate change goal that involve pricing carbon, such as carbon taxes and cap and trade systems, involve less economic damage to businesses and families than the alternatives. Carbon pricing is good for several reasons:

    a) **Pricing allows each business and family to choose the response that is best and most efficient for them.** Firms and families will differ greatly in the options they have for reducing their use of carbon, as well as in the value they place on carbon-generating activities. Price mechanisms give everyone the incentive to reduce their carbon use, but to do so to the degree and in the way that is best for them. This is the main reason that pricing policies are the lowest-cost way to meet our climate change goals.

    b) **Pricing induces innovation**. As the price of carbon increases, users of carbon intensive goods will demand alternatives. This will induce innovations in the goods and services that are produced, how those goods and services are produced, and the way people live. By moving relatively early in terms of climate policy, Canada has an opportunity to innovate and sell new technologies to the rest of the world.

c) **Carbon is almost certainly under-priced right now**. In a fully efficient price system, the price we pay for a product would reflect the full costs of producing and using it, including the costs to the environment. Prices do not currently reflect those environmental costs. When carbon is under-priced, consumers and businesses tend to use too much of it. Policies that increase the price of carbon provide the proper incentives for consumers and businesses when they are making their investment and consumption decisions.

5) **Regulation tends to be the most expensive way to meet a given climate change goal.** Under regulation, businesses and consumers are mandated to take particular actions related to carbon use (e.g., use a particular technology or stay under mandated levels with no option to trade carbon emission rights). As a result, they are not given the choice of adjusting in the way that is best for them. Regulation therefore increases the costs of achieving carbon reduction compared to when pricing mechanisms such as a carbon tax or a cap and trade system are used. Furthermore, while regulations imposed on firms may appear to be so far removed from the typical consumer that they might think they will not bear these costs, this is not true. Those increased costs will be passed on to consumers due to normal market forces. There may be circumstances when regulation is the appropriate policy tool, but in most cases it is the most economically damaging.

6) **A carbon tax has the advantage of providing certainty in the price of carbon.** Under a carbon tax, a charge is added to the sale of all fuels according to the carbon emitted when they are used. With a well-designed carbon tax strategy, the tax will be introduced gradually and increased in pre-announced increments until the environmental target is reached . This provides investors with a degree of certainty that is good for business, and allows consumers to make adjustments knowing what is coming. The exact impact of the price increase on the quantity of carbon emitted can be predicted, although with some margin of error. A carbon tax thus involves choosing price certainty but accepting some uncertainty in total carbon emissions.

7) **A cap and trade system provides certainty on the quantity of carbon emitted, but not on the price of carbon and can be a highly complex policy to implement.** In a cap and trade system, an upper limit (cap) is set on carbon emissions, usually for a particular industry. The government must then make a decision about whether to auction the permits (known as allowances), requiring each firm to buy enough allowances to cover its total emissions. Normal market forces then determine the price of these allowances such that supply equals demand. The price cannot, however, be predicted in advance. A cap and trade system with auctioned allowances then acts much like a carbon tax. Alternatively, the government can issue allowances to firms without charge, then open up the market for trading. In this situation, there is both the uncertainty about the price and potential for significant problems to emerge in the market based on how the allowances are initially allocated. The Emission Trading System in the European Union began by distributing too many allowances and as a result the price fell to close to zero, rendering the policy ineffective. Thus, while a cap and trade system can in principle be equivalent to a carbon tax in terms of its ultimate impacts on the price and quantity of carbon, and will generally give more certainty in meeting environmental targets if the allowances are properly chosen, the price uncertainty in the cap and trade system generally implies a worse environment for long-range decision-making on the part of businesses and consumers.

8) **Policies that impose costs on producers (big or small) affect consumers**. Some voters seem to think that policies like cap and trade, which apply directly to producers, have less impact on the prices they face than carbon taxes, where the impact can be seen immediately. In fact, voters would do better to assume that all such policies would, ultimately, affect the prices they pay. Indeed, since the goal of these policies is to change what we buy, policies applied to producers must affect the prices faced by consumers if they are to meet environmental goals. The argument that a policy capable of reducing carbon emissions will only affect producers is without economic merit.

9) **Price mechanisms can be regressive and our policy should address this**. Like most taxes on goods and services that are widely consumed, carbon pricing will have a larger negative effect on lower income Canadian families than others. As we have stated, the same is true of regulation since regulation also raises

costs of production and those increased costs will ultimately show up in higher prices. Thus, whatever policy is used, a complete policy should include some element of redistribution to address the impacts it will have on the least well off in our society. Not only will the costs to consumers ultimately be lower under a carbon tax or auctioned emission permits, these latter policies also have the potential to bring revenue into the government that can be used to help offset any inordinate hardship experienced among the least well-off. This is not true of regulatory approaches, or of a cap and trade system in which the allowances are allocated without charge to emitters.

10) **A pricing mechanism can allow other taxes to be reduced and provide an opportunity to improve the tax system**. With the revenue brought in from a carbon tax or from auctioning the allowances in a cap and trade system, governments can provide general cuts in income and/or corporate taxes. Such systems can be "tax neutral", meaning the increased burden of the carbon taxes is exactly offset by tax reductions elsewhere, but this result will depend on the details of the particular policy adopted. Under such a plan, lighter carbon users will tend to pay lower taxes overall, while heavier polluters will pay more, corresponding to their greater negative effects on the environment. At the same time, all individuals will continue to have an incentive to reduce their carbon emissions when prices include the cost of their carbon usage. If the tax redesign is done thoughtfully, Canada could move toward an overall tax system, which imposes fewer burdens on the economy and, as a result, leads to a more productive economy for all Canadians.

In closing, we ask you, the leaders of Canada's major political parties, to immediately begin a substantive public debate, grounded in the generally accepted economic principles outlined above, on the best ways to address climate change. Our collective future is truly in your hands.

2008 election was a turning point in GHG policy at the federal level. With the election of a second minority Conservative government, virtually all pretense of substantive action on climate change abated. During their first term in office, the Harper government said it would bring in a form of GHG emission trading (with targets based on emission intensity rather than aggregate emissions and setting a $15/tonne cap on the price), but this policy never was enacted. Instead, the government continued with incentives for carbon storage, ethanol subsidies, promotion of energy efficiency, and other modest incentives. Prime Minister Harper made a number of statements to the effect that Canada would not implement any form of carbon pricing until the United States did, and then we would adopt their policies. There were high expectations that the election of Obama in the U.S. would usher in meaningful carbon policies. Several bills to implement a cap and trade system (e.g., the Waxman-Markey bill) were debated in Congress, but attempts stalled when the recession of 2008 intensified. As of 2010, Canada has no substantive federal policy to achieve significant reductions in GHG. Why has so little progress been made in Canada? The reasons are found in Chapter 15: as a federation, Canada faces multiple political jurisdictions with diverse interests, varying dependence on fossil fuels, and economic conditions. Action in Canada has shifted more to the provincial level.

Provincial Policy to Reduce GHG Emissions

Canadian provinces had adopted their own versions of many of the federal policies – energy efficiency incentives, subsidies to promote the use of renewable energy sources to generate electricity, consumer information on how to reduce GHG emissions, subsidies for technology, etc., but starting in 2007, a number of provinces began to take more substantive action to use pricing to aid in reaching the targets most had set for the year 2020. Table

Consider the following identity that expands on the one presented in Chapter 1.

$$GHG = [(GHG/Energy) \bullet (Energy/Output) \bullet (output)]$$

An energy efficiency policy only addresses the ratio of energy to output. Subsidies to renewable energy affect the GHG/Energy ratio. An emission standard covers [(GHG/Energy) •)(Energy/Output)]. It is only carbon pricing that covers all three terms on the right-hand side. This is one important reason why economists feel carbon pricing is a necessary part of any climate change policy package. Table 20-1 illustrates the type of carbon pricing policies implemented at the provincial level.

Table 20-1: Provincial Carbon Pricing Policies

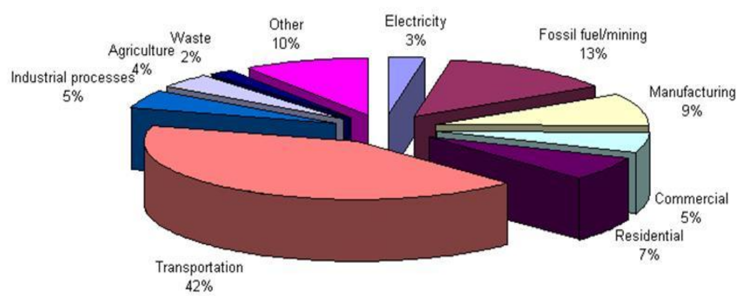
Province	**Carbon Pricing Policy**	**Date Enacted or Expected Implementation**	**Approximate Percent of GHGs Covered**
British Columbia	Carbon tax (starting at \$10/tonne CO2) rising to \$30 by July 2012 Western Climate Initiative (WCI) signatory	2008 Legislation 2008, expected implementation 2012 to 2015	77% 50% initially rising to 80% over time
Alberta	Intensity-based cap & trade with a price ceiling at \$15/tonne; paid into a technology fund energy industry can access	2007	55%
Saskatchewan	None	--	--
Manitoba	WCI signatory	Implementation 2012 to 2015	50%, rising to 80%
Ontario	WCI signatory	Implementation 2012 to 2015	50% rising to 80%
Quebec	Carbon tax at \$3/tonne CO2 WCI signatory	2007 Implementation 2012 to 2015	70% 50% rising to 80%
New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland & Labrador	None	--	--

Source: Adapted and updated from Nic Rivers, "Federal and Provincial Climate Change Policy: Repeating Past Mistakes?" in Tom Courchene and John Allen (eds.) *Carbon Pricing and Environmental Federalism,* in the series, *Canada, The State of the Federation, 2009*. Montreal: Queen's-McGill Press, 2010.

Carbon Taxes in Canada

British Columbia's carbon tax was noted in Chapter 17. It is a broad-based tax that covers all GHG sources from combustion in the province. Emissions not covered are predominately 'fugitive emissions' not easily measured that need to be covered by regulations, methane from agriculture and landfills, and non-combustion industrial sources. Figure 20-2 shows the sources of BC's carbon emissions in percentages; note that the majority emanate from transportation. This is because unlike some other parts of Canada (e.g., Alberta, Saskatchewan, Ontario and some of the Maritime provinces), a very small share of GHG emissions comes from the combustion of fossil fuels to generate electricity. BC, like Manitoba and Quebec, rely predominately on hydroelectricity. The carbon tax in BC, by applying to all motive fuels thus covers these significant sources of GHGs. When the legislation for the carbon tax was introduced, the government announced the tax rates through to 2012. Starting at \$10 per tonne CO_2e, the tax would rise each year by another \$5/tonne. Rates beyond 2012 were to be announced in time to help consumers and industry make changes to their lives and invest so as to reduce their carbon-intensity. The government did not expect the carbon tax to immediately lead to a significant reduction in GHG emissions. As explained in Chapter 12, all the revenues from the carbon taxes collected over the 2008 to 2012 period flow back to households and industry in the form of cuts to personal and corporate income tax rates, tax credits for low income and rural households, and some property tax relief for industry. If tax rates rise beyond 2012, it remains to be seen if any of that incremental tax revenue will flow to greater government expenditures, for example, to fund public transit infrastructure that helps reduce the emissions from the transportation sector, or to other carbon-reducing infrastructure and technologies.

Figure 20-2: Source of Greenhouse Gas Emissions for British Columbia, 2008



Source: Data from Ministry of Environment, Climate Action Secretariat, British Columbia Greenhouse Gas Inventory Report, 2008, available at http://www.env.gov.bc.ca/cas/mitigation/ghg_inventory/index.html#6, Key Data Tables, BC Greenhouse Gas Emissions in 2008 by Greenhouse Gas type.

BC's carbon tax led to heated political debate when first introduced, and as with the "Green Shift" of the federal Liberal party in the 2008 election, the rhetoric from opposing parties and individuals tried to paint the carbon tax as unfair, a 'gas tax', and conveniently ignored its broad base and return of tax revenues to the province. The "axe the tax" movement was prevalent in the 2009 provincial election, but did not lead to a change in government. Since that time, opposition has mostly abated. BC's carbon tax was hailed world wide as a textbook tax on pollution, just as put forth in Chapter 12.

Emissions Trading Principles and Application

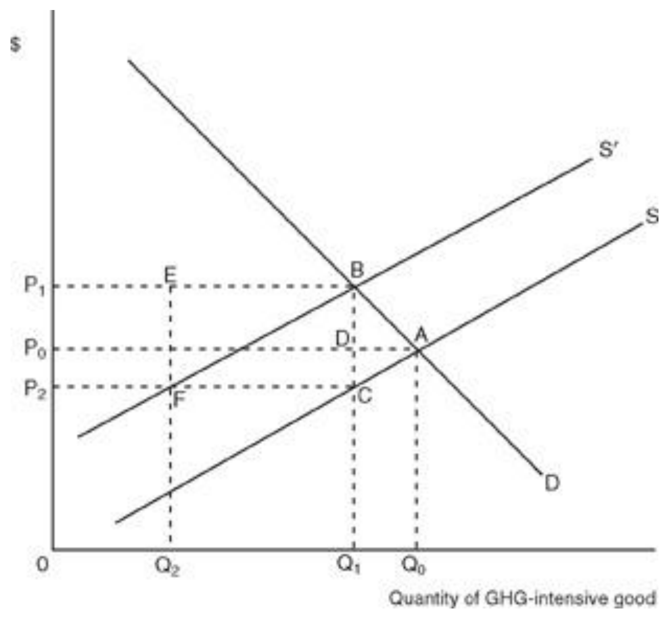
Review Chapter 13 so that you are familiar with the principles and concepts behind a TEP system. How might a TEP approach be used in Canada to reduce GHG emissions? Some of the practical issues of implementing and operating a TEP system are discussed below, followed by a discussion of the policy under development for four Canadian provinces – the Western Climate Initiative.

How Will Permits be Allocated?

Recall how an emissions trading system works. Figure 20-3 illustrates in the context of supply and demand curves for a source covered by the system. As examined in Chapter 13, permits can be either auctioned or distributed without charge. Figure 20-3 shows how the two methods of allocation would affect producers and consumers of GHG-related goods. With no GHG policy, the initial equilibrium is at Q_0 output with a price of P_0. Assuming that the introduction of a TEP system on producers of GHG goods does reduce the amount of emissions of GHGs (e.g., the permits issued whether auctioned or not are less than current emissions), the supply curve will shift from S to S′, reflecting costs of abating emissions.[24] Output falls to Q_1 and price increases to P_1. The magnitude of these changes will depend on how elastic are the supply and demand curves. If the permits are auctioned, the producer will incur permit plus abatement costs equal to area P_1BCP_2. Its producer surplus will fall by P_0ACP_2. Consumer surplus will decline by area P_0ABP_1. If the government recycles the revenues from the initial permit auction back to the economy in the form of reductions in, say, income-tax rates, some of the loss in consumer and producer surplus would be offset. But, because these losses also reflect real resource costs in the form of total abatement costs, there will be a net loss in consumer and producer surplus. This is the cost of the policy. The benefits are, of course, the potential improvement in environmental quality resulting from a reduction in GHGs. If a proportion of the permits are given to the producer without charge, its loss of producer surplus will diminish. For example, if the government gives the producer permits sufficient to produce Q_2 units of output, it will receive an effective lump-sum transfer of area P_1EFP_2.

24. This reflects a movement up the MAC curve in the MAC-MD framework from, for example, no abatement to some positive level of pollution abatement to comply with the number of permits issued.

Figure 20-3: The Impact of an Emissions Trading System on Output and Price of a GHG-Intensive Good



The introduction of a TDP system increases the costs of producing a GHG-intensive good, as producers must either cut production or incur abatement costs to reduce GHG emissions. The supply curve shifts from S to S′ as a result. Output will fall to Q1 and price will rise to P1. The magnitude of these shifts is dependent on the elasticities of each curve. If the permits are auctioned, the producer will pay P1BCQ1 for permits and abatement costs. Producer surplus will fall by P0ACP2, consumer surplus by P0ABP1. If some permits are given to the producer without charge (e.g., enough to produce Q2 units of output), producers will get a scarcity rent transfer of P1EFP2. This transfer will not affect the equilibrium price of the good, simply the net change in producer surplus.

The simple economics of the TEP system show that

1. the TEP system will affect product prices and quantities produced of GHG-intensive goods.

2. producers and consumers will "share" in the burden of the system. There will be a loss of producer and consumer surplus, ignoring any of the benefits of GHG reductions.

3. if permits are given away instead of auctioned, the loss of producer surplus can be greatly reduced (producers who are low-cost abaters of GHGs will gain the most, as was shown in Chapter 14). Consumer surplus losses are unaffected.

4. if permits are auctioned, governments could recycle the revenue in the form of tax cuts to offset some losses.

Design Issues: What Exactly Will Be Traded?

In Chapter 13, we simply referred to TEPs as emission permits. The holder of the permit is entitled to emit x units of pollution. In practice, a TEP system can be designed not only for emissions, but also for other actions polluters take to reduce emissions. While the vocabulary is not uniform, the following are the types of TEP schemes under discussion around the world.

- ***Credit trading.*** Credits are given to polluters from documenting a reduction in emissions. This is also called a ***baseline-and-credit system***. The credits can be sold to others to use for compliance with regulations. Credit trading has already occurred in Canada on a voluntary basis. A key issue is how to verify that the reductions represent actual decreases in emissions from what previously existed. Monitoring of emissions is crucial to this (and all systems). The ultimate use of credits will depend on how government determines the allowed level of emissions of each source, (i.e., what is the baseline).[25] A related issue is whether any credit will be given for the creation of carbon sinks.

[25.] The clean development mechanism under the UN is a type of baseline-and-credit system that allows emitters in the developed countries (Annex 1) to purchase a credit for emissions reductions in developing countries.

- ***Substance trading.*** This approach allows for the trading of permits denominated in units of the polluting substance. In the case of GHGs, this could be the carbon content of fuels, the nitrogen content of fertilizers, and so on. In a TEP system of emission trading, there will be an overall limit or cap on the total quantity of the substance consumed domestically, which means a limit on the sum of production plus imports minus exports. The system works on GHGs indirectly, through the reduction in demand by consumers in response to price increases of GHG-intensive products (as was illustrated in Figure 20-4).
- ***Emission-rights trading.*** This system limits aggregate emissions of a GHG from specific sources at the point of release into the atmosphere. Sources emitting the GHG would have an annual cap on emissions, and permits can be traded among the sources. This is also called a ***cap-and-trade system*** – the system proposed by the Western Climate Initiative and operating in the eastern United States in the Regional Greenhouse Gas Initiative (RGGI).

No one system is likely to be perfect. Each has pluses and minuses depending on the GHG and its source. No one policy can effectively deal with as complex an environmental problem as climate change. No one is suggesting, for example, that a TEP system directly cover GHGs released from household energy use (home heating, transportation). Other policies would have to apply to this sector.

The Western Climate Initiative: ***http://www.westernclimateinitiative.org/***

RGGI: The Regional Greenhouse Gas Initiative: www.rggi.org/

Implementation Issues: The Western Climate Initiative (WCI)

Emission trading is not slated to occur in Canada until 2012. Four Canadian provinces have signed on to the Western Climate Initiative (WCI) which is developing a cap and trade emission trading system for a number of the western U.S. states as well as BC, Manitoba, Ontario, and Quebec. While the market is to commence operation in 2012, loss of interest in climate policy in the U.S. combined with the withdrawal of some of the states from the agreement, puts the policy in some jeopardy. [New Footnote #1] The WCI sets an overall target reduction in greenhouse gas (GHG) emissions of 15 percent below 2005 levels by 2020. This level was set by aggregating the 2005 emissions and emission targets of the members of the WCI. Approximately 90 percent of the WCI's GHG emissions will be included in the cap and trade market when the system is in full operation. If the WCI begins operation in 2012, it will cover large stationary sources emitting 25,000 tonnes of CO_2e. These sectors include combustion at industrial and commercial facilities, industrial process emission sources including oil and gas process emissions, and electricity generation. The market will operate in what are called compliance periods of three years. GHGs from residential, commercial and industrial fuel combustion at facilities with emissions below the threshold as well as transportation fuel combustion from gasoline and diesel will come into the system in the second compliance period in 2015, but individual units will not hold allowances as this would be impractical. Allowances will be distributed to entities upstream of these points of discharge where the fuels enter into commerce.

New Footnote #1: **See Nancy Olewiler "A Cap and Trade System for Reducing Greenhouse Gas Emissions in British Columbia: A Preliminary Evaluation of the Western Climate Initiative Design Proposal" Pacific Institute for Climate Solutions, White Paper Series at: www.pics.uvic.ca for more details on how the WCI might affect British Columbia. Information for this section is taken from that paper and the references therein.**

Cap and trade markets are complex; care must be taken to ensure the market will operate effectively, efficiently, and equitably. All the signatories to the WCI have been in the process of designing the specific aspects of the policy that they are responsible for. These include: how many emissions are covered, what share of allowances are auctioned versus distributed to emitters (some form of grandfathering), whether to introduce safety valves and other means of reducing price volatility in the market, and how to handle offsets – the market for activities that sequester carbon. The following are principles that economists studying cap and trade systems have developed to help design the system.

- *Cover a broad base of emitters.* The initial phase of the WCI looks to cover about 40 percent of BC's emissions; more of Ontario's due to their dependence on coal-fired generators for a share of their electricity production. The smaller the share of GHG emissions covered by the system, the greater the need for other pricing policies to fill the gap. BC has its carbon tax, but Manitoba does not and Quebec's carbon tax is at a low rate and not designed to have much impact on emissions of sectors not covered by emissions trading.

- *Auction as high a percentage of allowances as possible to ensure efficiency and obtain revenue needed to address equity issues.* Auctioning, as we saw in Chapter 13, helps maximize the trading volume and hence, makes it more likely an efficient price will be set in the market. Auctioning also avoids establishing complex rules for the free allocation of allowances and avoids distributing all the rents that a cap and trade system generates to non-government parties. On the other hand, auctioning makes it more difficult politically to introduce a cap and trade system. The WCI mandates a minimum of 10 percent of allowances must be auctioned in the intial compliance period; rising to 25 percent by 2020.
- *Minimize price volatility.* Estimates for a nation-wide cap and trade system in the U.S. are that prices may fluctuate initially between \$24 and \$160 per tonne CO_2e. We saw the large fluctuations in prices in the U.S. sulphur dioxide market in Chapter 17. Large swings in prices make it difficult for covered sources of emissions to plan their efficient responses to the policy. Volatility can be reduced by a number of means. One is to allow banking and borrowing (as described in Chapter 13). The WCI will allow banking but not borrowing. Safety valves in the form of price ceilings and floors are another option. If the price floor and ceiling are close together, cap and trade becomes much like a carbon tax, and a carbon tax is a much simpler pricing policy instrument. Another response to volatility is to index the system to economic activity. The Alberta cap and trade system (and the proposed, but never implemented federal system) operates with a cap that is tied to emissions intensity which allows emissions to grow in absolute terms, but the economy becomes relatively less carbon intensive over time. An indexed cap provides covered sources with more flexibility, but reduces the likelihood the policy will be effective in reaching targets.
- *Use offsets with care in their design.* The WCI omits fugitive emissions from agriculture and forestry due to the complexity and high cost of monitoring these sources. This reduces the potential number of trades and one way to expand the range of options for covered sources and keep costs lower than they might otherwise be is to allow them to purchase verifiable emission reductions known as offsets from these uncovered sectors. An offset policy allows reductions in emissions from the uncovered sectors below a set baseline level to be sold into the market. Offsets either allow the same level of emission reduction at lower cost than in a system without them (due to the expansion of ways to reduce emissions; an offset would not be purchased if its price exceeded that of the allowance), or allows the system to achieve greater emissions reduction at a the same cost because the offset works like a withdrawal of allowances from the market. If for example, the price of a offset is \$20/metric tonne, the WCI estimates their inclusion leads to a predicted allowance price of \$6/mt in 2015, rising to \$24/mt in 2020.[New Footnote #2]

[New Footnote #2] See Western Climate Initiative, "Design Recommendations for the WCI Regional Cap-and-Trade Program" September 23, 2008, p. 60. Available at: http://www.westernclimateinitiative.org/the-wci-cap-and-trade-program/design-recommendations. Accessed 15 October 2010.

Offsets add considerable complexity to a cap and trade system. The main challenge is to be convinced that reductions actually occur that would otherwise not exist. The literature has come up with five criteria that should be satisfied to establish an effective offset system that leads to real emission reductions.

- *Certainty* in the measurement and monitoring of emission reductions or sequestration;
- Verify *additionality*: the emission reductions backing the offset would not have occurred in the absence of the cap and trade system;
- The *baseline* level of emissions from the offsetting source is appropriately measured;
- *Leakage* in the form of shifts in emissions outside the market boundaries is minimized; and
- Any *reversals* in the form of subsequent releases of carbon from the offsetting source are themselves offset or covered by allowances.

An oversight agency is necessary to monitor the actions by the entities selling offsets and guard against fraud. The success of a cap and trade system with offsets is dependent on the success of the monitoring agency.

Provincial GHG Reduction Targets

Each province has set explicit target reductions in their GHG emissions from a base year to a target year. For the six provinces that have some form of carbon pricing, Table 20-2 shows their emission reduction targets for 2020 and emissions data for 1990 and 2008. The table also provides an estimate of the marginal abatement cost required to reach each province's 2020 target. Canadian provinces and the country as a whole face many challenges. Note that only Quebec has reduced its emissions below their 1990 level. BC's emissions in its base year of 2007 were 66 Mt, so it has reduced emissions by 1 Mt below that level in 2008. The marginal abatement cost at province's 2020 targets ranges from a low of 134 in Alberta to a high of 266 in BC. The range is due in part to the carbon intensity of electricity generation. Because Alberta and Saskatchewan use coal as their major feedstock, the substitution of lower-carbon fuels could provide them with significant GHG reductions. GHG reductions in other provinces will have to come from other sources due to their use of zero-carbon hydroelectricity. The bottom line is that no single policy instrument, even carbon pricing in the form of a tax or cap and trade system will allow the provinces to reach their targets cost effectively. There is no uniform carbon price across the country that will allow each province to meet its target. Provinces thus need to employ a suite of policies to reduce GHG emissions as well as provide incentives to invest in new technologies to reduce emissions and/or sequester carbon.

Table 20-2: Provincial GHG Targets, Emissions and Marginal Abatement Costs

Province	1990 GHG Emissions Mt CO_2e (million tonnes)	2008 GHG Emissions Mt	Emission Reduction Target for 2020	Estimated Marginal Abatement Costs to Reach Target*
British Columbia	51	65	33% below 2007 level (22 Mt)	\$266/tonne CO_2e
Alberta	170	244	Covered sources must reduce emissions intensity by 12% from individual baselines	\$159
Saskatchewan	44	75	20% below individual baselines	\$134
Manitoba	18	22	6% below 1990 level	\$226
Ontario	175	190	15% below 1990 level	\$257
Quebec	85	82	20% below 1990 level	\$219
Canada	592	734	17% below 2005 level	

Sources:
Emissions data: Environment Canada, Greenhouse Gas Emissions Data Tables, http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=BFB1B398-1#ghg3_en, accessed 15 October 2010.
Emissions targets: provincial web pages
Marginal abatement costs: Nic Rivers, "Federal and Provincial Climate Change Policy: Repeating Past Mistakes?" in Tom Courchene and John Allen (eds.) *Carbon Pricing and Environmental Federalism,* in the series, *Canada, The State of the Federation, 2009*. Montreal: Queen's-McGill Press, 2010.

Carbon Pricing Policies in the European Union

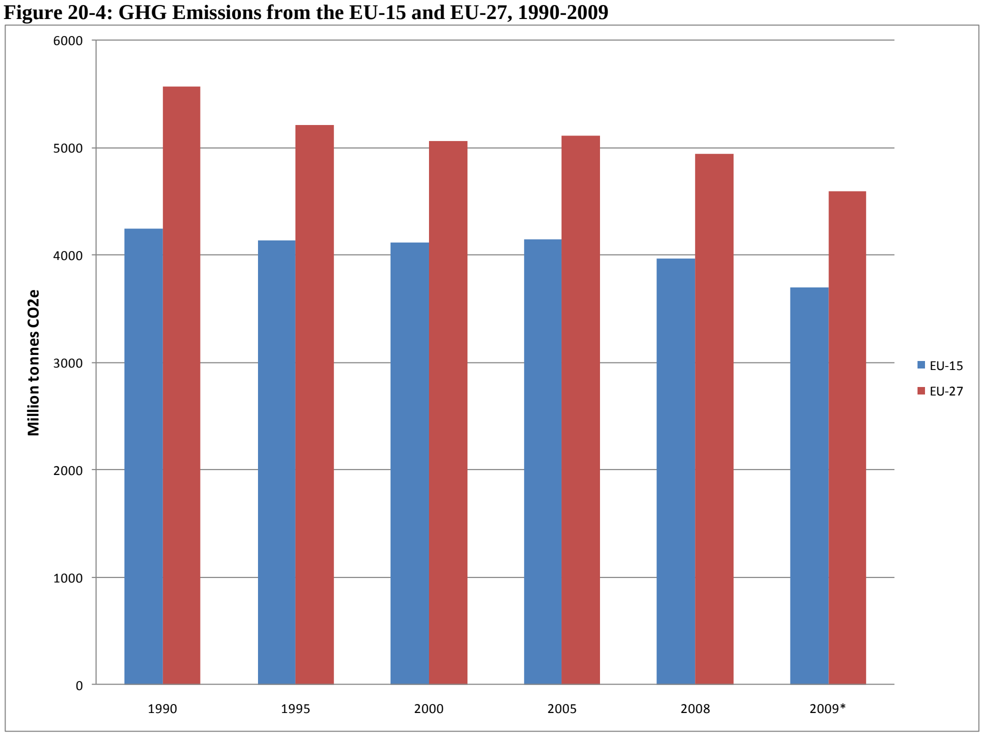
While Canada has failed to live up to its Kyoto agreement, European countries enacted a number of measures to help reduce their GHG emissions and meet their commitments made under the Kyoto Protocol. Figure 20-3 shows levels of GHG emissions in the fifteen western European member countries (EU-15) and the EU-27 since 1990. New Footnote #3

The EU-27 countries have reduced their emissions by over 17% since 1990. They have done so with a combination of pricing policies – the European Union's Emission Trading System (ETS) and carbon taxes in some countries (with tax bases covering a smaller percentage of sources than in BC). Numerous reports cite the recession of 2007 to 2009 as a major factor in the deep drop in recent years rather than carbon policies. New Footnote #4 It remains to be seen whether the downward trend continues. Nonetheless the EU is way ahead of Canada and the United States in that their emissions have actually fallen rather than risen since 1990. There is concern that these gains will be lost if carbon price signals are not made stronger. The ETS has been the only mandatory emission trading scheme for carbon, but it covers only about 40 percent of GHG emissions, and critics have argued that its free allocation system, combined with over allocation in the first period in which it operated (2005-2007) led to volatile and low carbon prices on the market. ADD FOOTNOTE: Éloi Laurent and Jacques LeCacheux "Policy Options for Carbon Taxation in the EU" OFCE - Centre de recherche en économie de Sciences Po, Working Paper No. 2010-10, June 2010. Available at: http://www.ofce.sciences-po.fr/pdf/dtravail/WP2010-10.pdf, accessed 15 October 2010. The second trading period, which began in 2008, has also seen prices collapse, likely due to the recession. One suggested change is to introduce a price floor to provide a stronger incentive for covered sources to reduce their emissions (Laurent and LeChacheux, 2010).

New Footnote #3: The EU-15 consist of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom. The EU-27 adds: Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, and Slovenia. See European Environment Agency Annual European Greenhouse Gas Inventory 1990-2008 and Inventory Report 2010. Technical Report No. 6/2010. 02 June 2010. Accessed at: http://www.eea.europa.eu/publications/european-union-greenhouse-gas-inventory-2010 on October 30, 2010.

New Footnote #4: See, for example, European Environment Agency, Tracking Progress Toward Kyoto and 2020 Targets in Europe. Technical Report No.7/2010, 12 october 2010, accessed at: http://www.eea.europa.eu/publications/progress-towards-kyoto/ on 30 October 2010.

Figure 20-4: GHG Emissions from the EU-15 and EU-27, 1990-2009



Note: * Preliminary estimate.

Sources: Data from the European Environment Agency from the following:.

For 1990 to 2008 data: *Annual European Greenhouse Gas Inventory 1990-2008 and Inventory Report 2010.* Technical Report No. 6/2010. 02 June 2010, Table ES.8, page 12, accessed at: http://www.eea.europa.eu/publications/european-union-greenhouse-gas-inventory-2010

For 2009 data: for EU-27: European Environment Agency, GHG Trends and Projections in the EU-27, available at: http://www.eea.europa.eu/themes/climate/ghg-country-profiles/tp-report-country-profiles/eu-27-greenhouse-gas-profile-summary-1990-2020.pdf;

For EU-15: European Environment Agency, GHG Trends and Projections in the EU-15, available at: http://www.eea.europa.eu/themes/climate/ghg-country-profiles/tp-report-country-profiles/eu-15-greenhouse-gas-profile-summary-1990-2020.pdf

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The European Union Emission Trading System:
http://ec.europa.eu/environment/climat/emission/index_en.htm/
The European Environment Agency: http://www.eea.europa.eu/

Other critiques of the EU policies include an over reliance on emission standards and a weakening of the share of energy-related taxes to GDP, falling 0.2 percent over the period 1995-2007 (Laurent and LeCacheux, 2010, Table 3). But it is important to recognize the European countries have had carbon taxes for a number of years. These countries include – the UK, Norway, Denmark, Sweden, Finland, and Germany. Norway's carbon tax covers 65 percent of emissions, but excludes GHGs from energy-intensive industries and energy sources. The tax varies from \$13 to \$63 per tonne CO_2. [New Footnote #5] The UK introduced its carbon tax in 2001 to apply to electricity fossil fuels used at the industrial and commercial levels, but exempts household use and the transportation sector. The rates are low -- £0.0045/kwh electricity and £0.00015/kwh for coal and gas. These prices rise at the rate of inflation starting in 2007. The UK government announced in 2010, it planned to broaden the base of the climate levy and increase the tax rate due to the low prices of allowances on the ETS.

Question to explore: Why might a carbon tax be difficult to implement in the EU?

One way to compare tax regimes for fossil fuels across countries is to compute an *implicit carbon tax*. This approach is based on the existing tax structure, combining all the taxes on carbon-based energy that change the price of the fuel. Estimates have been done at different points in time. [New Footnote #6]. A recent study Lachapelle (2010) has been done comparing Canada to other OECD countries, and also reports implicit carbon tax rates in Canada over time. [New Footnote #7] The tax rates are shown per tonne of CO_2 to ensure a common metric and values are converted to Canadian dollars (adjusting for exchange rates).

[New Footnote #5] Information on European carbon taxes is found in National Round Table on the Environment and Economy, Achieving 2050: A Carbon Pricing Policy for Canada, Technical Report (2009). Available at www.nrtee-trnee.ca.

[New Footnote #6] Peter Holler and Jonathan Coppel "Energy Taxation and Price Distortions in Fossil-Fuel Markets: Some Implications for Climate Change Policy," chapter 12 in *Climate Change: Designing a Practical Tax System, (1992)* Paris: OECD, pp.185-211. Jack Mintz and Nancy Olewiler "A Simple Approach for Bettering the Environment and the Economy: Restructuring the Federal Fuel Excise Tax" (2008). Ottawa: Sustainable Prosperity, www.sustainableprosperity.ca

[New Footnote #7] Erick Lachapelle The Hidden Factor in Climate Policy: Tracking Implicit Carbon Taxes in the OECD and Implications for Canadian Policy Makers" (2010). Ottawa: Sustainable Prosperity, www.sustainableprosperity.ca.

Table 20-3: Implicit Carbon Tax Rates Across OECD Countries, 2008 (in Canadian \$/tonne CO_2)

Fossil Fuel	Canada	United States	Germany	United Kingdom	Norway
Gasoline	$146	$62	$590	$560	$625
Diesel	99	56	273	368	275
Light fuel oil	34	17	108	93	229
Heavy fuel oil	17	9	13	50	72
Steam coal	0	0	0	3	34
Natural gas (industrial use)	0	0	17	5	N/A

Source: Data from International Energy Association as compiled by Erick Lachapelle The Hidden Factor in Climate Policy: Tracking Implicit Carbon Taxes in the OECD and Implications for Canadian Policy Makers" (2010). Ottawa: Sustainable Prosperity, www.sustainableprosperity.ca.

Table 20-3 shows the large range in implicit carbon tax rates for Canada, the US, and a selection of European countries. Two points are immediately clear.

1. Canada, while having implicit carbon tax rates that are above those of the United States, has rates significantly below those in Europe.
2. Implicit carbon tax are inversely related to the carbon intensity of the fuel. The lowest rates in all countries are on the most carbon intensive fuel – steam coal.

Lachapelle has also computed Canada's implicit carbon tax rates over time in real terms (adjusted for inflation). Figure 20-4 illustrates. Implicit tax rates are falling for all fuels except light and heavy fuel oil (and coal's implicit tax rate remains at zero). Taxes for the remaining fuels have not kept up with inflation. Canadian governments thus have 'fiscal room' to raise these taxes to keep pace with inflation. Raising these tax rates would provide stronger incentives to reduce GHG emissions.

Figure 20-5: Implicit Carbon Taxes in Canada: 1999-2008 (constant (2000) Canadian dollars)

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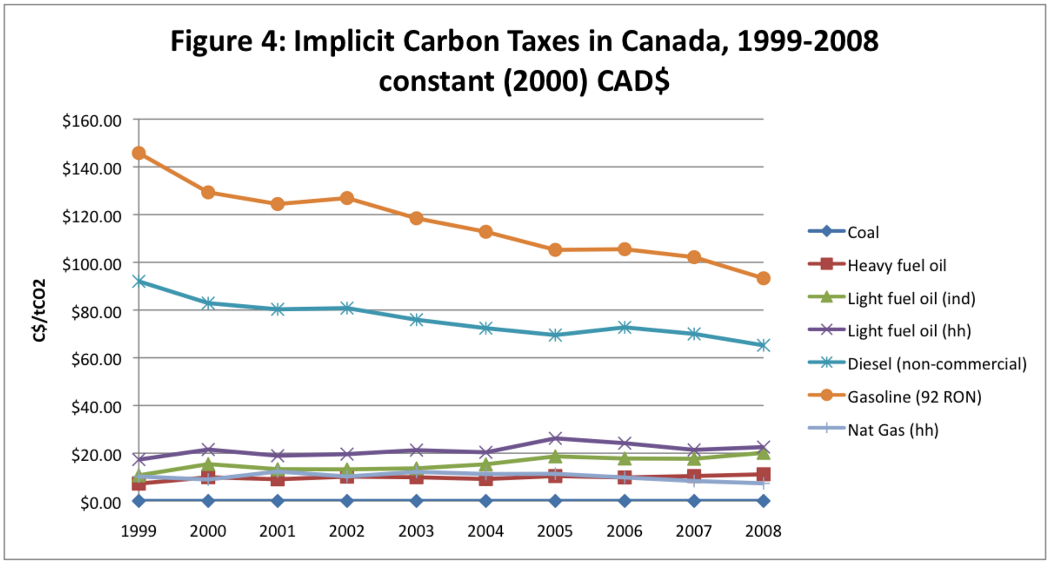

Source: Erick Lachapelle The Hidden Factor in Climate Policy: Tracking Implicit Carbon Taxes in the OECD and Implications for Canadian Policy Makers" (2010). Figure 4. Ottawa: Sustainable Prosperity, www.sustainableprosperity.ca. Reprinted with permission.

Why do International Environmental Agreements Work or Not?

Climate Change: Countries meet every other year as part of the UN Framework Agreement on Climate Change UNFCC process to discuss setting targets to reduce GHG emissions and policies to help achieve these targets. There was hope that the meeting in Copenhagen in 2009 would result in an international accord with specific targets set for major emitters, but the meeting ended with a weak statement that promised to provide more funds to developing countries for climate adaptation, but no meaningful agreement on targets or policies. However, even if a country signs an agreement to cut their GHG emissions, there is no method by which it can be forced to meet its targets. Some of the world's largest sources of GHGs, notably China, India, and the United States, continue to emit large quantities of CO_2. World emissions continue to rise as we saw in Chapter 1. Countries ask why they should reduce their emissions if China and the United States will not. Free-rider problems abound. Fossil fuels are such a pervasive part of each country's economy that the perceived costs in terms of forgone output from reducing GHG emissions are high. Political leaders are not prepared to make the current sacrifices to achieve uncertain future gains. It is also much easier to measure costs of adopting a policy than the benefits the reduction of GHGs may generate. The costs and benefits of mitigation are also very unequally distributed. Small island nations may be destroyed by increases in sea level, yet they contribute negligible amounts of GHGs. However, all international agreements are not doomed to fail. We turn first to a success story – the Montreal Protocol to eliminate ozone-depleting compounds, and then look at examples of agreements to protect natural capital. [New Footnote #8].

[New Footnote #8] Another international treaty that addresses environmental issues is the North American Free Trade Agreement (NAFTA) signed by Canada, the United States, and Mexico in 1993. NAFTA contains a 'side agreement' that addresses the impacts of trade on the environment. The objective of this agreement was to monitor the impacts of trade liberalization on the environment in the three countries to ensure that pollution did not rise as a result of greater volumes of trade or by creating incentives for industries to move to regions where environmental regulations were less strict. An agency, the Commission for Environmental Cooperation (CEC), was created to address these concerns, help prevent trade and environment conflicts, and promote enforcement of international environmental law. The CEC provides environmental information on the three countries and produces reports in a number of areas including biodiversity conservation, the impact of the economy on the environment, the effects of toxic chemicals on health and the environment, and enforcement of environmental regulations. Their webpage is: www.cec.org

Ozone Depletion

The Environmental Problem

At the surface of the earth ozone is a pollutant produced when emissions of hydrocarbons and nitrogen oxides interact in the presence of sunlight. A variety of health problems and agricultural crop damages have been traced to elevated levels of surface ozone. But most of the ozone in the earth's atmosphere is located in the stratosphere, a zone extending from about 10 km to about 50 km in altitude. This stratospheric ozone is critical in maintaining the earth's radiation balance. The atmosphere surrounding the earth essentially acts as a filter for incoming electromagnetic radiation. The atmospheric gas responsible for this is ozone, which blocks a large percentage of incoming low-wavelength, or ultraviolet, radiation.

Several decades ago scientific evidence began to appear that the ozone content of the atmosphere was showing signs of diminishing. In the late 1970s a large hole appeared in the ozone layer over Antarctica. Significant ozone reduction has now been found throughout the entire stratosphere, including parts of Canada, Australia, New Zealand, and South America. In the 1970s scientists discovered the cause of this phenomenon. It had been known for some time that the chemical content of the atmosphere has been changing at a rapid rate and on a global scale. Atmospheric concentrations of carbon dioxide, nitrous oxide, and various chlorinated gases were increasing at rates of 0.2 percent to 5.0 percent per year.[1] Ozone disappearance was linked to the accumulation of chlorine in the stratosphere. The source of the chlorine turned out to be a variety of manufactured chemicals that, released at ground level, slowly migrated up to higher altitudes. The culprits are substances called halocarbons. The primary halocarbons are called chlorofluorocarbons (CFCs) and halons.

[1.] Robert T. Watson, "Atmospheric Ozone," in James G. Titus (ed.), *Effects of Changes in Stratospheric Ozone and Global Climate,* Volume 1, Overview (Washington, D.C.: U.S. Environmental Protection Agency, 1986), 69.

CFCs were developed in the 1930s as a replacement for the refrigerants in use at the time. CFCs are extremely stable, non-toxic, and inert relative to the electrical and mechanical machinery in which they are used. Thus their use spread quickly as refrigerants and also as propellants for aerosols (hairsprays, deodorants, insecticides), industrial agents for making polyurethane and polystyrene foams, and industrial cleaning agents and solvents. Halons are widely used as fire suppressors. When these substances were introduced attention was exclusively on their benefits; there was no evidence that they could have long-run impacts on the atmosphere. After surface release, they drift up through the troposphere into the stratosphere, where they begin a long process of ozone destruction.

Several years ago it was thought that ozone depletion might confine itself to small parts of the stratosphere, in which case damages from the increasing surface flux of ultraviolet radiation would be limited. But strong evidence has appeared that damages are likely to be much more widespread. Scientists generally believe that each 1 percent drop in stratospheric ozone will produce a 2 to 3 percent increase in ultraviolet radiation at the earth's surface.[2] On this basis, radiation increases over this century are expected to be at least 3–4 percent at the tropics and 10–12 percent at the higher latitudes. Two main sources of damage from ozone depletion are health impacts and agricultural crop losses. Health damages are related to the increased incidence of skin cancers (including melanomas, the most dangerous form of skin cancer) and eye disease such as cataracts in both humans and animals. Increased UVB radiation can also be expected to increase food production costs because of the physical damages it produces in growing plants. Damages are also expected in other parts of the earth's physical ecosystem, such as phytoplankton, a vital organism in the food chain in oceans.

[2] Alphonse Forziati, "The Chlorofluorocarbon Problem," in John H. Cumberland, James R. Hibbs, and Irving Hoch (eds.), *The Economics of Managing Chlorofluorocarbons* (Washington, D.C.: Resources for the Future, 1982), 54.

Policy Responses: The Montreal Protocol

The seriousness of the ozone-depletion problem led to some vigorous policy responses. Initially several countries took unilateral actions. In 1978, Canada, the United States, Sweden, Norway, and Denmark banned CFCs in aerosol cans, but not as a refrigerant. In the 1980s the continued scientific evidence of ozone depletion led to international action. Under the auspices of the United Nations, in 1987 24 nations signed the *Montreal Protocol on Substances That Deplete the Ozone Layer*. It committed the high CFC-using signatories to phasing down CFCs and halons to 50 percent of their 1986 levels, to be achieved by 1998. Signatory countries then using low levels of CFCs were given a ten-year grace period: starting in 1999 they were to cut back to 1995–1997 levels.

United Nations Programme, "The Montreal Protocol on Substances That Deplete the Ozone Layer": http://unep.org/ozone/Treaties_and_Ratification/2B_montreal_protocol.asp

Soon after the Montreal agreement it became clear that this reduction was not enough for two reasons: continuing research showed that the problem was getting worse, and some large CFC-producing countries had not signed the original agreement. In 1990 the Montreal Protocol countries agreed to phase out the production of CFCs completely by the year 2000, to add carbon tetrachloride and methyl chloroform to the list, and to introduce a longer-run schedule for phasing out HCFCs. It also instituted a fund, created from contributions of developed countries, to be used to help finance CFC-reducing technological changes in developing countries. Additional countries signed the agreement in subsequent years. In the 1991 meeting, China finally agreed to sign the protocol, leaving only India as the major CFC-using nation still outside the agreement. In 1992, phase-out of ozone-depleting compounds was accelerated once again. It was believed that substitution of hydrochlorofluorocarbons (HCFCs) for CFCs would result in limiting equivalent CFC use to 5 percent of its 1989 level. HCFCs were then supposed to be phased out by 2030. Another ozone-depleting substance, methyl bromide, used as a pesticide and soil fumigant, was to be frozen at 1991 production levels by the year 1995. The following factors help explain why the Montreal Protocol was a successful international treaty, while efforts to reach international agreement on how much to reduce GHGs have stalled.

Factors helping to make the Montreal Protocol a successful international treaty:

1. The link between the pollutants released and environmental damages was clearly established by the science.

2. Political leaders accepted the scientific evidence.

3. There were relatively few compounds responsible for ozone depletion. The CFC-producing industry comprises a few large chemical companies. So international policy has been driven not only by scientific results, but also by international competition in this industry. Large multinational firms such as DuPont have been leaders in developing substitutes for CFCs, and they, therefore, have led the charge for a CFC phase-out.[3]

[3] DuPont was very supportive of the Montreal Protocol because it had already developed substitutes for CFCs and was therefore in a position to capture a large share of the new market for these compounds.

4. The treaty contained a compensation method for developing countries that allowed them to sign the agreement. Without the compensation fund, developing countries would have been much less likely to participate because

the costs of phasing out the ozone-depleting compounds would put a bigger burden on their economies than those of the wealthier nations.[4]

[4] The fund for developing countries is an example of the Coase theorem at work (refer back to Chapter 10). The parties bargained to a solution that internalizes the externality and compensates those made worse off.

Have the targets of the Montreal Protocol been met? For the developed countries, the answer is yes. Canada and the United States have eliminated the production and importation of CFCs, and are phasing out other ozone-depleting compounds. Each country enforces its own cutbacks as it sees fit. One of the side effects of the ban was, however, a black market (especially in CFCs used as refrigerants) that operates out of some developing countries that have a longer time period to comply with the treaty. This undermines the protocol, allowing illegal CFC sales to continue in countries that have already banned production and consumption. There are no direct enforcement steps that may be undertaken by international authorities, in this or in any other agreement. International embarrassment is not enough of a deterrent to stop these practices. And, while great progress has been made on reducing the flow of new CFCs to the stratosphere, ozone depletion is only slowly diminishingdue to the large stocks of ozone-depleting compounds still in the atmosphere. Scientists estimate it will take almost to mid-century before the process is completely reversed.

Policies Used by Canada and the United States to Phase Out CFCs

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In economic terms, we have a problem here that is similar to the phasing out of leaded gasoline. The objective is reasonably clear and widely shared; the basic problem is how to bring it about in different countries. In advanced economies the main focus has been put on developing substitute chemicals that will perform the same tasks as CFCs—as refrigerants, cleaning agents, and so on—but that have little or no ozone-depleting impact. What essentially drove the rate of CFC phase-out in advanced economies was the cost of developing these substitutes, together with the costs of changeover from the old to the new chemicals. Some substances may be simply "drop-in" substitutes, while others will require getting rid of old capital equipment (refrigerators, air conditioners) and installing new equipment.

Canada

To meet timetables agreed upon under the Montreal Protocol, each country adopted policies for production, imports, and exports of the targeted substances. In Canada, manufacture of CFCs ceased early in 1993. Consumption was banned in 1995. Environment Canada has used a type of *quota system* to phase out the chemicals. The quota limited total supply (production and importation) of CFCs and halons to their 1986 levels, beginning in 1989.[6] There were no restrictions on the supply of *specific* CFCs or halons: the quota was in terms of ***ozone-depleting potential (ODP)***,[7] which allowed for flexibility in meeting the target. For example, a company can increase its production of a CFC compound with a low ODP as long as it cuts production of another CFC compound enough that the total ODP is not exceeded. Although the quota was not marketable, it is possible that private agreements were struck among the Canadian producers to redistribute production of the different CFC compounds in a cost-effective way. Total costs of the phase-out were likely lower than they would have been if producers had to meet specific quotas for each chemical. As well, the market system would work with regard to consumption. Given the quota on ODP, one would have expected to see price variability among the types of CFCs in response to production costs, degree of substitutability in use, and so on. The key point is that efficiency is enhanced by putting the quota on ODP rather than on each compound. However, as pointed out below, producers of CFCs could still have earned high profits due to the restriction in aggregate supply.

[6] Information on the Canadian CFC policy is taken from Douglas A. Smith, "The Implementation of Canadian Policies to Protect the Ozone Layer," in G. Bruce Doern, Getting It Green (Toronto: C. D. Howe Institute), 1990.

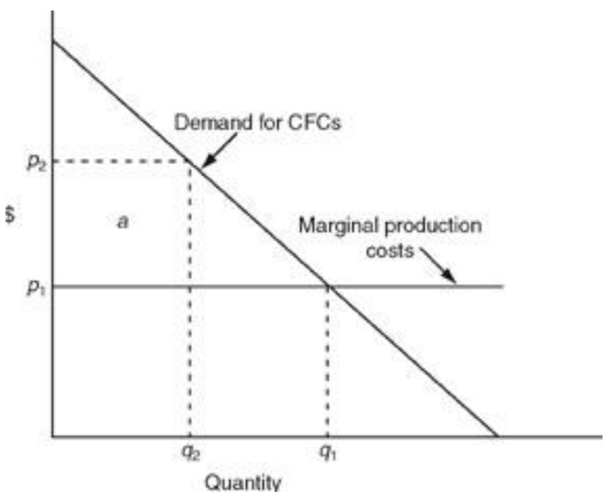
[7] The ozone-depletion potential (ODP) of a compound is defined as the estimated ozone depletion of a unit mass of the compound divided by the ozone depletion of a unit mass of CFC-11.

The United States

In the United States, the approach has been for the U.S. Environmental Protection Agency to allocate *transferable production quotas* among the five domestic CFC producers. Each of these firms is required to reduce its CFC production in stages to meet the mandated phase-out schedule. A major problem with setting production ceilings in this way is that it can lead to unwarranted increases in profits for current manufacturers of CFCs. In effect it gives firms in the industry, which may have been operating as rivals, a way of acting like monopolists.

Figure 20-5 illustrates the potential impact of the production ceiling using a simple market model. It shows a typical downward-sloping demand curve for CFCs, together with a flat marginal cost curve. In a competitive market, production would be at q_1 and a price that equals marginal production costs. But if public authorities limit production to q_2, the price increases to p_2, which is substantially above production costs. Area *a* is then the potential excess profits earned in the industry because of the output restrictions.

Figure 20-6: Government-Imposed Production Limitations Lead to Monopoly Profits



A production ceiling of q_2 in an industry leads to a price, p_2, that is above the competitive price of p_1. Area *a* represents the excess profits earned in the industry due to the production ceiling.

There was widespread feeling in the United States that at least some of these excess profits should accrue to the public. Several means were discussed. One was to auction off CFC production rights to the various chemical-producing companies. The bidding process, if it worked well, would transfer some portion of the excess profits to the public. The other approach, which was finally adopted, was to *tax the production of CFCs*.

In theory, a tax equal to $(p_2 - p_1)$ would transfer all of the excess profits to the public. It could then be used for any number of purposes, perhaps put into general revenues or used specifically to help the CFC conversion process. The system adopted establishes a base tax rate, then sets different taxes on the various ozone-depleting chemicals according to the expression:

$$\text{Tax rate} = \text{Base rate} \times \text{Ozone-depleting potential}$$

Canada did not experiment with any taxes on ozone-depleting chemicals. One of the difficulties seen with using a tax in Canada is that we import products containing ozone-depleting chemicals. The U.S. deals with this problem by levying a tax on the amount of these chemicals in the products. Canadian officials were unwilling to implement this complex tax. To deal with the problem of these compounds still in use in refrigerators, air conditioners, and other products, all provinces began implementing CFC recycling and recovery initiatives in 1993. The most common approach has been to use regulations on the disposal of products containing ozone-depleting compounds rather than any economic incentive-based strategies.

The Montreal Protocol also contains a type of pollution-trading arrangement that could reduce the overall cost of meeting its targets. This is the trading of emission-reduction credits among countries. Thus, if a country fails to meet its required production cutback because of the needs of "industrial rationalization," it is supposed to offset the excess emissions by getting comparable reductions in other countries.

Biological Diversity and Protecting Natural Capital

A global problem of perhaps great importance to the survival of life on earth is the worldwide destruction of natural capital, and, in particular, reduction in diversity among the elements of the biological system. Biological diversity refers to several levels: diversity in the stock of genetic material, species diversity, or diversity among ecosystems. But the long-run health of the whole system requires that there be diversity among its parts. Biological uniformity produces inflexibility and weakened ability to respond to new circumstances; diversity gives a system the means to adapt to change.

The human population cannot maintain itself without cultivating certain species of animals and plants. But the continued vigour of this relationship actually also depends on the stock of wild species. About 25 percent of the prescription drugs in the developed societies are derived from plants.[30] Diseases are not static; they evolve in response to efforts made to eradicate them. Thus, wild species of plants constitute a vital source of raw material needed for future medicines. Wild species are also critical for agriculture. Through traditional plant and animal breeding, and even more through modern methods of biotechnology, genetic material and the qualities they entail may be transferred from wild species into cultivated ones. In 1979, a species of wild maize resistant to an important crop virus was discovered in a remote corner of Mexico. When transferred to species of domestic corn, this charsacteristic substantially enhanced the agricultural value of that crop.

30. U.S. Office of Technology Assessment, *Technologies to Sustain Tropical Forest Resources and Biological Diversity* (Washington, D.C., May 1992), 60.

The stock of species at any particular time is a result of two processes: the random mutations that create new species of organisms and the forces that determine rates of extinction among existing species. Scientists currently estimate the number of extant species at between 5 and 10 million, of which about 1.4 million have been described. When a species goes extinct, we lose forever whatever valuable qualities that organism may have had. The normal, long-run rate of species extinction has been estimated at about 9 percent per million years, or 0.000009 percent per year.[31] Thus, this is the normal rate at which the information contained in the species stock vanishes. At several times in the geological past, the rate of extinctions has been very much higher. One of these times was the period, millions of years ago, during which the dinosaurs died off. Another is today. But while the earlier period was the result of natural causes, today's rapid destruction of the stock of species is due primarily to the actions of human beings.

31. Edward O. Wilson (ed.), *Biodiversity* (Washington, D.C.: National Academy Press, 1986).

Some species go extinct because they are over-exploited. But the vast majority are under pressure because of habitat destruction. This comes primarily from commercial pressures to exploit other features of the land—logging the trees for timber or wood, converting the land to agricultural uses, clearing the land for urban expansion, and so on. This has been a particular problem in many developing countries, which contain a disproportionately large share of the world's wild species, but which are also under great pressure to pursue modern economic development. Developed countries have already undergone massive changes in habitats and have seen extinction of species and reductions in biological diversity.

The information contained in the global stock of genetic capital has consistently been undervalued. This is partly because we do not know what is there or what portions of it may turn out to be important in the future. It is also because, almost by definition, it is impossible to know the value of the genes in a species that has gone extinct: How can society value something it never realized it had? But primarily the undervaluation of the stock of wild germ plasm is a function of the institutional structures governing the management of wild species. Whereas the market values of conventional products ensure that their production will be pursued with vigour, there are normally no comparable market values for the information contained in the wild gene pool.

Canada's efforts with regard to biological diversity are varied, but involve little in the way of specific regulation. The federal government passed endangered species legislation in 2002. Canada monitors certain at-risk species, particularly migratory birds. The federal government contributes to the Endangered Species Recovery Fund, which involves the World Wildlife Fund Canada, the Natural Sciences and Engineering Research Council, and Environment Canada. The fund's objective is to support universities and the private sector in undertaking projects that benefit endangered species and their habitat. Canada is also a signatory of the U.N. Convention on Biological Diversity and CITES – the Convention on International Trade in Endangered Species. There are a number of other international conventions devoted to the protection of species and prevention of pollution in oceans, as well as protection of specific species (e.g., whales) from harvest. The federal government has set aside land as protected space, and is investigating the creation of more wildlife corridors to permit migration of species. Some provincial governments have been active in setting aside land in parks. However, only 10 percent of Canada's vast lands are in protected areas. Many natural areas, especially those close to urban development are highly threatened.

Convention on International Trade in Endangered Species: www.cites.org
Convention of Biological Diversity: www.cbd.int

The effective maintenance of biodiversity depends on the maintenance of habitats in amounts big enough that species may preserve themselves in complex biological equilibria. This involves first identifying valuable habitats and then protecting them from development pressures that are incompatible with preserving the resident species. Canada has a network of reserved lands that have been preserved in the public domain in national and provincial parks, wilderness areas, wildlife refuges, and the like. However, the world's primary areas of genetic and species abundance and diversity are in developing countries in Central and South America, Africa, and Southeast Asia.[32]

[32.] The countries especially recognized for biological diversity are Mexico, Colombia, Brazil, Zaire, Madagascar, and Indonesia.

Efforts have been made in some of these countries, sometimes vigorously and sometimes not, to protect areas of high biological value by putting them into some sort of protected status—sanctuaries, reserves, parks, and so on. But here the situation is usually much more complicated by high-population pressures. People who are struggling to get enough resources to achieve some degree of economic security may feel that something called "biological diversity" is not particularly relevant. Land reservation for species preservation is essentially a zoning approach, and it suffers the same fundamental flaw of that policy: it does not reshape the underlying incentives that are leading to population pressure on the habitats.

One suggestion that has been made to change this is to create a more complete system of property rights over genetic resources. At the present time, property rights are recognized for special breeder stock, genetically engineered organisms, and newly developed medicines. This provides a strong incentive for research on new drugs and the development of improved crops. But this incentive does not extend backward to the protection of wild gene plasm, especially in developing countries. Some have suggested clarifying property rights in wild species, then letting countries themselves exercise these property rights in world markets for genetic information.[33] By being allowed to sell the rights to parts of the genetic stock, countries would have a way of realizing the values inherent in these stocks and so would be motivated to devote more effort and resources to their protection. Countries would also have stronger incentives to inventory and describe species that are still unknown.

[33.] See the discussion in Roger A. Sedjo, "Property Rights for Plants," *Resources* 97 (Fall 1989): 1–4.

Despite these efforts, habitat destruction and species loss continue to occur. There is still much more to do both nationally and internationally. This chapter just alerts the reader to this topic, vital to the earth's survival. Ultimately, each one of us will have to decide what sort of world we want to live in. If it is one with diverse and healthy ecosystems, environmental consequences of economic decisions will need to be assessed. This text has provided an introduction to the role that environmental economics and economists can play in a quest for better environmental quality.

SUMMARY

The world is now faced with a number of global environmental problems, especially those dealing with the disruption of the global atmosphere. These are public externalities in the purest form. Burning fossil fuels has increased the CO_2 content of the atmosphere and may affect the earth's radiation balance and lead to an increase in mean global temperatures and other climate changes. Major climate change would affect all aspects of life and economic activity on the planet—aquatic and terrestrial life, agriculture and forestry, water supplies and levels, and much more. A rise in the sea level will have profound impacts on coastal communities. Reduction in CO_2 emissions will require cutting back on the use of fossil fuels and other GHG-generating activities. All countries are dependent to a greater or lesser extent on fossil fuels to power their economies. Cost-effective policies such as carbon taxes and tradeable permits could be used to improve energy efficiency and to provide incentives to switch to fuels that emit less CO_2. International consensus on reducing GHG emissions is now largely form without substance. The record of Canada's federal government has been abysmal – while there are a number of programs supporting the reduction of GHG emissions, there are no explicit price incentives to help spur substitution away from carbon-intensive fuels and activities at the federal level. A number of Canadian provinces are taking more definitive steps including the introduction of carbon taxes and plans to add an emissions trading regime.

Depletion of the earth's protective ozone layer has been a result of the widespread use of chlorofluorocarbons for refrigerants, solvents, and other uses. The increased ultraviolet radiation this will produce at the earth's surface is expected to increase skin cancers and eye cataracts, and have a substantial impact on agricultural production. In recent years, chemical companies have had success in developing substitutes for CFCs. This greatly facilitated the signing of the Montreal Protocol, an international agreement among most of the nations of the world that has led to the phase-out of the production and consumption of CFCs.

The destruction of biological diversity is an insidious global problem because often people don't recognize how serious the impacts are on the planet until the species and ecosystems are gone. Dealing with this problem will require greater efforts and incentives to preserve habitat and promote economic activities compatible with species preservation.

KEY TERMS

Biodiversity
Cap-and-trade system, 416
Carbon allowances
Carbon Offsets
Energy efficiency, 403
European Trading System (ETS)Implicit carbon taxes
Ozone-depleting potential (ODP), 396
Price volatility

ANALYTICAL PROBLEM

1. Using Figure 20-3, analyze the impact of a TeP system. Assume (1) that demand for the GHG-intensive good is perfectly inelastic, then (2) that supply is perfectly elastic. How then would the TDP system affect consumer and producer surplus, market prices, and output?

DISCUSSION QUESTIONS

1. What are the potential costs and benefits of introducing a carbon tax in Canada? List these and explain.
2. Contrast mitigation with adaptation as means of addressing GHG emissions and accumulation in the atmosphere.
3. Should Canada adopt a carbon tax or TEP system for GHGs if no other countries do so? Take a position and defend it using economic arguments.
4. Why are TEP systems receiving more attention and interest than carbon taxes as instruments to help reduce GHGs?
5. Rather than placing a tax on fuels or the carbon content of fuels, taxes might be put on fuel-using items, such as gas-guzzling cars, less efficient appliances, or houses with poor insulation. Which type of tax would be more efficient?
6. Look at the data in Figure 20-1. What factors do you think might explain why Canadian GHG emissions declined from some years to the next? Provide economic arguments.