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Trade and the Environment - Case Study Colombia The Impact of Carbon Tax on the Energy Sector

(Final Report)

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1. Introduction and Outline of the Study

The U.N. has chosen Colombia to prepare a series of case studies illustrating the relationships between trade and the environment. The studies are to be designed to illuminate two aspects of this relation. Part one studies are to investigate the effect that international environmental regulations may have on the domestic economy. Part two studies are to investigate the effect that increased trade and "openness" of the economy may have on the environmental quality of the country.

Traditionally the connection between international trade and the quality of the environment in a country was viewed as one dimensional. First it has always been assumed that environmental management and protection are strictly domestic or national issues. This means that other countries would make no demands nor place any trading restrictions on a country to force it to conduct any particular type or level of environmental protection activity.

Second, it has been assumed that regulations imposed within a country to protect its environment were expected to increase the cost of production of goods and services. The increase in cost would tend to lower competitiveness in export markets and to increase the likelihood that foreign goods would imported to compete with domestic production. The effect of this change in relative cost is to decrease net exports and hinder economic growth and development. As a result, many analysts have feared that developing countries would be tempted to avoid environmental protection and become "pollution havens" where dirty but low cost production activities would generate jobs.

Recent events have shown that both of these assumptions may be wrong. With respect to the first issue, the emergence of global environmental problems has made pollution control worldwide a concern of all nations. The possibility of global warming and destruction of the stratospheric ozone layer are caused by emissions of gases all over the world. The maintenance of carbon sinks and biodiversity in the form of tropical rainforests has also become a global concern. These examples illustrate that environmental protection is quickly becoming an international issue which will no longer be left to the private decisions of individual countries.

The second assumption of a tradeoff between environmental protection and economic development is also being questioned. First, many new and more productive technologies are also cleaner than older production techniques. So in some circumstances, pollution can be reduced with no increase in production cost. Second, there is growing acceptance that a sound environment is a necessary basis for development. Polluted air and water causes significant health effects reducing labor productivity and

requiring direct medical expenditures. Damage to the natural resource base of a country also reduces the long term productivity of agriculture, forests and fisheries.

The U.N. has recognized these changing perceptions, and the fact that the world economy is evolving away from a set of isolated economies into a truly global economy dominated by multinational corporations. In the short term, there will be conflicts between the desire for competitiveness and environmental protection. And there will be pressure brought to bear on the developing world to do more to prevent pollution. Potentially these pressures may involve trade restraints.

Granting these concerns, the case studies should be designed to help individual developing nations to prepare for the transition from closed economies with little environmental protection to open economies operating under policies of sustainable development and conforming with international norms for environmental management.

The case study being proposed here, is a study of the effects of a carbon tax on Colombia's energy sector and a comparative analysis of an alternate set of taxes on air pollutants that cause local damages. This case study would fit into the comprehensive plan in section 5, (International Environmental Agreements).

The Case Study Problem

Global warming is thought to be caused by emissions of "greenhouse gases" carbon dioxide being the largest in volume of these. The questions of whether warming is occurring, whether greenhouse gases are the cause, and what the effects might be are being extensively studied and are not the topics of the present proposal.

Instead we accept that concerns about the problem are rising and that many nations are discussing policies for the control and ultimate reduction in the emissions of such gases. One fact suggests that some international agreement, similar to the Montreal Protocol for the control of cloroflourocarbons, may be proposed in the next few years. The basis of this prediction is that it will take years before there is sufficient data available to determine with some certainty whether the problem exists. If we wait until the scientific community establishes proof of the phenomenon, we probably will have lost whatever opportunity we may have to avoid or mitigate the damages from warming. Thus it is likely that the international community will feel compelled to make a decision in the near future.

One possibility is that an international agreement would be signed committing each nation to impose a tax on the production, use or sale of fossil fuels with the size of the tax determined by the content of carbon in the particular fuel being taxed. The "carbon

tax" is gaining increasing support as one of the most efficient and equitable strategies to induce reductions in the worldwide emissions of greenhouse gases. A uniform tax on the carbon content of fuels is workable because this contaminant once released anywhere in the world undergoes perfect mixing in the atmosphere. As a result the location of its discharge does not matter. All units of emission cause the same damage. Hence a uniform tax would be efficient in an economic sense and relatively easy to administer.

In general this tax would change the cost structure of the fossil fuels. Coal holds the greatest carbon per unit energy, followed by oil and natural gas.

The benefits of a carbon tax are not accepted by everyone. Countries that are rich in coal would be disproportionately hurt. This group includes small countries such as Colombia as well as the vary largest such as China. Also global warming is a textbook example of a global common property problem. Individual countries can argue that their sacrifice in reducing greenhouse gas emissions would provide only small direct benefits to themselves. In addition small countries can argue that their share of total emissions is small and therefore their contribution to solving the problem would be small in the world context while costing them dearly at home. These considerations suggest that the free rider problem will be significant.

In response to these concerns, it has been suggested that a carbon tax be established but the size of the tax should be based on the local benefits to be received by the individual countries in the form of associated reduction in local air pollution. In light of these arguments we are including in this study examples of carbon taxes that might be justified by local pollution control objectives. And we also analyze alternative taxes that might be imposed directly on two major air pollutants that are of local concern: particulate matter and sulfur dioxide.

Outline of the Study

The following section presents a review of the current policy debate, and identifies a likely range of alternative tax levels that might be adopted. For example, the tax could be based on the estimates of marginal damage, or on politically chosen goals for reduction of these gases.

Section 3 describes the energy sector in Colombia and assembles the data that is needed for evaluation of the possible effects of a carbon tax. This section presents data on fossil fuel production, consumption and exports as well a review of the types of energy used at the point of consumption in Colombia.

Section 4 presents estimates of the change in sales price for each of the major fuels produced in Colombia. Since Colombia produces fuels with a wide range of carbon content, prices would not only rise but also the relative structure of prices will change. For example, coal will become relatively more costly in comparison with oil and natural gas. This section also contains estimates of the potential revenue to be earned from a carbon tax.

With respect to domestic consumption, we estimate the effect of the new price structure on demand and expenditures. And with respect to exports, we estimate the effect that the change in relative prices will have on Colombia's competitiveness in international energy markets. This part of the study is somewhat limited since it requires knowledge of how the price structure of energy fuels in other countries might change in response to a carbon tax.

Section 5 consists of a review of the impact of this tax system on the major energy consumers in Colombia. The electricity sector is not much affected due to its high reliance on hydroelectric projects. Certain energy intensive industries such a cement will face cost increases. At the household level, gasoline consumption is probably the effect of greatest interest.

Section 6 presents the analysis of alternative taxes, or "emissions fees" that could be imposed on particulate matter, sulfur dioxide or nitrogen dioxide. This tax strategy would create economic incentives for polluters to search for and employ the most cost effective control strategies. Such controls may include fuel switching, choice of cleaner production technology, or installation of pollution control equipment. In general, it is widely recognized that economic incentives lead to the most efficient and lowest cost forms of pollution control. This alternative would lead to some reduction in greenhouse gas emissions, it could be designed to generate the same amounts of revenue as a carbon tax and it would provide direct benefits to the people of Colombia.

The last section discusses the results and policy implications that Colombia may wish to consider in its future negotiations regarding a carbon tax and other forms of pollution control.

2. Carbon Tax Proposals under Consideration

Schelling (1992) points out that expenditures of the level of two percent of GDP would be needed to cause any significant decrease in carbon emissions. Moreover a tax in the developed countries would have to be in the range of a dollar a gallon tax on gasoline. Such a tax on coal, petroleum and natural gas would generate half a trillion dollars of revenue per year in the U.S. These magnitudes lead him to argue that neither the developing countries nor the industrialized nations will seriously agree to a carbon tax.

On the other hand, the tax has been proposed by many other analysts as the fairest and most efficient mechanism for reducing carbon emissions worldwide. The U.S. Environmental Protection Agency has endorsed the carbon tax as a policy alternative worth considering (Lashof 1989). General Motors Corporation has argued that the carbon tax would be preferred to increasing motor vehicle mileage standards (Petrauskas 1989). And many economists have supported the use of a tax on efficiency grounds.

According to economic theory, the proper method for determining the optimal tax level focuses on the damages caused by carbon dioxide emissions and damages caused by simultaneous pollution generated during combustion of fossil fuels. But, for the reasons explained below, this approach is not feasible.

The potential damages caused by global warming are extremely difficult to predict. The analysis must cover a time period of at least fifty to one hundred years and requires prediction of not only the effects of warming but also the social, technological and economic conditions that will prevail during this time period.

In fact, a simple warming trend is not the primary source of damage from the greenhouse effect. Weather patterns are likely to change in unpredictable ways. Some regions may get warmer while others get colder. For example, ocean currents are affected by temperature and in turn influence air temperature in large regions. If the Gulf stream were to change course and move farther away from northern Europe, that area might well become colder. Moreover, the intensity of storms is primarily a result of the amount of heat available in the weather system. One likely effect of warming is that storm systems will be larger, more violent and possibly occurring in unpredicted areas.

In addition, ecological systems will be affected. Agricultural productivity may change significantly, with some regions gaining and others losing. Disease vectors may be altered bringing tropical diseases into areas previously free of them and therefore potentially more vulnerable.

Finally, technological and economic conditions will no doubt change drastically over the next one hundred years. Imagine how analysts would have predicted the effects of global warming in the northern hemisphere if the exercise had been performed one hundred years ago. Most of the population then lived on farms and agriculture was the dominant source of income. Clearly a disruption of agricultural productivity would have been seen as the greatest risk. In fact over the last century most people have moved from farming to industry and are now little affected in their work productivity by the weather.

All of these effects are now thought to be more likely than the sea level rise that was just a few years ago thought to be the greatest risk from global warming.

For all of these reasons, no analyst can seriously attempt to estimate monetary damages from warming. At best, various groups have developed descriptive scenarios of what might happen. Consequently we cannot hope to set a carbon tax equal to the marginal damage caused by its release as would be needed for a theoretically optimal tax.

As an alternative, there are two serious bases that can be used to choose a tax level: estimation of local damages from pollution caused in the combustion of fossil fuels and estimation of tax levels that will cause certain reductions in CO2 emissions.

Larson and Shah (1992) presents estimates of the health and other local damages caused by fossil fuel pollutants as a basis for setting a reasonable carbon tax. Specifically with reference to the developing world, they point out that much can be accomplished merely by eliminating subsidies on energy. But beyond that, they argue that a tax of $10 per ton would make sense for developing nations as well as industrialized countries as a mechanism for reducing local pollution damage as well as reducing the emission of greenhouse gases.

Hall (1990) estimates the external cost of CO2 emissions by measuring the cost of switching to non-polluting energy sources such as solar and wind. This approach does not actually measure the damages of global warming but it results in a marginal "external cost" in terms of units of fuel. On this basis, he recommends a tax on the order of $26 per ton of carbon.

The other major approach focusses on preselected emission reduction goals, or on goals of reducing the growth in emissions. The American Petroleum Institute (Anderson, et. al. 1990) notes that a tax of five cents a pound ($100 per ton) on carbon would be needed to achieve a reduction of U.S. CO2 emissions by twenty percent from a 1988 baseline. However they only include in their analysis the effect of a one cent per pound tax ($20 per ton).

The Edison Electric Institute, a research arm of the U.S. electricity industry, has prepared analyses of carbon taxes as high as $100 per ton. A tax of $100 per ton is thought to be needed if the goal is to reduce global carbon emissions by 5% with all reductions occurring in the industrialized nations. Industrial nations now account for about 43% of total CO2 emissions from fossil fuels consumption. But the developing world is expected to become a major contributor in the near future. This tax rate in the U.S. would raise the price of a ton of coal by 230%, of oil by 65% and of natural gas by 90%. This implies an increase of about 2.4 cents per kilowatt-hour of electricity from coal burning

plants, on a national average price of about 7.5 cents - an increase of thirty-two percent.

On the basis of these proposals under consideration, we will assess the effects on the Colombian energy sector of carbon taxes ranging from $10 per ton of carbon to $100 dollars per ton. The lower figure is the rate that could probably be justified on the basis of local benefits to the Colombian people from reduced air pollution. The high end of the range represents the maximum tax levels under consideration, but which in all likelihood would not be adopted in international agreements.

3. The Energy Sector in Colombia

Table 1 contains basic information about fossil fuel production and sales in Colombia. All monetary and price information in this paper are presented in terms of U.S. dollars. Of the 23 million tons of coal mined in Colombia, more than two-thirds is exported, generating $622 million in revenue at $38 per ton. The domestic price is significantly lower at about $18 with total expenditures of $123 million.

Although coal is mined in many parts of the country, the largest single source of coal is the north coast region of the country. El Cerrejón located in the department of Guajira is one of the largest open pit mines in Latin America. The mine is operated for Colombia by Intercor, an affiliate of the Exxon corporation, and more than 3,000 workers are employed locally.

Petroleum is the dominant fossil fuel, both in terms of quantity and value. With 1992 production at nearly 160 million barrels, crude oil export revenues are just short of a billion dollars per year. For domestic consumption, we have calculated the weighted average price of the various derivative products at $34 per barrel and domestic expenditures at $3.67 billion. In addition, the country imports 11.6 million barrels of gasoline costing $267 million per year and exports 17.5 million barrels of fuel oil for a $200 million dollar income.

The country produces only 144 million mcf of natural gas and consumes all of it domestically. The current market price is $2 per thousand cubic feet (mcf) which is about half the price in the United States for domestic consumption. There is an aggressive plan to expand the delivery system for gas to households, so we can expect the production and consumption of this clean fuel to increase steadily over the years.

TABLE 1

Fossil Fuels - Colombia

	Energy Source			Major Derivatives	
	Coal (tons)	Oil (barrels)	Gas (mcf)	Gasoline (barrels)	Fuel Oil (barrels)
Production:					
Quantity (millions)	23.2	159.6	143.9	30.5	24.5
Domestic Consumption:					
Quantity (millions)	6.9	108	143.9	42.1	1.5
Price	$17.82	$34.00	$2.00	$36.00	$14.00
Expenditure (millions)	$123	$3,672	$288	$1,516	$21
Exports:					
Quantity (millions)	16.3	51.6	0	-11.6	17.5
Price	$38.13	$17.82		$23.00	$11.40
Export Revenue (millions)	$622	$920		($267)	$200
Carbon Content:					
Tons carbon per unit of fuel	0.61	0.133	0.0165		
Implicit price ($/ton domestic)	$29	$256	$121		
Implicit price ($/ton export)	$63	$134			
Total Carbon (million tons)	14	21	2		
Domestic Emissions (million tons)	4	14	2		

Note: The domestic price of oil represents the weighted average price of its derivative products.
All monetary values are in U.S. dollars.

Source: Ecopetrol , Carbocol 1992

Coal is the dirtiest of the fuels, containing 1220 pounds of carbon in each ton of coal. This compares with 266 pounds per barrel of oil and only 33 pounds per thousand cubic feet of natural gas. The relatively high carbon content of coal together with its low price means that the effect of any given carbon tax will be a large percentage increase in the price of coal relative to the effects on the prices of oil and gas.

Another way to see this is to calculate the current implicit price of carbon in each of the fuels. By dividing the unit price of each fuel by the amount of carbon per unit, we see that in coal, carbon is priced at only $29 per ton on the domestic market. Clearly taxes between $10 and $100 per ton carbon will have extreme effects in the coal market. At the other end of the spectrum, the implicit price of carbon in domestically sold oil is already $256, so the imposition of carbon taxes will not cause such a large impact.

Colombia is not a significant contributor to the global warming problem either in terms of production of fossil fuels nor in the release of carbon through domestic combustion of fuels. The total carbon content of fossil fuels produced in 1991 was 37 million tons. The total amount of carbon released to the environment from domestic combustion of these fuels was only 20 million tons. This compares with 1987 emissions of 1,246 million tons in the United States, and total global emissions of nearly 6,000 million tons. So Colombia's contribution to the problem is on the order of 0.3% to 0.6% depending on whether you count production or domestic consumption.

Table 2 (Flavin 1990) shows how Colombia ranks in terms of carbon emissions in comparison with some developed and less developed countries. Colombia's low rank in terms of emissions per capita is partly due to the large reliance on hydroelectric power as compared with other countries.

Moreover Birdsall and Dixon (1991) points out that the developing countries as a group contribute only 20% of total global emissions. But the industrialized countries, with only 15% of world population, release over 50% of the carbon emissions. And the former soviet states and eastern Europe, with 10% of the worlds population, contribute more than a quarter of the total emissions. These statistics begin to suggest that small developing countries such as Colombia bear little blame for the global warming problem. But in the future the developing world will account for a large part of the expected increase in carbon emissions. In particular, China has vast reserves of coal that will be increasingly used to fuel economic development.

Table 2

Fossil Fuel Carbon Emissions

	tons/year per capita	grams per $GNP
U.S.	5.03	276
Australia	4.24	247
Soviet States	3.68	436
Poland	3.38	492
Japan	2.12	156
France	1.70	133
S. Korea	1.14	374
Mexico	0.96	609
Colombia	0.63	476
China	0.56	2,024
Brazil	0.38	170
Nigeria	0.09	359

4. Direct Effects of Carbon Taxes

During the first few years after imposition of a carbon tax, consumers will not be able to alter their consumption pattern very much because of existing investments in combustion technology. This will be true for the residential sector with its existing stock of vehicles, appliances and heating systems as well as for the commercial and industrial users that have larger and longer lasting investments in combustion technologies. Therefore, to illustrate the near term impact on energy users, we assume that the quantity of fuels consumed will remain the constant. The prices of fuels will rise according to their carbon content and these price increases will be absorbed by the residential sector and partly passed on to consumers by the industrial and commercial sectors in the form of higher product prices. Over time, demand for the three basic fuels will adjust to the new set of relative prices. But this adjustment will be gradual, extending over ten to fifteen years for industrial energy users with extensive physical plant.

Short Run Fuel prices and tax revenues

Table 3 provides a summary of the direct, short term effects of a carbon tax set at various levels. As discussed above, we have identified a range of tax rates that are being discussed in various forums. The low end of the range, $10 per ton carbon, represents the tax level that could be justified on the basis of local pollution control objectives. Rates of $20, $50 and $100 per ton carbon reflect the higher tax levels that have been proposed as

realistic attempts to control emissions. Although several institutions have discussed a rate of $100, few analysts expect that any rate nearly this high would be politically acceptable to either the developed or the less developed nations.

These results were calculated as follows. The beginning point is the amount of carbon contained in each unit of fuel. These contents are listed in Table 1. Next the tax rate per ton carbon is multiplied by the amount of carbon contained in each unit of fuel to determine the dollar amount of tax per unit fuel. Finally this dollar tax is represented as a percentage increase in the end user price of the fuel as it is sold in domestic or international markets. Since in this short run analysis, we are assuming that the quantities of fuels sold does not change, we calculate the total annual tax revenue expected from the tax based on current "pre-tax" sales.

To illustrate, suppose Colombia imposed a tax of $10 per ton carbon on its three principle fossil fuels. The tax would be $6.10 per ton of coal, $1.33 per barrel of oil or refined product and only $0.17 per mcf of natural gas. Since coal is sold so cheaply in domestic markets, and due to its high carbon content, the effect on the price would be a 34% increase, whereas the increases for petroleum products and gas sold domestically would be only 4% and 8% respectively. Note that natural gas prices rise by a greater percentage than petroleum products even though gas is cleaner in terms of carbon content. This is because the pre-tax price of gas at $2 per mcf, is so much lower than the pre-tax weighted average price of refined petroleum products, at $34. No result is shown for the export market in the natural gas column since all gas is consumed domestically, and no exports are expected in the near future.

The amount of tax revenue generated even by this lowest rate under study is impressive. Total potential annual tax revenue is $378 million with almost 45% of the total coming from exports. Overall, coal would generate carbon tax revenues of $141 million per year, petroleum $213 million and gas $24 million.

When we analyze higher possible tax rates, the effects increase in proportion to the rate. Possibly the most dramatic and important result of this exercise is the extreme effect on the price of coal that would result from imposition of tax rates in the range of $20 to $50 per ton carbon. These rates represent realistic efforts to control the growth of carbon emissions and slow global warming. They are likely to be promoted both on the basis of the potential damages caused per unit of carbon emissions and on the basis of the cost of switching to less polluting energy technologies. Hence this range may well be at the center of discussions of carbon tax strategies.

TABLE 3

Direct Short Term Effects of a Carbon Tax

		Coal (tons)	Oil (barrels)	Gas (mcf)
Tax per ton Carbon	**$10**			
Tax Rate ($/unit fuel)		$6.10	$1.33	$0.17
Domestic Price Increase		34%	4%	8%
Export Price Increase		16%	7%	
Short Run Annual Tax Revenue				
Domestic (millions)		$42	$144	$24
Export (millions)		$99	$69	
Total (millions)	$378			
Tax per ton Carbon	**$20**			
Tax Rate ($/unit fuel)		$12.20	$2.66	$0.33
Domestic Price Increase		68%	8%	17%
Export Price Increase		32%	15%	
Short Run Annual Tax Revenue				
Domestic (millions)		$84	$287	$47
Export (millions)		$199	$137	
Total (millions)	$755			
Tax per ton Carbon	**$50**			
Tax Rate ($/unit fuel)		$30.50	$6.65	$0.83
Domestic Price Increase		171%	20%	41%
Export Price Increase		80%	37%	
Short Run Annual Tax Revenue				
Domestic (millions)		$210	$718	$119
Export (millions)		$497	$343	
Total (millions)	$1,888			
Tax per ton Carbon	**$100**			
Tax Rate ($/unit fuel)		$61.00	$13.30	$1.65
Domestic Price Increase		342%	39%	83%
Export Price Increase		160%	75%	
Short Run Annual Tax Revenue				
Domestic (millions)		$421	$1,436	$237
Export (millions)		$994	$686	
Total (millions)	$3,775			

Countries such as Colombia cannot ignore the effect of these rates on coal prices. A twenty dollar per ton tax on carbon could increase the domestic price of coal by 68% and a fifty dollar tax would cause a price increase of 170%. Needless to say, these are not marginal changes in the coal market. The effects on the prices of petroleum products and gas are in the more manageable range of 8% to 17% for a twenty dollar tax and 20% to 40% for a fifty dollar tax. At the high end of the range of proposed tax rates, a one hundred dollar tax seems entirely unrealistic, requiring increases of up to three and a half times in the case of coal.

Potential tax revenues also rise in proportion to the carbon tax rate. A twenty dollar tax would yield $755 million per year in the short term, a fifty dollar tax yields $1,888 million while a $100 tax would generate $3,775 million.

Clearly the imposition of a carbon tax at the higher rates would be deflationary for the economy and could not be enacted without reducing other taxes. This represents both a problem and an opportunity. The country may see the global warming negotiations as a mechanism to substitute a carbon tax in place of income or other types of taxes. Since carbon taxes can be collected from producers, the administrative cost may be lower and the success of enforcement greater than for income taxes.

Moreover, the carbon tax serves two additional purposes beyond the generation of revenue: reduction of local air pollution and a contribution to the control of global warming. On the other hand, as noted in the next section, energy consumers will respond to the tax by reducing their overall energy use and changing the mix of fuels used. As a result, the revenues from a carbon tax will fall over time. Thus this tax does not offer a source of income as stable as that of an income tax.

On the basis of this preliminary analysis, we must agree with many other analysts that carbon tax rates much above the ten dollar level would be very disruptive to energy markets and to consumers. The immediate policy implication is that such taxes would either have to be phased in over a fairly long time period in order to allow consumers an adjustment period, or the tax would have to incorporate some modification to reduce its effect on coal markets.

It is also evident that Colombia would have to take some action with respect to natural gas because of the planned role the government has for this fuel in residential consumption. The government hopes to expand greatly the distribution system for gas and bring this clean and safe fuel into much wider use among residential energy consumers. Considering the fact that many of the potential new household consumers have relatively low incomes, the expansion plan would be severely affected by imposition of high carbon taxes.

In section 7, we will discuss these implementation problems further and offer some ideas for negotiating a carbon control strategy that is feasible in the context of the country's development plan.

Demand Response

The taxes considered above would cause large percentage increases in the prices of the fuels under study. Both export markets and domestic consumers will react to these price increases by changing the amount and pattern of their energy consumption. In general the demand for coal will be the most affected since its relative price would rise by such a great extent. Petroleum products become more expensive but also offer a cheaper alternative to coal. So depending on the percentage change in price, demand may rise or fall since consumers are responding to two pressures. First they see the absolute price of oil rise inducing a reduction in demand. But also they see that oil has become relatively less expensive as compared with coal, thus inducing a substitution of oil products in place of coal. Natural gas would experience a fairly low absolute increase in price and is subject to the same conflicting forces as petroleum.

Adjustment Time Period

The time needed for consumers to respond is difficult to estimate. In general, the response time will depend on the ability of consumers to adjust their ownership of the capital stock which complements energy use. Coal users typically are burning the fuel in large combustion facilities such as industrial boilers or ovens. These facilities are capital intensive and have long useful lives on the order of twenty to thirty years. Hence we might expect that coal users will require the longest time to adjust fully to increased prices.

On the other hand the physical life of the combustion plants is only one factor in the adjustment decision. As the price of the fuel rises, the cost of production rises and at some point the existing production technique becomes unprofitable. In other words, the economic life of the facility may be shorter than its physical life as changing economic conditions render the plant economically obsolete.

Some industrial petroleum users will be in the same situation as coal users. But much of the demand for refined petroleum products comes from the transportation sector. So the time needed for demand reaction depends on the useful life of cars, trucks and planes etc. and on the ability to either replace them with more fuel efficient models or switch to alternate transportation methods. In Colombia, the fleet of vehicles does not turn over rapidly. The average age of vehicles on the road is about fifteen

years. Therefore we can expect this sector to respond more quickly than the coal using sector, but slower than might be expected in a more developed economy with a faster fleet replacement period.

Methods

Because of the complexity of predicting the time needed for adjustment to higher energy prices, in this study we only assess the long run demand response. The actual change in quantity demanded for the various fuels will occur gradually and at different speeds in different end use sectors. The results presented here illustrate the final demand that can be expected at the end of the adjustment period.

The demand analysis results are shown in Table 4. The top part of the table presents the long run elasticities of demand used in the analysis. The direct price elasticities shown on the diagonal of the matrix are negative, showing the degree of decrease in demand due to a percentage increase in the own price of the fuel. The off diagonal elements are the cross elasticities of demand which show the degree of substitution effects between fuels.

These elasticities are taken from a study of world energy markets, (Edmonds and Reilly 1983) and assume that energy prices everywhere are experiencing the same changes. Clearly if one country were to impose taxes unilaterally on only its own energy production, the demand response would be much greater than if all countries simultaneously adopted the same tax system.

For the case of coal, we have calculated the demand changes separately for the domestic and export markets to reflect the fact that the base (pre-tax) prices are substantially different. But in the case of petroleum we use the weighted average price of refined products as the base for both domestic and export markets. This approach recognizes that it is the end user price that is paid by customers whether the petroleum is refined in Colombia or elsewhere. Thus it is correct to represent the carbon tax in terms of the percentage increase in price that will ultimately be paid by consumers. Since natural gas is not exported, only a domestic response is presented.

TABLE 4

Long Run Demand Responses

Long Run Energy Demand Price Elasticities

	Coal	Oil	Gas
Coal	-0.56	0.22	0.16
Oil	0.1	-0.7	0.1
Gas	0.12	0.13	-0.52

Source: Edmonds and Reilly (1983)

Long Run Changes in Quantity Demanded (percent)

Carbon Tax		Coal	Oil	Gas
$10	Domestic	-17%	2%	0%
	Export	-7%	-1%	
$20	Domestic	-34%	3%	1%
	Export	-15%	-2%	
$50	Domestic	-85%	8%	2%
	Export	-37%	-6%	
$100	Domestic	-100%	15%	3%
	Export	-73%	-11%	

Results

As expected, the demand for oil and gas is only moderately affected by a carbon tax. Even at the unrealistic level of one hundred dollars per ton carbon, the domestic demand for oil increases 15% and the demand for gas increases 3%. These increases represent switching of consumption away from coal to these relatively cleaner fuels. In the export market, the demand for oil falls by 11%. The different response between the domestic and export markets is due to the fact the base price of coal is lower in the domestic market leading to a higher percentage effect of the tax and greater substitution of oil for coal.

The major impact is seen in the markets for coal. A ten dollar carbon tax will ultimately cause the domestic demand to decline by 17% and the export demand to fall by 7%. These reductions might be tolerable for the Colombian economy, but as higher carbon taxes are considered, the effect on coal demand becomes very disruptive. A twenty dollar carbon tax could cause domestic coal demand to fall by one third and exports to decline by one sixth. Such large reductions in export earnings from the coal sector accompanied by small decreases in earnings from oil exports could damage the balance of payments accounts substantially.

The results for fifty and one hundred dollar carbon taxes are reported but should not be taken as exact estimates. This is because all estimates of elasticity of demand are based on small or "marginal" price changes. As we extrapolate away from the range of price changes that were used to estimate the original elasticities, the validity of the response is lowered. If prices for coal increased suddenly by as much as 35% to 100% there would certainly be extreme responses in user markets, but the size of the demand reduction could not be predicted with accuracy. Therefore we offer the demand results at the higher tax rates as cautionary illustrations only.

To illustrate this problem, note the results for a one hundred dollar carbon tax in the domestic market for coal. The domestic price would rise by 342%. If we calculate the demand change exactly, using our long run elasticities, the result is a 170% decline in the quantity demanded. Obviously demand cannot fall below zero unless consumers are bringing stored coal out of their basements and selling it back to the mines. So in Table 4, we report a truncated result of a 100% decline in demand. Again this result is not reasonable as it implies that no coal is burned in Colombia.

These results underscore the comments made earlier that it is very unlikely that countries of the world would actually adopt carbon taxes at the higher end of the range currently being debated in the academic and policy literature. Nevertheless "forewarned is forearmed".

If negotiations were conducted regarding a multilateral carbon tax, two issues need to be given thorough discussion. First, the tax can have large impacts on the prices of the affected fuels. And these fuels are basic energy sources for industry, transportation and households. Given the existing investment in combustion technology including vehicles, the users will need several years to adjust to the proposed taxes. If the tax was introduced suddenly, it could cause unacceptable disruption to the user sectors and potentially severe macroeconomic shocks, particularly to small economies. To reduce this disruption the tax should be introduced gradually over a several year period. Small economies like Colombia should argue in favor of a long phased implementation period.

Second, the effect on coal markets is likely to be very great. Even though coal is the largest contributor per unit fuel to the greenhouse gas problem, some moderation of the tax as applied to coal may be justified on the grounds of industry and macroeconomic stability. Again in the case of a country like Colombia, with a significant coal production industry, it might be prudent to argue in favor of a graduated tax that imposes a relatively lower rate on coal. This could moderate the increase in the price of coal and avoid some of the negative impacts on the coal industry and on coal export earnings.

To conclude this section, we can point out that tax revenues expected from the carbon tax would also be reduced in proportion to the long run decline in demand. A seven percent decline in the quantity of coal exported would also mean a seven percent decline in the tax revenue earned from export consumers. Instead of bringing in nearly $100 million from external coal consumers the carbon tax at the ten dollar rate would only bring in $93 million.

5. Effects of the Tax on Energy Consumers

The major energy consuming industries are listed in Table 5. These six industries are likely to experience to greatest impact from a carbon tax because of their relatively high use of fossil fuels. As energy intensive industries, they will be forced to pay the largest share of any carbon tax.

Among these industries we can first examine the quantities of fuels consumed at the present time, that is before imposition of any carbon tax. The largest consumer of coal is the cement industry with an annual purchase of more than one million tons. The next largest consumers are stone, glass and ceramics and then the paper and printing industries. The production technologies used in these manufacturing processes require large amount of fuels for physical processing of raw materials. As a result, there is relatively little that can be changed to reduce energy usage. Instead we can expect fuel switching to occur in response to a carbon tax and also

some increase in the price of the final products as firms pass on to consumers some of the cost of the carbon tax.

With respect to petroleum products, the highest consumer is the food, drink and tobacco industry, with annual consumption of more than 1200 thousand barrels, followed by the stone, glass and ceramics industry with annual consumption of nearly 900 thousand barrels. Although the impact of a carbon tax on the price of oil is not nearly so great as the case of coal, tax rates above fifty dollars per ton carbon can raise the price of petroleum products more than twenty percent. So the effect on these two industries will be substantial.

Finally, to identify the industries that will be most affected, we can observe the last column in table 5, showing the percentage of total cost attributed to fossil fuel consumption. By far the largest cost share is found in two industries, cement, with a cost share of over eight percent and stone, glass and ceramics, with a cost share of almost six percent. These industries will be forced most of all, to reduce energy use, switch away from coal wherever possible, and raise product prices.

Looking at the intersection of these indicators can help us to identify which industries will be most affected overall by a carbon tax. It is apparent that the cement industry will have the greatest difficulty adapting to a carbon tax. Cement manufacturers are the largest consumer of coal, and the share of fossils fuels in total cost is the highest of the energy intensive industries. Stone, glass and ceramics is the next most vulnerable industry in the group as the second highest coal consumer and with the second highest cost share for fossil fuels. The data clearly suggests that these two industries deserve the greatest attention in any further evaluation of carbon tax proposals.

Table 6 presents data on the structure of these industries and allows a preliminary assessment of the indirect impacts of a carbon tax. First, we note that the two industries most directly affected by a tax, cement and stone, glass and ceramics, are not as important in the national economy as the other energy intensive industries. In terms of domestic sales, exports and employment, these two industries rank relatively low. Fortunately any increase in production cost and associated decreases in output, will not create as great a secondary effect as might have been expected from some of the other industries in this group.

Nevertheless, the stone, glass and ceramics industry is a substantial exporter and employer, so there will be some concern in that industry about international competitiveness. And the cement manufacturers, of course, are important suppliers to the entire domestic construction industry. Infrastructure is heavily dependent on cement and also the large majority of residential and commercial structures in Colombia are built with cement. Therefore

the entire construction industry will be concerned about the effects of a carbon tax.

If a carbon tax is to be considered further, this preliminary analysis of secondary impacts should be expanded. For example, in the case of international competitiveness, we would have to collect information about the cost structure of similar industries in the major competing countries and analyze the resulting effects on relative prices. In the case of domestic consumption, most importantly for the cement industry, we would have to conduct an analysis of the availability and cost of alternative materials. For example, the use of cement could be reduced in construction of new buildings and replaced by wood, and steel framing materials.

The scope of the present study does not allow further analyses of this type to identify the full range of secondary impacts. But we have been able to identify four industries that may be most affected and which deserve further consideration. The cement, and the stone, glass and ceramics manufacturers will be the first concerns. Then to a lesser extent we should assess the impacts on paper and printing because of the high current coal consumption. And finally the food, drink and tobacco sector should be examined further since it consumes reasonably large amounts of both coal and petroleum products and because it is the largest industry in terms of production value and employment. If serious carbon tax negotiations are undertaken, the government can expect that the trade associations representing these four industries will want to be consulted.

Table 5

Major Energy Consuming Industries - Energy Consumption

	Coal (000 tons)	Oil (000 bbls)	Gas (000 mcf)	Expenditures ($ millions)	Cost Share (percent)
Food, Drink and Tobacco	228	1237	2358	42	0.79
Textiles and Clothing	370	491	261	19	1.07
Paper and Printing	515	534	1800	19	1.7
Chemicals	172	414	15632	67	1.55
Cement	1043	185	13252	27	8.16
Stone, Glass and Ceramics	693	866	498	53	5.89
Iron, Steel and Non-ferrous	160	296	1093	15	1.98

Sources: DANE - Annual Survey of Manufacturers, 1989,
Minstry of Mines and Energy - Energy Information System, 1992.

Table 6

Major Energy Consuming Industries - Structure

	Domestic Sales ($ millions)	Export Sales ($ millions)	Value Added ($ millions)	Employment
Food, Drink and Tobacco	655	5,250	2,433	104,372
Textiles and Clothing	228	1,706	1,047	101,558
Paper and Printing	47	1,151	526	33,240
Chemicals	609	3,719	1,602	72,486
Cement	31	315	211	6,509
Stone, Glass and Ceramics	57	870	521	33,195
Iron, Steel and Non-ferrous	163	605	413	12,225

Source: DANE

6. Alternative Pollution Taxes

In the review of arguments and analyses about a carbon tax, we noted that several analysts have suggested a tax rate based on the amount of local damages caused by air pollution from burning of fossil fuels. In particular, Larson and Shah 1992 argue that a reasonable policy for the developing world would be to introduce low rate carbon taxes that would be designed in part to reduce local air pollution.

In this section, we take this recommendation a step further. Instead of designing a carbon tax rate on the basis of local pollution damages, it might make sense to consider adoption of an alternative tax placed directly on the emissions of those air pollutants that cause local damage. Such a tax would create incentives for the energy using sectors to reduce pollution in a cost effective manner; it would contribute somewhat to the reduction of greenhouse gas emissions; and it would generate revenue for the government. In this sense such an alternative would be directed more to the welfare of the country itself.

Alternative Pollution Control Options

There are four major conventional pollutants that cause damage to the localities near the emission sources: particulate matter, sulfur dioxide, nitrogen dioxide and carbon monoxide. In addition, combinations of these gases can react in the presence of sunlight to form ozone which is also damaging at high concentrations.

The primary type of damage caused by these contaminants is adverse health effects in humans. Air pollution induced illnesses include a wide variety of respiratory effects ranging from eye and throat irritation to emphysema and lung cancer. Other types of illnesses such as cardiovascular disease and other cancers can also be caused by prolonged exposure to air pollution. The costs of these effects include reduced expected life span, medical expenditures for treatment, lost work productivity, developmental effects in children and pain and suffering. The scope of this study does not include estimation of the damages caused by pollution, but there is a large literature providing evidence of the relationship between exposure to air pollution and health effects. Margulis (1991) provides an excellent example of estimation of the costs of pollution in a developing country context. This literature has shown that cost effective reduction of ambient air pollution in urban areas generally is justified on the basis of cost-benefit analysis.

Given that control of these pollutants seems justified from a local perspective, the next question is what type of regulatory strategy to use. Tradition approaches, termed "command and control" are

usually not cost effective. Command and control involves specifying that polluters install certain types of abatement technology, switch to less polluting fuels or comply with fixed constraints on the amount of pollution released. It is now commonly recognized that command and control does not allow enough flexibility nor does it create the proper incentives for polluters to adopt the most efficient control techniques. Economic incentives such as emission taxes, by contrast do allow flexibility in the choice of controls and do create incentives for firms to search for and adopt the most cost effective controls.

Table 7 presents a numerical example showing the difference in cost effectiveness between the traditional "equal percentage emissions reduction" control plan and a cost effective control plan. In this illustration, we describe three pollution sources of different sizes, firm one begins with uncontrolled emissions of 500 pounds per day while firms two and three discharge 1000 and 2000 pounds respectively. Due to economies of scale, the smallest firm has the highest unit cost of abatement, $3.00 per pound and the cost of abatement is $1.50 and $1.00 per pound at the larger plants. These the cost differences create an opportunity for efficiency gains through use of innovative control strategies as compared with the traditional approach. This pattern of sizes and costs represents realistic relations found among actual polluters, but it is only a generic illustration not a picture of any actual situation.

The overall goal is to reduce emissions by eighty percent for a total reduction of 2800 pounds per day. A traditional strategy would be to require each firm to reduce its effluent by eighty percent. In the table this is shown as strategy one, "Equal Percentage Reduction". Firm 1 reduces effluent by 400 pounds at a cost of $1,200. Firm 2 controls 800 pounds at a cost of $1,200 and firm 3 controls 1600 pounds at a cost of $1,600. The total amount spent on pollution control is $4,000.

Strategy two, "Cost Effective Reduction Pattern" places a greater control requirement on firm 3 since it has the lowest unit cost. In this strategy, a total of 2800 pounds of pollutant is eliminated and the overall goal is achieved, but the total expenditure on pollution control is only $3,200 for a saving of $800 or twenty percent.

It is clear that for the group of three firms, strategy two is preferred. But we must also consider the equity of the efficient plan. In strategy two, firm 1 does not spend any money on control and continues to pollute as much as before the plan was introduced thus saving $1,200. Firm two spends the same amount in both strategies. But firm 3 must completely eliminate its effluent and spend $400 more than it would have under strategy one. The simple solution is that firm one could compensate firm three for its extra effort. Firm one would be willing to pay any amount up to $1,200

and it would still be better off than under strategy one. Firm three needs to collect only $400 to compensate it for the extra control it has constructed. Hence a payment between $400 and $1,200 from firm one to firm three would leave all parties better off under strategy two.

This efficient pattern of reductions would be achieved if all sources were subject to a tax per unit of emission. Each firm then is free to reduce its emissions to avoid the tax and will do so as long as the cost of control is lower than the tax. In the end, all firms will control up to the point where the marginal cost of control is equal to the tax. Thus the low abatement cost firms will reduce their emissions more and the high cost firms will control less, as in the illustration above. This same illustration demonstrates why a carbon tax is being proposed as the most effective strategy for controlling the global warming problem.

TABLE 7

Cost Effective Pollution Control

Illustrative Example

Total Initial Emission Quantity	3500	Total Cost Strategy One	$4,000
Total Reduction Goal (%)	80%	Total Cost Strategy Two	$3,200
Total Reduction Goal (pounds)	2800	Saving (percent)	20%

Strategy One	EQUAL PERCENTAGE REDUCTION			
	FIRM 1	FIRM 2	FIRM 3	Grand Total
Unit Abatement Cost ($/pound)	$3.00	$1.50	$1.00	
Initial Emission Quantity (pounds)	500	1000	2000	3500
Emission Reduction (percent)	80%	80%	80%	
Emission Reduction Quantity (pounds)	400	800	1600	2800
Total Cost	$1,200	$1,200	$1,600	$4,000

Strategy Two	COST EFFECTIVE REDUCTION PATTERN			
	FIRM ONE	FIRM 2	FIRM 3	Grand Total
Unit Abatement Cost ($/pound)	$3.00	$1.50	$1.00	
Initial Emission Quantity (pounds)	500	1000	2000	3500
Emission Reduction (percent)	0%	80%	100%	
Emission Reduction Quantity (pounds)	0	800	2000	2800
Total Cost	$0	$1,200	$2,000	$3,200

With regard to the air pollutants of concern, only three of them represent opportunities for control through emissions taxes: particulate matter, sulfur dioxide and nitrogen oxides. The reason for this is the practical problem of enforcement. Any strategy that tries to control emissions, whether through taxes or permits, must include a system for monitoring the emissions from every individual source.

Carbon monoxide and the precursors to ozone are mainly emitted by mobile sources such as cars and trucks. Clearly these sources are less easy to control, and the specific emissions from each vehicle are impossible to measure with current technology. Therefore a tax on source emissions is not feasible, and the best control is through a combination of technical requirements (catalytic converters), cleaner fuels, engine maintenance standards, and by investment in public transit.

Particulate matter, sulfur dioxide and nitrogen oxides are emitted primarily by stationary industrial sources so they can be monitored and a fee system enforced. Also these sources are concentrated in urban areas where local damage is great.

In the sections following we describe in very simple terms a program for a national tax on emissions. Although this is not a detailed proposal, it can be considered as a possible alternative to a carbon tax that would have greater local benefit.

Summary of National Emissions

Table 8 provides summary information about the emissions of particulate matter, sulfur dioxide and nitrogen oxides in Colombia. These statistics are estimated by the Ministry of Mines and Energy. They are calculated by using "emissions factors" developed in the United States. An emission factor gives the amount of pollution released per unit of manufactured product or per unit of energy produced or consumed depending on the sector under study. Since the basic production and combustion technologies in use in the U.S. are generally more modern and cleaner than those of Colombian industry, the estimates probably represent a lower bound on the actual emissions generated in Colombia.

Moreover in order to implement a system of emissions fees, the country would have to develop a monitoring system capable of measuring the actual emissions being released per time period from individual polluting facilities. Nevertheless, these data can serve as the basis for an estimate of the effects of a system of emission taxes imposed on point sources.

TABLE 8

Conventional Air Pollutant Emissions
(1991 tons)

Source	PM	SOx	NOx
Industry	163,263	20,973	65,526
Electricity	20,908	5,786	26,801
Refining	804	556	2181
Total	184,975	27,315	94,508

Source: Energy Information System, Ministry of Mines and Energy

Choice of Tax Rates

Although there is a very large literature discussing and recommending the use of pollution taxes, very few governments have actually implemented them. In part, this is due to a conservative view that command and control will generate more certainty in the degree of abatement actually achieved. Yet increasingly the merits of incentives are being recognized and we can point to two examples which have achieved some degree of success.

In 1985 France implemented a charge on sulfur dioxide emissions. The charge applied to about 400 firms that generate 50 mw or more of electricity or emit over 2,500 tons of sulfur oxides or nitrogen oxides per year. The charge rate was ECU 19 or approximately $21 per ton and yielded total revenues of ECU 13 million.

In May 1990 France significantly broadened its taxes on air pollution. The taxes cover most industrial facilities and will be in effect until at least 1994. Emissions of sulfur compounds expressed as units of sulfur dioxide, nitrogen oxides and hydrochloric acid emissions will all be taxed at the rate of $27.50 per ton. The taxes are payable annually and will be used for air pollution reduction, development of technologies for monitoring and control as well as for administrative costs of air quality regulation.

The Air Quality Management District of South Coast California in the U.S. began a comprehensive program of emissions fees in 1976. This region covers the Los Angeles area, one of the most highly polluted regions of the U.S. The program began by charging relatively low fees on the order of $10 per ton for particulate matter, sulfur oxides, nitrogen oxides and organic gases. And in

the early years the charge only applied to emissions in excess of certain baseline "allowable" emissions.

Table 9 shows the fees charged in recent years and illustrates the rapid increase in the level of fees over time as part of the strategy to force firms gradually to control their emissions.

Table 9

California Emission Fees

Year	Part. Matter	Gaseous Sulfur	Nitrogen Oxides
1980	$27/ton	$25/ton	$21/ton
1981	$30	$28	$24
1982	$30	$28	$24
1983	$39	$36	$30
1984	$39	$36	$30
1985	$43	$39	$33
1986	$54	$49	$41
1987	$184	$167	$139
1988			
5-25 tons	$221	$200	$167
>25 tons	$250	$226	$188

Source: South Coast Air Quality Management District, Emissions Fee Schedules and Revisions of Rule 301 and 301.2

On the basis of the experience in France and California, we will examine the effects of emissions fees in the range of $30 to $175 per ton for three major pollutants. We have constructed an illustrative schedule of fees in which the fee gradually rises over time. To allow firms the time to plan and implement a response to the fee system, we suggest that the entire schedule be announced at the beginning of the program. For example, the program could be announced in 1993 with the first fees scheduled to be implemented in 1995 and gradually rising over a ten year period.

There are three stages of response to an emissions tax:

1. Product cost and price increases and associated demand decline,

2. environmental auditing and adoption of cleaner techniques, and

3. installation of end of pipe abatement systems.

At the first stage, the affected firms will analyze their emissions and calculate the potential effect on production cost in the event that they do nothing to reduce emissions and have to pay the fee on the baseline quantities of emissions. Second they will conduct environmental audits to identify "in-plant" changes in factor inputs, production processes and product characteristics that might allow low cost reductions in residual emissions. Finally they will estimate the cost of traditional "end-of-pipe" emissions controls to further reduce emissions.

This analysis would be conducted during the years between announcement of the program and the first year of implementation. Each firm can then determine what combination of control responses is optimal and how much reduction is planned during the ten year introduction of the fee system. Some firms may elect to reduce emissions greatly and avoid most fee liability. Other firms, which find that pollution control is very costly, will elect to continue releasing most residuals and pay the fees.

Direct Effects of the Fee System

Table 10 presents an illustration of a possible fee system with a two year lag to first implementation and a ten year graduated increase to final fee levels. The fee levels are adapted from the California program but smoothed out over time to represent a planned response time for industry. The revenue estimates are based on the current actual emissions being released in the country. Therefore these revenues represent the payments that would have to be made if all firms elected to maintain their emissions at current levels with no investment in controls. Thus these payment estimates reflect the pressure that would be put on domestic industry to search for and implement controls that cost less than the estimated fee payments.

Clearly some controls would cost less than the fees, so over the ten year period, firms would plan to implement controls and reduce emissions. As this occurred, fee revenues would decline and air quality would improve. This study was not designed to present a comprehensive proposal for emissions fees nor an accurate analysis of the potential for control. These results should only be viewed as an illustration of a possible strategy for efficient air quality control in the country.

Table 10

A Pollution Tax Schedule 1995-2005

		Particulate Matter	Sulfur Oxides	Nitrogen Oxides
Total Emissions		184975	27315	94508
1995-6				
Tax rates ($/ton)		$20	$18	$15
Revenues		$3,699,500	$491,670	$1,417,620
Total Revenue	$5,608,790			
1997-8				
Tax rates ($/ton)		$30	$27	$23
Revenues		$5,549,250	$737,505	$2,173,684
Total Revenue	$8,460,439			
1999-2000				
Tax Rates		$50	$45	$38
Revenues		$9,248,750	$1,229,175	$3,591,304
Total Revenue	$14,069,229			
2001-02				
Tax Rates		$100	$90	$75
Revenues		$18,497,500	$2,458,350	$7,088,100
Total Revenue	$28,043,950			
2003-04				
Tax Rates		$150	$135	$113
Revenues		$27,746,250	$3,687,525	$10,679,404
Total Revenue	$42,113,179			
2005-				
Tax Rates		$175	$158	$131
Revenues		$32,370,625	$4,315,770	$12,380,548
Total Revenue	$49,066,943			

For example, in the first two years of the program, fees would be very low on the order of fifteen to twenty dollars. In this phase, firms would probably not elect to reduce emissions significantly. Therefore the estimates of fee revenues may be reasonable accurate, with total payments to government on the order of five to six million dollars.

As the fees increased over time firms would be installing new technologies to reduce emissions and the fee revenues would be lower than shown in the illustration. But the revenue estimates based on initial emissions are significant in one respect. They show the maximum amount that will be spent by industry for the control of these air pollutants. If any firm finds that control costs more than the fee, then it would elect to pay the fee rather than invest in abatement.

This maximum cap on the financial liability to the private sector is a major advantage of a fee strategy. The government and industry can be sure at the beginning of the program what is the maximum amount that any firm will have to pay. In contrast, if quantity permits are used to control emissions, the cost of achieving the target may have been underestimated, and firms may find that the financial burden of complying with the program is greater than anticipated.

Finally, we should note that the cost of monitoring emissions from individual point sources can be very costly. In recognition of this, the program in practice should probably only be applied to large sources of emissions. In the case of large facilities, control cost savings can be great enough to justify the investment in monitoring devices.

This limitation can be applied in two ways. The government, working with industry can estimate the costs of monitoring and the potential control cost savings achievable at plants of different sizes. Based on this analysis, the program can specify that the fees are only to be paid by sources above a certain minimum scale. An alternate approach would make the plan voluntary. All sources can be told that they have the option of entering the emissions fee program with the requirement that they must invest in the appropriate monitoring equipment. Or they can enter an alternative control program that would require installation of specified control technology that does not require emissions monitoring. Under the dual option plan, each firm can conduct its own comparison of the costs of the two systems using proprietary information and makes its choice in private.

To conclude this section, we should repeat that the fee strategy outlined above is only a very preliminary illustration which shows the potential for a program tailored to the benefits of the country. Any serious design of a pollution fee system will require substantial further analysis.

7. Policy Implications

The direct and indirect effects of possible carbon tax systems have been detailed in the preceding sections. In addition, we have described a possible alternative to carbon taxes in the form of local emissions taxes. To conclude this study, we will briefly summarize the principle conclusions that we have found through this analysis. These conclusion can used by negotiators to prepare for any discussions on proposals for international carbon tax strategies.

1. Colombia as a producer and consumer of fossil fuels is not a major contributor to the problem of global greenhouse gas emissions. Because of its small size, its reliance on hydroelectric power and its efficient use of fuel. It is responsible for about one half of one percent of global emissions of carbon dioxide. For this reason it should not be expected to bear a large burden in any program to control greenhouse gas emissions.

2. Colombia could be greatly affected by a carbon tax in its export markets for coal and oil. In particular, the export of coal could be significantly reduced if carbon taxes above twenty dollars per ton were imposed. With taxes in the range of fifty to one hundred dollars per ton carbon, exports of coal could fall by forty to seventy percent. The sectoral and regional impacts of this would be severe. To moderate the potential impact, the country may wish to negotiate some form of compensation, graduated tax system or partial waiver from the tax.

3. The current industrial restructuring program may result in potentially large improvements in energy efficiency and consequent reductions in emissions of greenhouse gases. Because of this trend and the great reliance on hydroelectric power, a carbon tax may not affect domestic consumers or industry as much as in many other nations both developed and developing. Some energy intensive industries may need assistance. In particular, the cement and the stone, glass and ceramics industries should be studied further with the goal of moderating any impact on them.

Carbon taxes at the higher end of the range under consideration would cause significant welfare costs on a broad range of businesses and consumers in Colombia. It is even possible that there would be macroeconomic effects. These impacts could be mitigated if the tax revenues were returned to the economy by payments from government or by compensating reductions in other taxes.

4. Colombia has great potential for alternative action to reduce the global warming problem through reforestation and improved forest management. Thus Colombia, like other countries with large

tropical forest reserves, has an opportunity to offer alternative contributions to resolving the problem in place of imposing a carbon tax. The management of forest lands should be included in carbon tax negotiations as an additional control option that may involve lower economic impacts to the nation but equal or greater contributions to the global warming problem.

5. The damages from global warming to Colombia cannot be predicted in sufficient detail to justify policy action on this basis. If the nation determines that an emissions control program should be based primarily on domestic costs and benefits, then it may be more appropriate to focus on the control of contaminants that cause adverse health effects to the exposed populations. Imposition of emission fees on SOx, NOx and PM could be considered as a contribution to resolving the greenhouse gas problem as well as a method of providing direct benefits to the country.

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Para el cumplimiento de sus objetivos, adelantará directamente o con la colaboración de universidades y centros académicos, proyectos de investigación sobre problemas de interés nacional.

Entre los temas de investigación que han sido considerados de alta prioridad están la planeación económica y social, el diseño de una política industrial para Colombia, las implicaciones del crecimiento demográfico, el proceso de integración latinoamericana, el desarrollo urbano y la formulación de una política petrolera para el país.

FEDESARROLLO se propone además crear una conciencia dentro de la comunidad acerca de la necesidad de apoyar a las Universidades colombianas con el fin de elevar su nivel académico y permitirles desempeñar el papel que les corresponde en la modernización de nuestra sociedad.