THE ENVIRONMENT IMPACT OF A CARBON TAX IN NEW BRUNSWICK

by

Joe Ruggeri

Working Paper Series 2009-01



DEPARTMENT OF ECONOMICS
THE UNIVERSITY OF NEW BRUNSWICK
FREDERICTON, CANADA

THE ENVIRONMENTAL IMPACT OF A CARBON TAX IN NEW BRUNSWICK

1. INTRODUCTION

The introduction of a carbon tax modeled on the one recently introduced in British Columbia is a key component of the tax reform package proposed by the New Brunswick Government in its *Discussion Paper on New Brunswick's Tax System,* released in June, 2008. While its introduction is explained as pro-environment, this new tax would help offset the revenue loss from the combination of a two percentage point increase in the HST and large reductions in personal and corporate income taxes.

The proposal for a carbon tax in New Brunswick is notable for its lack of details. According to the *Discussion Paper* (p.29):

New Brunswick could consider implementing a carbon tax based on the British Columbia model – a tax on all forms of carbon or carbon-equivalent emissions, phased in gradually over several years, with a reimbursement credit to offset the impact of this tax on low-income New Brunswickers....

The New Brunswick Carbon Tax would support the government's Climate Change Plan initiatives and help fund reductions in personal and corporate income taxes, allowing the overall tax changes to be fiscally neutral.

The Government of New Brunswick has not released any studies that measure the extent to which this new tax would reduce carbon emissions, the channels through which its environmental effects would be generated, and how the burden of this tax would be distributed among New Brunswickers in different economic positions.

As a result, we find ourselves in a quandary. Without further details we cannot perform a proper evaluation of the proposed tax. Yet, no responsible government would introduce a major new tax without a full analysis of its potential impact.

I address this quandary by assuming that New Brunswick would implement the B.C. carbon tax in its entirety. This assumption contains three elements. First, I include only the carbon tax and not the other fiscal elements that make the full package of tax reform. Second, B.C.'s carbon tax has a four-year schedule where the rates rise from a base of $10 per tonne of emissions to a base of $30 per tonne of emissions. I used the full implementation rates to maintain consistency with the examples of the effects of personal income reductions shown in the *Discussion Paper.*

The incidence of this type of carbon tax among New Brunswick families with different income levels was evaluated by Ruggeri and Bourgeois [2009]. This paper focuses on the environmental effects of the above tax which are estimated through a variety of steps. Section II discusses some conceptual issues in the analysis of the environmental effects of a carbon tax. Section III presents some information on existing taxes on carbon fuels

and compares them with the imposition of a BC type carbon tax. Section IV shows data on energy consumption in New Brunswick and the associated carbon emissions for 2006, the latest year for which official data are available on a consistent provincial and national basis. Section V shows the carbon tax rates and the distribution of the revenue from a carbon tax by fuel type and by income class derived by Ruggeri and Bourgeois [2009]. Section VI discusses the methodology used in measuring the environmental effects of a carbon tax in New Brunswick. Section VII presents details of my estimates of the environmental effects of a carbon tax, and the final section contains some concluding comments.

The overall conclusion is that the proposed carbon tax would impose a disproportionate burden on lower income New Brunswickers but would have small effects on greenhouse gas emissions.

II. CONCEPTUAL ISSUES

Before I proceed with the required calculations, it is useful to develop a conceptual framework for the analysis of the environmental effects of a carbon tax. This framework is divided into four main areas: (a) fuel consumption, (b) prices, (c), revenue neutrality versus fiscal neutrality, and (d) demand versus supply policies.

A. Fuel Consumption

In theory, a carbon tax affects carbon emissions by changing the prices of the taxed fuels relative to the prices of all other goods and services, thus providing an economic incentive for reducing the consumption of carbon-based fuels. This shift takes place on three levels: (1) fuels used in electricity generation, (2) energy used by the industrial-commercial-institutional sector, and (3) energy used directly by the final consumer (the residential and public administration sectors) with no possibility of passing on the cost to others. These three levels of carbon fuel use change may be viewed in a sequential fashion. Electric utilities transform primary sources of energy, including carbon-based fuels, into electricity, which is then sold to economic agents in both private and public sectors. Customers in the residential and public administration sectors use electricity and other energy sources as final products. For the industrial-commercial-institutional sector, all forms of energy are an input into the production of goods and services. Therefore, electric utilities and the industrial-commercial-institutional sectors have the opportunity to shift the burden of a carbon tax other economic agents. This shifting capacity has important implications for determining the environmental effects of a carbon tax, as will be explained later.

1. Electricity Generation

In the process of electricity generation we may identify three categories of primary energy: (1) carbon-based fuels - coal, crude oil (in the form of refined petroleum products), natural gas, and biomass; (2) nuclear power, and (3) renewable energy (solar,

wind, hydro, tidal). The main distinction between the first two categories and the third one is that the former energy sources are destroyed in the process of electricity generation while the latter is not. Even biomass, which originates from a renewable resource, is destroyed as it is transformed into electricity.

Within the context of a carbon tax, the most important distinction is that only the first category of primary energy releases carbon as it is transformed into electricity. Therefore, it is the only input that would attract a carbon tax. In the case of electricity generation, the carbon tax raises the price of the carbon-based fuels relative to the price of the other inputs, which remain untaxed. In theory, this change in relative prices should result in a rearrangement of the primary energy mix leading to a reduction in the use of carbon-based fuels. In practice, this rearrangement is affected by a variety of other factors.

First, it is seldom possible to make marginal adjustments to the energy mix for electricity generation because of constraints in electric generating capacity. For example, the amount of hydroelectricity that can be generated in a year with the existing capacity is determined entirely by weather condition. Similarly, electricity generation cannot be increased in the case of a nuclear generating plant operating a full capacity. Therefore, unless there is a change in the mix of generating capacity, the response to a carbon tax is limited to a reduction in the use of carbon-based fuels to accommodate the lower demand for electricity that would accompany an increase in electricity rates.

Second, even over the long-run the generating capacity mix can be changed only in discrete amounts. The size of additional hydroelectric capacity is determined by geographic factors and water flows, and nuclear generating plants come in large standard sizes. Even in the case of solar and wind energy, where small increments are technically feasible, economies of scale may justify only discrete increments.

Third, changing the generating capacity mix is a costly undertaking. It requires spending on the new capacity and spending on decommissioning existing capacity. Therefore, carbon tax rates must be high enough to induce such discrete changes in the generating capacity mix.

Fourth, on the institutional side, electric utilities are generally set up as Crown corporations, as is the case with the New Brunswick Electric Power Commission (NB Power). This means that, while they operate in the "market" as purchasers of inputs and sellers of goods and services, they cannot act as private sector economic agents. Decisions about generating capacity and electricity rates are public policy issues influenced by provincial government decisions. This means that such decisions do not require market mechanisms. For example, the government of New Brunswick does not need to impose a carbon tax on its own Crown Corporation in order to replace existing coal generating capacity with wind power. It can decide to proceed with the replacement, even if the cost of wind power is higher than coal-generated power, and let NB power pass on the higher cost to consumers through higher electricity rates.

Fifth, since the demand for electricity is price-inelastic (the quantity demanded declines less than proportionately to an increase in price), it is possible to pass the cost of the carbon to the consumers of electricity. To the extent that the additional cost of electricity generation imposed by a carbon tax can be shifted forward to electricity users, there is no incentive to rearrange the mix of primary energy sources used in electricity generation. In this case, the adjustment in the primary energy mix induced by a carbon tax would not be determined by the change in the relative price of primary energy sources but by the response of electricity users to higher electricity rates.

2. Industrial-Commercial-Institutional Sector

In this sector, all forms of energy are an input into the production of goods and services. The carbon tax would apply directly to the carbon-based fuels purchased by this sector. How much of the carbon tax levied on fuel used in electricity generation is incorporated into the price of electricity depends on NB Power's ability to shift the extra cost to electricity users, which in turn depends on the price elasticity of demand and on government decisions. In the case of full forward shifting, the entire cost would be passed on to electricity users. When a portion of electricity generation is not subject to the carbon tax (hydro, nuclear, and purchases from other jurisdictions), the percentage change in electricity rates is less than the percentage change in the price of the taxed inputs. Depending on the energy mix used in electricity generation, the percentage change in electricity rates may by higher or lower than the percentage change in the price of the carbon-based fuels purchased by business sector. The carbon tax, therefore, would produce two changes in relative prices for this sector: (a) an increase in the price of carbon-base fuels relative to that of electricity and (b) an increase in the price of energy in general relative to the price of all other inputs, including labour.

In the short-run, the options for responding to these changes in relative prices are very limited and may be confined to simple and inexpensive energy saving activities. In the long-run there are greater opportunities through changes in production processes and the installation of energy-generating and energy-saving equipment. Long-run structural changes, however, are likely to involve substantial expenditures which must be justified by reductions in energy costs.

The need for these investments depends partly on the ability of firms to shift the additional costs of the carbon tax forward to consumers backward to labour. In this respect, we must distinguish between firms producing tradable goods and firms producing non-tradable goods and services. The firms in the first category are faced with prices determined in the international market and cannot do forward shifting. Unless they can shift the extra cost backward to labour, they will face competitive pressures to make structural adjustments. The firms in the second category may be able to pass some of the extra cost to consumers through higher prices, but the extent of this forward shifting is determined by the price elasticity of the demand for the good and services produced by a given industry.

The general conclusions for this sector is that in the short-run energy consumption may respond weakly to the introduction of the carbon tax, but this response will be stronger in the long-run, but not uniform among sub-sectors. The incentives for restructuring generated by the carbon tax will be weaker for firms that produce goods and services largely for the provincial market because of the opportunity for some forward shifting of the extra costs.

3. Public Administration

In this sector, energy is also an input in the production of services, but these services are not sold in the market. For the provincial government, the carbon tax would not generate any net revenue because the extra spending by some departments would be offset by the extra revenue collected by the Department of Finance. For other governments there would be additional costs, which would have to be offset either through higher taxation or reduced spending.

The fundamental feature of the public administration sector is that it does not need market incentives to make decisions about the use of environmental policy instruments. The provincial government does not need to introduce a carbon tax in order to initiate a program aimed at improving the energy efficiency of its building and it does not need higher gasoline prices to change the fleet of motor vehicles used by politicians and civil servants. Therefore, this component of energy consumption should be excluded from the calculations of the environmental effects of a carbon tax, as is done in this study.

4. Residential

For the residential sector, we can identify three components of the costs of a carbon tax. First there is the higher price of energy, which may not be uniform among energy sources. The price of carbon-based fuels will incorporate the full carbon tax, wood as a heating source may be left untaxed, and the increase in the price of electricity depends on the proportion of generation from fossil fuels and the degree of forward shifting of the extra generation costs. To the extent that there are changes in the relative prices of the various energy sources, there may be some changes in the energy mix used by this sector. Second, a portion of the carbon tax paid by the industrial-commercial-institutional sectors may be incorporated in the price of the goods and services purchased by the residential sector. This increase in the price of goods and services reduces the effect of the carbon tax on the price of energy relative to the price of other products, thus lowering its potential environmental effect. Finally, for final consumers (which unlike firms cannot claim input tax credits) the price effect of the carbon tax will be magnified by the HST, which is levied on the selling price including the carbon tax. Since it is applied uniformly, except for basic groceries, the HST will generate only an income effect, by reducing the quantity of goods and service that can be purchased with a given income.

In the short-run, individuals and families have limited opportunities in their responses to a carbon tax. Most of the response would be in the form of reduced utilization of the existing energy using equipment (lowering thermostat settings, turning off lights,

reducing the miles driven, and the like). Over time, greater reductions in the use of carbon-base fuels can be achieved by changing energy-using equipment and by tapping the power of renewable energy sources. These more ambitious changes, however, are costly and, as long-term investments, must meet some rate of return criteria. In this respect, it must be pointed out that the financial capacity to undertake these investments will differ among families in different economic conditions. Because wealthier families have greater economic power to undertake these investments, they have greater capacity to escape the burden of a carbon tax over the long run. Therefore, a carbon tax will tend to increase inequality of living standards as its well-documented regressivity in the short-run [Ruggeri and Bourgeois 2009] will tend to increase over time.

B. Prices

In the previous sub-section it was mentioned that the environmental effects of a carbon tax are generated by adjustments in the input mix at the business level in response to changes in the prices of the taxed energy sources relative to the price of all other inputs and adjustments in fuel consumption by the ultimate consumer in response to changes in the price of the taxed energy sources relative to the prices of all other final goods and services. These effects, therefore, are measured as the combination of the change in the appropriate price indicator and the response by the economic agents to this price change. The percentage change in relative prices multiplied by the price elasticity of demand for the taxed items (the percentage change in the quantity demanded divided by the percentage change in the relative prices) measures the percentage change in the quantity demanded of the taxed items. Since generally higher prices lead to lower quantity demanded, in the case of the carbon tax the result would be a reduction in the consumption of carbon-based fuels and a reduction in carbon emissions. In order to derive consistent measures of the environmental effects of a carbon tax, we need reliable estimates of the demand elasticities and appropriate measures of the change in relative prices.

For this purpose, three sets of prices may be identified: (1) absolute prices, (2) nominal relative price, and (3) effective relative prices.

Absolute Prices. A carbon tax would raise the price of carbon-based fuels by adding another layer of taxes, based on a predetermined price of carbon emissions. Let us consider the case of gasoline with a retail selling price of 80 cents per litre. Currently, in New Brunswick this price would comprise 50.1 cents of pre-tax value, 10.0 cents of federal excise taxes, 10.7 cents of provincial excise taxes, 3.5 cents of the federal HST component, and 5.7 cents of the provincial HST component.

A carbon tax at B.C. rates would add 7.02 cents to a litre of gasoline. This tax would raise the pre-HST price from 70.8 to 77.82 cents per litre. The HST now would increase from 9.2 cents to 10.12 and the selling price would rise by 9.9 percent from 80 cents to 87.94 cents per litre

Nominal Relative Prices. The nominal relative price is the ratio of the absolute price of a given energy source and the absolute price of all other goods and services. Let us consider the case of gasoline. The carbon tax raised the price of gasoline through two channels: the carbon tax itself (7.02 cents) and the associated HST (0.92 cents). Since the HST is applied to a broad base of goods and services, the only tax that affects the nominal relative price of carbon-based fuels is the carbon tax. Therefore, in calculating relative prices, we should focus on the carbon tax only. The percentage change in the nominal relative price, therefore, may be defined as the percentage change in the pre-HST absolute price of the taxed fuels minus the percentage change in the absolute price of all other goods and services, which in this case is zero. In our case above the percentage change in nominal relative prices is 77.82/ 70.8 – 0 = 9.9. However, since the HST is imposed at a uniform rate on all taxed fuels in this case the percentage change in nominal relative prices equal the percentage change in the absolute price of the tax fuels, including the HST (87.94/80 – 0 = 9.9 percent).

Effective Relative Prices. The above special results do not hold when (a) a value-added tax like the HST does not cover all goods and services, and (b) some of the taxed fuels are inputs into the production of goods and services. In these cases we need to use the effective relative prices.

Let us start with electricity. The carbon tax generates environmental effects in this sector only when the electricity producers use carbon-based fuels in electricity generation. This self-evident fact indicates that estimates of the environmental effects of a carbon tax for jurisdictions that use little or no carbon-based fuels for electricity generation, such as Quebec and British Columbia, cannot be generalized to jurisdictions where most of electricity is generated from carbon-based fuels, such as Alberta and New Brunswick. To the extent that some electricity is generated with nuclear power and renewable energy, the price of electricity will increase by less than the price of the carbon-based fuels used in electricity generation even under full forward shifting. This price increase, however, will not include the extra HST because electricity producers can claim input tax credits equal to the HST paid on their purchases.

The business sector (not including electricity generation) faces higher input prices for electricity and carbon-based fuels. As a result, it experiences two changes in relative prices. First, the price of carbon-based fuels changes relative to the price of electricity, thus providing an incentive for inter-fuel substitution. Second, the price of the "energy" input increases relative to the price of all other inputs, inducing a shift in factor proportions. However, when the price of electricity does not increase as much as the price of carbon-based fuels, the effective relative price increase of the "energy" input" is less than the increase in the nominal relative price of the carbon-based fuels used by the business sector. In this case, the use of nominal relative prices would overestimate the environmental effects of a carbon tax generated in the business sector. As in the case of electricity generation, the HST is not relevant because of the input tax credits.

A similar situation occurs in the residential sector (the ultimate consumer) except for the HST. Consumers also face two changes in relative prices. First there is the change in relative prices among energy sources, particularly when electricity rates increase at a different rate than the price of carbon-based fuels and renewable energy, including wood and wood bi-products, is not taxed. Second, there is the change in the price of the "energy" good relative to the price of all other goods and services. Therefore, a carbon tax has the potential of altering the energy mix as well as reducing energy consumption.

The magnitude of the second effect depends on the degree to which business shifts its increased energy costs to consumers through higher prices of the goods and services it sells domestically. Forward shifting in practice transforms a potential substitution effect at the input stage into an income effect at the product stage. The increase in the price of goods and services raises the overall rice index and reduces the increase in the effective relative price of energy faced by consumers, thus lowering the environmental impact of a carbon tax.

The HST paid by consumers imposes a net burden on them because they cannot claim tax credits. The component of the HST paid on the price increase caused by the carbon tax on direct purchases of energy by consumers raises the relative price of energy and adds to the environmental effect of this tax. The component of the HST increase due the higher prices of all goods and services resulting from forward shifting by the business sector reduces the relative price of energy. Whether the presence of the HST increases or reduces the change in effective relative prices depends on the relationship between these two effects, which in turn is determined by the share of energy consumption by the residential and business sectors and by the degree of forward shifting by the latter.

C. Revenue Neutrality Versus Fiscal Neutrality

As shown in Ruggeri and Bourgeois [2009], a B.C. type carbon tax applied in New Brunswick has the potential to generate a substantial amount of revenue for the provincial government. Its potential effect on carbon emissions depends both on its rates and the use of the revenue it generates.

Revenue Neutrality. When the revenue raised by a carbon tax is used entirely to reduce other taxes, a carbon tax is said to be *revenue-neutral.* In this case all the changes occur on the revenue side, the environmental effects are confined to the carbon tax and are produced entirely by the response of economic agents to the tax-induced changes in relative prices. If the response is strong (if the elasticity of substitution among inputs and the price elasticity of demand for the taxed fuels by consumers are large), purchases of the taxed fuels will fall drastically, the initial revenue will also fall substantially, thus leaving limited funds for restructuring the tax mix, and a revenue-neutral carbon tax becomes an effective tool of environmental policy. When these responses are weak (low elasticitites), the quantity demanded of the taxed fuels will not fall much, the government will continue to collect most of the initial revenue, and the environmental impact will be minimal. In this latter case, a carbon tax becomes primarily a tax policy tool with little relevance for environmental policy.

Fiscal Neutrality. A carbon tax is said to be *fiscally-neutral* when the revenue it raises is also used to increase government spending. In this case, the above conclusions about its environmental effects on the revenue side still hold, but there is also the possibility to generate additional effects on the spending side. In the extreme case where the entire funds are returned to individuals and firms in the form of unconditional transfer payments, no environmental effects are generated on the spending side and a fiscally-neutral carbon tax is identical to a revenue-neutral carbon tax. If the funds are used to subsidize energy efficiency and the development of renewable energy sources, the spending side complements directly the revenue side by reinforcing the relative price effect. If the funds are used directly to change the revenue mix, the spending side adds a separate environmental dimension to the demand side.

D. Demand Versus Supply Policies

The above discussion suggests that we may distinguish between demand side and supply side components of a carbon tax. The former refers to responses by economic agents to changes in relative prices. The latter refers to policies directed at changing the energy supply mix. While the two components interact, creating joint demand-supply effects, separating them for analytical purposes provides insights into the channels through which a carbon tax may generate environmental effects. A summary of the main elements of these two components is shown in Table 1.

1. Demand Side Policies

In Table 1, I distinguish four types of demand side effects depending on the time frame for the responses. There is little that can be done in the period immediately after the introduction of a carbon tax. In this period, the response of economic agents will be limited to simple measures of energy conservation, such as turning off lights, lowering thermostats, keeping tires inflated, reducing the amount of idling and the like.

In the short-term, energy efficiency can be improved by adjustments that involve the introduction of existing products. These adjustments include improvements such as adding insulation, reducing air infiltration, replacing existing lighting with more efficient types, replacing old windows, and replacing old furnaces.

The medium term provides sufficient time to introduce new products in the market. These products may help improve the efficiency in the use of the existing energy mix, may lead to a change in the energy mix, and may offer the business sector opportunities for changing the input mix in the production process. More efficient lighting, more efficient furnaces, hybrid motor vehicles, more energy efficient equipment of all kinds, expansion of urban transit, expansion of rail transportation road transportation are also part of this stage.

Finally, in the long-run, the change in relative prices and different energy sources may stimulate research and development activities that will lead to major improvements in energy use, such as the development of fuel cells, better batteries, more energy efficient production processes.

2. Supply Side Policies

In the short-term there are limited opportunities to generate supply side responses to a carbon tax. In the medium term, it is possible to increase the supply of alternative energy sources by expanding investment in existing systems, such as accelerating the construction of wind farms. The long-run not only provides additional time for expanding the supply of renewable energy, but also offers the opportunity for research and development that reduces the relative cost of alternative energy.

Table 1. Demand Side and Supply Side Components of a Carbon Tax.

Time Frame	Response
	A. Demand Side
1. Immediate Impact	Energy conservation activities that do not involve changes in the input mix or changes in equipment (including light bulbs);
2. Short-term	Energy conservation and changes in the energy mix including change in equipment with existing problems;
3. Medium-term	As in 2 above, but with the introduction of new products;
4. Long-term	Tax-induced changes in technology affecting both energy efficiency, the available sources of energy and their relative costs.
	B. Supply Side
1. Immediate Impact	Not feasible
2. Short-term	Not feasible
3. Medium-term	Private and public spending on increasing the supply of alternative energy sources;
4. Long-term	Spending on new technology the increases the supply of alternative energy sources; Direct private and public spending that increases the supply of alternative energy sources.

Two fundamental points need to be stressed with respect to Table 1. First, a revenue-neutral carbon tax operates primarily as a demand side tool of environmental policy. Only to the extent that the change in relative prices leads to increased supply of alternative energy does a carbon tax generate supply side effects. A fiscally-neutral carbon tax can also generate demand and direct supply side effects, but it does so in a more direct manner. The strength of these effects depends on what portion of the carbon tax revenue is directed at energy efficiency and increasing the supply of alternative energy. Second, there are important interactions between demand and supply effects. Individuals and businesses can only use equipment that is available in the market and energy sources which are supplied. Although the relative price effects of a carbon tax provide incentives for more energy efficient equipment and the expansion of alternative sources, greater environmental effects will be generated if most of the revenue raised by the carbon tax is used for improving energy efficiency, expanding the supply of alternative energy, and intensifying energy research.

III. CURRENT TAXES ON CARBON-BASED FUELS

All the talk about the need to put a price on carbon leaves the impression that no taxes are being levied on carbon-based fuels. That's a gross misconception. Both federal and provincial governments impose taxes on selected fuels and the combined level of these taxes is quite substantial. Current fuel taxes and proposed carbon taxes, however, differ in two fundamental respects. First, with respect to the rationale for these taxes, existing fuel taxes are form of user fee for transportation. Their main purpose is to raise revenue for financing the building and maintenance of roads. Carbon taxes are directed at the environment and their specific purpose is to reduce greenhouse gas emissions. Second, with respect to coverage, carbon taxes affect all carbon based fuels whereas existing fuel taxes are imposed only on transportation fuels.

Since the proposed carbon tax in New Brunswick would be levied on top of the existing taxes, it is necessary to measure both types of taxes to determine their combined "price on carbon." Details on the existing federal and New Brunswick fuel taxes are shown in Table 1, which identifies two components of the overall burden of these taxes: (a) the taxes imposed on transportation fuels, and (b) the associated increase in the Harmonized Sales Tax (HST) which applies to the selling price of these fuels, including the federal and provincial taxes.

Table 1 shows that the federal excise taxes on transportation fuels focus primarily on gasoline which attracts a rate of 10 cents per litre. The other two fuels subject to federal taxation (diesel and aviation fuel) are taxed at less than half the rate for gasoline. The New Brunswick taxes are largely based on the energy content of each fuel. Therefore, the provincial gasoline tax is similar to the federal tax, but the tax on diesel is four times as high.

This table also shows that the additional HST arising from these fuel taxes is not trivial. In calculating the HST component, I used the following assumptions. First, I used the existing rate in 2008, i.e., 13 percent (5 % federal and 8% provincial). Second, the tax was applied to the following estimates of the pre-tax price of these fuels based on data from Natural Resources Canada: (http://www.fuelfocus.nrcan.gc/prov_map_e.cfm?ProvCode=NB). Since the HST is applied as a percent of the selling price of an item (including all excise taxes), its value is affected by fluctuations in pre-tax prices and changes in excise taxes.

Table 1 shows that the excise taxes on gasoline are roughly equal for the federal and provincial government, but the provincial HST component is higher for the provincial government. Combined, these taxes amount to 30 cents per litre of gasoline. The combined taxes on diesel are higher by 4 cents a litre because a lower excise tax by the federal government is more than offset by a much higher provincial excise tax. The total tax on propane as a motor fuel is half of that for diesel partly because of the absence of federal tax and partly because of a lower provincial tax. A slightly lower combined tax rate applies to aviation fuel. Light fuel oil (heating fuel) and natural gas attract only the HST.

Table 1. Current Taxes on Carbon-Based Fuels: 2008, Cents per Litre.

	Tax on Fuels			HST			Total
	Federal	NB	Sum	Federal	NB	Sum	
Gasoline	10.0	10.7	20.7	3.8	6.0	9.8	30.5
Diesel	4.0	16.9	20.9	5.0	8.1	13.1	34.0
Light Fuel Oil				4.2	6.8	11.0	11.0
Aviation Fuel	4.0	2.5	6.5	3.3	5.3	8.6	15.1
Propane*		6.7	6.7	4.1	6.5	10.6	17.3
Natural Gas c/GJ				48.5	77.6	126.1	126.1

**Used in Transportation.*

In Table 2, the above tax rates are transformed into taxes per tonne of carbon based on the rates used in the B.C. carbon tax. Since the environmental effects of taxes on carbon-based energy sources are based on the response of economic agents to changes in relative prices, and since the HST is applied at uniform rates to a broad base of goods and services, one may argue that it should be excluded from this calculation. In practice, the HST contains a variety of exemptions (the most notable being basic groceries) and special credits which lead to an effective rate less than the statutory rate. In New Brunswick the revenue from the provincial component of the HST yields an effective rate (its ratio to personal consumption expenditures) which is about two-thirds of the nominal rate of 8 percent. Since all the fuels in Table 1 are subject to the full HST rate when purchased by consumers as final products (rather than as inputs in the production

process), the HST will have an effect on relative prices and should be included in the calculation of the carbon tax equivalent. In Table 2, I included only one-third of the HST

Table 2 shows that transportation fuels already bear a substantial tax burden on their carbon content. Even when the HST component is excluded, the excise taxes are equivalent to nearly three times the B.C. carbon tax at full implementation in the case of gasoline and 2.6 times in the case of diesel.

Table 2. Equivalent Carbon Tax of Current Taxes: 2008, $ per Tonne of Carbon Emission.

	Fuel Taxes	Part of HST	Total
Gasoline	88.46	13.61	102.07
Diesel	77.70	15.83	93.53
Light Fuel Oil		13.29	13.29
Aviation Fuel	26.00	11.18	37.18
Propane	43.51	22.37	65.88
Natural Gas		8.26	8.26

IV. FUEL CONSUMPTION AND GREENHOUSE GAS EMISSIONS

This section contains the background information on energy consumption and greenhouse gas emissions for the calculation of the environmental effects of the proposed carbon tax.

Details on energy consumption in New Brunswick by sector and energy source for 2006 are shown in Table 3. Total energy demand amounted to 200,651 terajoules. Most of this energy demand was for electricity generation (44 percent) and transportation (30 percent), which combined accounted for three-quarters of the total. Among fuels, the largest share was for heavy fuel (26 percent), followed by gasoline and diesel which had roughly equal shares and in combination accounted for 36 percent of the total, and natural gas (14 percent).

Table 3. Energy Consumption in New Brunswick: 2006, Terajoules.

	Coal	NG	NGL	Coke	Gasoline	Diesel	LFO+K	HFO	Av.	Total	%
EL.	32,551	18,946				378	34	35,354		87,263	43.49
M+M		6,428	1,572	1,207		3,455	742	9,437		22,841	11.38
OIN			5			933	98	5		1,041	0.52
TR			12		34,988	23,254		497	1,807	60,558	30.18
AGR		689	24		831	482	283			2,309	1.15
C+I		1,071	896		688	5,412	3,035	5,215	495	16,812	8.39
PA					392	2,068	631	567	181	3,839	1.91
RES			238				5,211	539		5,988	2.98
TOT	32,551	27,134	2,747	1,207	36,899	35,982	10,034	51,614	2,463	200,651	100.00
	16.22	13.52	1.37	0.60	18.39	17.94	5.00	25.72	1.24		100.00

Note: EL = electricity, M+M = mining and manufacturing, OIN = other industries; TR = transportation, AGR = agriculture, C+I = commercial plus institutional, PA = public administration, RE = residential, NG = natural gas, NGL = natural gas liquids, LFO = light fuel oil (furnace fuel), K = kerosene, HFO = heavy fuel oil, AV = aviation fuel (almost entirely jet fuel).

The energy demand figures above were transformed into equivalent greenhouse has emissions by using the conversion factors contained in the 2004 edition of Statistics Canada's Inventory of Greenhouse Gas Emissions. A couple of special features of this table need to be highlighted. First, the data in Table 4 refer to emissions of carbon dioxide only. Second, the total level of emissions (13,781 kilotonnes of CO2) is lower than the level shown in Statistics Canada's Inventory of Greenhouse Gas Emissions for 2006. This difference is explained primarily by two items: (a) fossil fuel industries, and (b) rail and marine transportation. The data in Statistics Canada's Supply and Demand for Energy do not include the first item. For the second item it includes only the purchases in New Brunswick, which end up being very low. Since my calculations of the carbon tax revenue are based on the data from the above publication, I had to exclude these two items from the calculation of emissions in order to maintain consistency.

Table 4. Greenhouse Gas Emissions from the combustion of Fossil Fuels in New Brunswick: 2006, Kilotonnes of CO2.

	Coal	NG	NGL	Coke	Gasoline	Diesel	LFO+K	HFO	AV.	Total	%
EL.	2,530	936				27	3	2,570		6,066	44.28
M+M		318	17	94		246	55	686		1,416	10.27
OIN			0.1			67	7	0.4		75	0.54
TR			0.1		2,488	1,658			121	4,267	30.94
AGR		34	0.2		56	34	21			145	1.05
C+I		53	10		46	379	224	379	33	1,124	8.15
PA					26	147	46	41	12	272	1.97
RES			3				384	39		426	3.10
TOT	2,530	1,341	30	94	2,616	2,558	740	3,715	166	13,791	100.00
TOT -PA	2,530	1,341	30	94	2,590	2,411	694	3,674	154	13,425	

Table 4 shows that by far the largest source of CO2 emissions in New Brunswick is electricity generation with a share of 44 percent, followed by transportation with a share of 31 percent. The residential sector, which is often the target of environmental policy initiatives, accounts for only 3.1 percent of emissions. If the emissions from this sector were eliminated entirely, they would represent a reduction equivalent to 7 percent of the emissions from electricity generation.

A carbon tax is a demand-side market instrument of environmental policy. As I stressed in a previous section, however, electricity generation and Public Administration are two sectors that operate outside a market environment. In these two sectors, the effects that would be generated by a carbon tax can be created by decisions that do not require market signals. In the case of New Brunswick, one must question the use of a broad market instrument of environmental policy which in practice targets only about half of the emissions.

V. ELEMENTS OF A CARBON TAX IN NEW BRUNSWICK

This section shows the tax rates that would apply in New Brunswick under a B.C. type carbon tax, the revenues that such a tax would generate, and the burden that it would impose on New Brunswick families with different income levels.

A. TAX RATES

The carbon tax rates that would apply in New Brunswick if a B.C. type carbon were introduced are shown in Table 5.

Table 5. Carbon Tax Rates by Fuel Type According to the British Columbia System.

Fuel	Units for Tax Rates	Tax Rates*	
		July 1, 2008	July 1, 2012
A. Liquid Fuels			
Gasoline	c/litre	2.34	7.02
Diesel	c/litre	2.69	8.07
Heating Oil	c/litre	2.69	8.07
Locomotive Fuel	c/litre	2.69	8.07
Heavy Fuel Oil	c/litre	3.15	9.45
Aviation Fuel	c/litre	2.46	7.38
Jet Fuel	c/litre	2.61	7.83
Kerosene	c/litre	2.54	7.62
Naphta	c/litre	2.55	7.65
Methanol	c/litre	1.09	3.27
B. Gaseous Fuel			
Natural Gas	c/Gigajoule (GJ) c/litre	49.66	148.98
Propane	c/litre	1.54	4.62
Butane	c/litre	1.76	5.28
Ethane	c/litre	0.98	2.94
Refinery Gas	c/cubic metre	1.76	5.28
Coke Oven Gas	c/cubic metre	1.61	4.83
C. Solid Fuels			
Low Heat Value Coal	$/tonne	17.77	53.31
High Heat Value Coal	$/tonne	20.77	62.31
Coke	$/tonne	24.87	74.61
Petroleum Coke	c/litre	3.67	11.01
D. Combustibles			
Tires-Shredded	$/tonne	23.91	71.73
Tires-Whole	$/tonne	20.80	62.40
Peat	$/tonne	10.22	30.66

**These tax rates are based on a tax of $10 per tonne of carbon emission in 2008 and $30 per tonne in 2012.*

If the introduction of a carbon were associated with the elimination of all other excise taxes on carbon-based fuels, the above tax rates would be both the statutory and effective tax rates. However, as proposed in the Discussion Paper, the carbon tax would be imposed on top of the existing excise taxes. The total tax level of these combined taxes is shown in Table 6.

Table 6. Taxes on Carbon-Based Fuels Including Full Implementation of a Carbon Tax: 2008, Cents per Litre.

	Tax on Fuels			HST			Total
	Federal	NB	Total	Federal	NB	Total	
Gasoline	10.0	17.7	27.7	4.1	6.6	10.7	38.4
Diesel	4.0	25.0	29.0	5.4	8.7	14.1	43.1
Light Fuel Oil			8.1	4.4	7.0	11.4	19.5
Aviation Fuel	4.0	10.0	14.0	3.7	6.0	9.7	23.7
Propane		11.3	11.3	4.3	6.9	11.2	22.5
Natural Gas c/GJ		149	149	56.2	90.0	146.2	295.2
Coal (El), $/Tonne*		53.3	53.3				53.3
Heavy Fuel Oil*		9.5	9.5				9.5
Coke, $/tonne*		74.6	74.6				74.6

**I did not include the HST for these fuels because they are used almost entirely by the business sector.*

In Table 7, these tax rates are transformed into carbon-tax equivalents using the B.C. rates shown in Table 3. For the HST I used the same approximation as in Table 2. Two features of Table 7 require some elaboration: (a) the high level of the carbon tax equivalent, and (b) the high degree of variation among different fuels.

It is often argued that, because of low price elasticites of demand for energy, carbon taxes have to be imposed at rates at least equivalent to $100 per tonne of carbon emissions to be effective as instruments of environmental policy. Table 7 shows that in the case of gasoline and diesel, the $100 per tonne level is exceeded even when the applicable portion of the HST is excluded.

A main rationale for a carbon tax is that it is applied uniformly to all carbon-based fuels, thus preventing distortions in decisions by economic agents about the energy mix. This result is obtained only when the carbon tax is introduced as a replacement for the existing fuel taxes. This is not the case with the proposed carbon tax in New Brunswick, which would be imposed on top of the existing excise taxes. Therefore, this tax would raise the level of taxation, but would maintain the tax differential among the various fuels.

Table 7. Equivalent Carbon Tax Including the Carbon Tax: 2008, $ per Tonne of Carbon Emission.

	Fuel Taxes	Part of HST	Total
Gasonline	118.38	14.86	133.24
Diesel	107.70	17.04	124.76
Light Fuel Oil	30.00	13.77	43.77
Aviation Fuel	56.00	6.89	33.89
Propane	73.51	23.64	97.15
Natural Gas		9.57	9.57
Coal (EI), $/Tonne	53.3	53.3	53.3
Heavy Fuel Oil (EI)	9.5	9.5	9.5
Coke, $/Tonne	74.6	74.6	74.6

B. REVENUES

A full analysis of the incidence of a carbon tax is found in Ruggeri an Bourgeois 2009]. Here I present a summary of their results. The revenues that the New Brunswick government would receive from the carbon tax and associated HST are shown in Table 8. This table allocates the estimated revenue from the proposed carbon tax between the direct and indirect categories. The former refers to the tax paid directly by the users (including the tax collected from electricity generation which is passed on through higher electricity rates), which cannot be passed on to anybody else. The latter refers to the tax paid by businesses, which becomes part of the cost of doing business and may be shifted to other economic agents (consumers or workers). Case A shows the distribution when the carbon tax on electricity generation is fully shifted forward to all electricity purchasers through higher rates. Case B shows the case where only half of this tax is allowed to be passed-on through higher electricity rates and NB Power shifts part of electricity supply from thermal coal and oil generation to imports from the U.S. and other Canadian provinces.

In case A, the estimated revenue from the carbon tax alone is $370 million. This total is distributed almost equally between individuals and families (direct component with a 46 percent share) and the industrial/commercial/institutional sector (54 percent). Within the direct component, 47 percent is for transportation, 45 percent for electricity, and the rest for water and space heating with furnace oil and propane. For the indirect component, electricity accounts for 41 percent and carbon-based fuels for 59 percent.

In case B, the estimated revenue from carbon tax is reduced to $290 million as the revenue from electricity generation is cut in half, but the distribution between the direct and indirect components remains unchanged. What changes is the distribution within these categories as the share of electricity declines substantially.

Table 8 shows that in case A the additional HST revenue would amount to $41 million, $14 million of which would be received by the federal government. The combination of the carbon tax and associated HST would raise the tax burden on New Brunswickers by $410 millions in 2006, while yielding $419 million for the New Brunswick government ($397 from New Brunswickers and $22 million from other provinces). Under case B, the total tax burden would increase by $322 million and the provincial revenue by $333 million.

Table 8. Estimated Revenue from the Carbon Tax and Associated HST: 2006, $Million.

	Carbon Tax	HST Federal	HST NB	HST Total	Total Revenue
A. Full forward Shifting of the Carbon Tax on Electricity Generation					
Direct					
Electricity	78.0	3.9	7.8	11.7	89.7
Transportation	80.4	4.0	8.0	12.0	92.4
Other	13.4	0.7	1.3	2.0	15.5
Sub-total	171.8	8.6	17.1	25.7	197.5
Indirect*					
Electricity	82.1	2.1	4.1	6.2	88.3
Other	116.2	2.9	5.8	8.7	124.9
Sub-total	198.3	5.0	9.9	14.9	213.2
Total	370.1	13.6	27.0	40.6	410.7
B. Fifty Percent Forward Shifting of the Carbon Tax on Electricity Generation					
Direct					
Electricity	39.0	2.0	3.9	5.9	44.9
Transportation	80.4	4.0	8.0	12.0	92.4
Other	13.4	0.7	1.3	2.0	15.4
Sub-Total	132.8	6.7	13.2	19.9	152.7
Indirect*					
Electricity	41.1	1.0	2.1	3.1	44.2
Other	116.2	2.9	5.8	8.7	124.9
Sub-total	157.3	3.9	7.9	11.8	169.1
Total	290.1	10.6	21.0	31.6	321.7

Table 9 shows the distribution of the burden of the carbon tax by income class, both in total and in dollars per family under the assumption that the increase in electricity generation costs are fully passed on to electricity users. The total burden is made up by four components. First, we can distinguish between the direct component, the tax burden associated with the purchase of energy sources by the ultimate consumer, and the indirect component, the burden incorporated into the products purchased by consumers. For each of these two components, we can separate the burden imposed by the carbon tax and the burden imposed by the associated HST, which has a federal and a provincial component.

The last column of Table 9 shows that, on average, the carbon tax and associated HST would impose a burden of $1,151 per family. This burden differs considerably among families because of differences in family size and income levels. We notice that the burden per family increases steadily with income, rising from $281 for the average family in the lowest income class to nearly $6,000 for the average family in the highest income class.

Table 9. The Distribution of the Carbon Tax by Income Group under Full Shifting of Electricity Costs: 2006, $ Thousands.

Income Class	Direct			Indirect			Total	Per Family
$ thousands	Carbon Tax	HST	Subtotal	Carbon Tax	HST	Subtotal		
0 – 10	4,921	736	5,657	1,170	120	1,290	6,947	281.0
10 – 20	17,635	2,640	20,275	8,749	1,032	9,781	30,056	465.0
20 – 30	19,172	2,869	22,041	13,920	1,349	15,629	37,310	657.9
30 – 50	39,140	5,855	44,995	35,742	2,993	38,735	83,730	979.6
50 – 70	28,384	4,246	32,630	31,785	2,362	34,147	66,777	1,435.3
70 - 100	36,605	5,474	42,079	48,844	3,319	52,163	94,242	1,960.1
100 - 200	22,310	3,337	25,647	42,526	2,776	45,302	70,949	2,607.9
200 +	3,633	543	4,176	15,564	949	16,512	20,689	5,995.1
Total	171,800	25,700	197,500	198,300	14,900	213,200	410,700	1,151

Since the revenue from this tax is likely to be used either to increase government spending or to reduce other taxes, identifying winners and losers would require also an analysis of the distribution of use of these funds. As an example, Ruggeri and Bourgeois [2009] estimated the net burden of carbon tax by assuming that the revenue it generates is distributed among families in proportion to their incomes (either as direct transfers of proportional reductions in the personal income tax). The results are shown in Table 10, which addresses the following question: if the revenue generated by the carbon tax and associated HST is returned to taxpayers in proportion to their income, which income group will receive a net gain and which income group will bear a net cost?

The fourth and seventh columns of Table 10 identify clearly the winners and losers from the combination of a carbon tax, associated HST and a proportional rebate. In the case of full shifting of electricity costs, families with income below $70,000 (which account for 78 percent of all families) will bear a net burden while families with income above $70,000 will have a net gain. In the case of fifty percent shifting of electricity costs, only

78 percent of all families) will bear a net burden while families with income above $70,000 will have a net gain. In the case of fifty percent shifting of electricity costs, only the families with income above $100,000 (which represent 13 percent of all families) will have a net gain. All the other families will bear a net burden.

Table 10. Net Burden of the Carbon Tax in 2006, $ Thousands.

Income Class	Full Shifting of Electricity Costs			Fifty Percent Shifting		
$ thousands	Carbon Tax*	Proportional Rebate	Net Burden	Carbon Tax*	Proportional Rebate	Net Burden
0 – 10	6,948	3,258	3,690	5,251	2,553	2,698
10 – 20	30,056	23,885	6,171	22,396	18,715	3,681
20 – 30	37,310	35,565	3,745	28,521	26,299	2,221
30 – 50	83,731	79,208	4,523	65,245	62,063	3,182
50 – 70	66,775	65,884	891	52,679	51,623	1,056
70 – 100	94,242	95,044	-803	75,409	74,471	-938
100 – 200	70,949	80,873	-9,924	55,758	63,367	-7,609
200 +	20,689	28,983	-8,294	16,541	22,709	-6,168

Table 11 measures the net burden of this tax (gross burden minus rebate) as a percentage of a family's income. The third and fifth columns show clearly that a carbon tax would be quite regressive when the revenue it generates is redistributed to all families in proportion to their income. The average family in the lowest income group (those with income below $10,000) would end up with a higher tax burden equal to 2.7 percent of their income while the average family in the highest income group (income above $200,000) would enjoy the equivalent of a tax reduction of 0.7 percent its income. This result indicates that the funds generated by the carbon tax must be distributed, through transfer payments or tax cuts, in a manner that benefits disproportionately low income families if we want to avoid imposing on them a disproportionate burden of reducing carbon emissions.

The fundamental question at this stage is: what do we get in environmental gains from this shift of the tax burden from higher income to lower income families New Brunswick families? This question is addressed in the rest of this paper.

Table 11. Differential Incidence of the Carbon Tax on the Average Family by Income Group.

Income Class $ thousands	Full Shifting of Electricity Costs		Fifty percent shifting of Electricity Costs	
	Net Tax burden $	Percent of income	Net Tax burden $	Percent of income
0 – 10	149	2.68	109	1.96
10 – 20	95	0.61	57	0.36
20 – 30	66	0.26	39	0.16
30 – 50	53	0.14	37	0.10
50 – 70	19	0.03	23	0.04
70 - 100	-17	-0.02	20	0.02
100 - 200	-365	-0.29	-280	-0.22
200 +	-2,403	-0.68	-1,787	-0.50

VI. METHODOLOGY

The environmental effects of a B.C. type carbon tax in New Brunswick are estimated by following several steps. First, I estimate the percentage change in the effective relative price of the taxed energy sources, based on the information presented in Section III. Second, I select the relevant price elasticities based on a review of the literature. Third, I combine the two steps above to calculate the change in the consumption of the taxed energy sources. Finally, I transform the change in energy consumption into a change in carbon emissions, based on the implicit conversion factors shown in section III. The first two steps are discussed in this section and the results from the remaining two steps are presented in the next section.

A. Percentage Change in Effective Relative Prices

The first step in estimating the environmental effects of a carbon tax is the calculation of the percentage change in the effective relative price of the various energy sources. For analytical purposes, I have separated electricity from all other energy.

Electricity. For electricity, two separate cases have been considered. In the first case there is no inter-fuel substitution and the full amount of the carbon tax on electricity generation is shifted forward to consumers. In the second case, only half of the carbon tax is passed on through higher electricity rates and the other half leads to a change in the electricity generation mix through imports of electricity.

In the case of full forward shifting of electricity costs, the percentage increase in the price of electricity may be derived by relating the carbon tax collected from NB Power to the revenue it receives from the different categories of customers. The percentage increase in the second half is half that of the first case. The results of these calculations are shown in Table 12 where the percentage change in the absolute price was calculated as the ratio of the carbon tax assigned to a given sector and the payments by that sector for the

electricity purchased, multiplied by one hundred. Subtracting the percentage increase in the general price index due to the portion of the carbon tax on businesses that is passed on to higher prices of goods and services yields the percentage increase in the effective relative price.

My calculations show that, in the case of electricity, a fully forward shifted carbon tax would raise electric power rates by nearly 18 percent in the residential sector and about 15 percent in the other sectors. The higher increase in the residential sector is due to the effect of the additional HST for which this sector would not receive a credit. The increase in the effective relative price is nearly one percentage point lower due to the increase in the general price index. When only half of the carbon tax on electricity generation is shifted to electricity users, the effective relative price of electricity would increase by about 8 percent in the residential sector and 7 percent in the other sectors.

Table 12. Percentage Change in the Price of Electricity Due to a BC Type Carbon Tax.

Sector	Full Forward Shifting		Half Forward Shifting	
	Absolute Price	Effective Relative Price	Absolute Price	Effective Relative Price
Residential	17.8	16.9	8.9	8.2
Public Administration	15.4	14.5	7.7	7.0
Commercial/Institutional	15.4	14.5	7.7	7.0
Industrial	15.4	14.5	7.7	7.0

The percentage change in the price of carbon-based fuels is shown in Table 13. In this case the percentage change in the absolute price was calculated as the carbon tax rate (plus the HST for the residential sector) divided by the pre-carbon-tax price, all multiplies by one hundred.

Table 13 shows that the carbon tax would generate different percentage increases in both absolute and effective relative prices. This is due to the fact that the carbon tax is based on the carbon content of a fuel which is not directly related to the price paid for that fuel. In general, the lower the pre-tax price of the fuel, the higher the percentage increase in the price caused by the carbon tax. As shown in Table 13, the two fuel categories that would be hardest hit by a carbon tax are natural gas and heavy fuel oil.

Table 13. Percentage Change in the Price of Carbon-Based Fuels Due to a BC Type Carbon Tax.

	Residential Sector		Other Sectors	
	Absolute Price	Effective Relative Price	Absolute Price	Effective Relative Price
Gasoline	9.0	8.1	7.8	6.9
Diesel	8.4	7.5	7.4	6.9
Heating Oil	9.8	8.9	8.5	7.6
Heavy Fuel Oil	23.6	22.7	31.5	29.6
Propane-Auto	5.9	5.9	5.9	5.0
Propane-Heating	7.3	6.4	6.5	5.6
Natural Gas	24.0	23.1	37.0	36.1

B. Price Elasticities

The next step involves the selection of the appropriate price elasticities, which measure the response of various economic agents to the increase in energy prices. For the residential sector (for which energy is a final product), we may identify two sets of responses. The first is the response to a change in the price of a given energy source relative to the price of all other goods and services combined (called the own-price elasticity of demand). If the demand for that energy source falls as the relative price increase, the carbon tax would lead to a reduction in the quantity demand. The second is the response to a change in the price of a given energy source relative to the price of the other energy sources (called the cross elasticity of demand). This response would alter the energy consumption mix without changing the total energy consumption. A change in the energy mix, however, might affect carbon emissions if the emission intensity of the various energy sources are not equal.

For the business sector, where energy is one of the inputs, there is an additional response, namely, the change in the input mix as the price of energy increases relative to the price of other inputs. The empirical evidence suggests that these elastiticies of substitution are quite small. For example, according to COMETR (2007, p. 29) in Europe "factor substitution between labour and energy is not very strong." For Canada, Jaccard and Bataille [2000, p.1], found "only weak substitution between capital and energy....this could mean that our energy efficiency efforts will be less effective than sometimes thought." Low elasticities of inter-factor substitution between energy and labour and between energy and capital were also found by Ma, Gibson Loxley and Kim [2008] in the case of China.

Because of these low elasticities of inter-factor substitution and because inter-fuel substitution does not affect total energy consumption and can reduce carbon emissions only when elasticities of inter-fuel substitution are high, relative price changes among energy sources are large, and differences in carbon emissions among fuels are substantial, I confined my calculations to the energy demand effects resulting from the own-piece elasticities. For this step, I surveyed the literature and at the end selected values that fell within the range of the available estimates. We can identify two groups of studies: (a) those that are based on total energy consumption, and (b) those that differentiate among energy sources.

Total Energy. The most general estimate of elasticities is the one that does not differentiate either among energy sources or among sectors of the economy. A major study of this type [COMETR 2007] found that price elasticities of demand for energy in Europe were in the range of -0.2 and -0.5. A similar study for China [Ma, Gibson, Loxley and Kim, 2008] estimated a price elasticity of total energy of -0.47.

A study for Quebec [Bernard 2006] made a distinction between the residential, commercial, and industrial sectors. It also estimated short-run and long-run elasticities. The results are very similar to those of COMETR but show differences among the three sectors. They also show that price elasticities are substantially larger in the long-run than in the short-run. The short-run elasticities range between -0.21 in the industrial sector and -0.40 in the commercial sector. The corresponding long-run values range between -0.36 for the industrial sector and -0.46 in the commercial sector. The residential sector has short-run and long elasticities roughly in the middle of the range (-0.29 and -0.40).

Another study for Canada [Bataille 2008], estimated even lower total energy elasticities for each of the above three sectors. Their full equilibrium elasticities (which approximate the long-run) are -0.27 for the entire economy, -0.24 for the residential sector, -0.25 for the commercial sector, and -0.28 for the industrial sector.

A number of studies have measured the price elasticity of total energy demand in the industrial sector. Hunt and Lynk [1992] found an elasticity of -0.3. Other studies have estimated elaticities in the range of -0.4 to -0.5 at the low end of the range and -0.6 to -0.8 at the high end.

Electricity. There are many studies on the demand for electricity and they provide a wide range of estimates of own-price elasticity. For mot studies, however, the range of those elasticities is fairly narrow. These studies show that (a) short-run elasticities are quite low, (b) long-run elasticities are much higher, and (c) the range of long-run elasticities is narrower. For Ontario, Angevine and Hrytzak-Lieffers [2007] found very low elasicities for the industrial sector (between -0.10 and -0.14). Liu [2004] also found that hort-run elasticities are very low for both the residential sector (-0.03) and the industrial sector (-0.13) in OECD countries, but increased substantially in the long-run reaching values of -0.16 and -0.44, respectiviely. For the residential sector in New England, Stevens and Adams [1986] estimated a short-run elasticity of -0.32 and a long-run elasticity o -0.46. For the entire US, the EIA [2003] derived short-run elasticities of about -0.25 for the

residential sector and about -0.16 for the business sector. It also estimated long-run elasticities of -0.49 and -0.45, respectively. In Australia, the NEM [2007] estimated long-term elasticities of -0.25 for the residential sector, -0.35 for the commercial sector, and -0.38 for the industrial sector. Filippini [1995] estimated a long-run elasticity of residential electricity demand in Switzerland of -0.30, while Ma et al [2008] estimated an elasticity of -0.405 for the residential sector in China. A study by the OECD [2006] shows a short-run elasticities of -0.43 for Norway and between -0.16 and -0.62 for the US, with the corresponding long-values of -0.49 for Norway and -0.55 for the US.

The above studies suggest that (a) for the residential sector, the short-run own-price elasticity of demand for electricity is about -0.25 and its long-run value double that, (b) elasticities may be similar for the commercial and industrial sectors, and (c) these sectors have short-run elasticities lower than for the residential sector and roughly the same value for the long-run.

Transportation Fuel. The empirical evidence indicates that the demand for gasoline is price-inelastic in both the short- and long-run. Brons, Nijkamp, Pels and Rietveld [2006] estimated price elasticities of - 0.22 for the U.S. but higher price elasticities for the Netherlands (-0.53). A survey of various studies in the U.S. by Espey [1998] estimated a short-run elasticity of -0.26 and a long-run elasticity of -0.58. Another survey by Goodwin, Dargay and Hanly [2008] concluded that the price elasticity of the demand for gasoline is -0.25 in the short-run and -0.64 in the long-run. For OECD countries, Liu [2004] estimated short-run elasticities of -0.19 and long-run elasticities of –0.6. A study for Canada by Nicol [2003] found price elasticities of -0.40 for the country as a whole and -0.45 for Atlantic Canada.

There is some evidence that the price elasticity of demand is even lower for diesel. Liu [2004] estimated that in the OECD the short-run price elasticity for diesel [-0.094] is about half that for gasoline and the long-run elasticity [-0.267] is less than half.

Heating Fuels. The results of studies on the price elasticity of heating fuels find similar values for natural gas and furnace fuel. For the residential sector in the U.S., the IEA [2003], estimated short-run price elasticities for both fuels at -0.25 and -0.23, respectively, while Joutz et al. [2008] found a long-run elasticity of -0.3. For Europe, Asche et al. [2008] derived short-run elasticities of the residential demand for natural gas -0.20 and long-run elasticities in the range of -0.23 and -0.76. For the OECD countries, Liu [2004] estimated short-run elasticitries of -0.10 for natural gas and -0.14 for furnace fuel, and corresponding long-run elasticities of -0.34 and -0.32, respectively.

Heavy fuel oil is used primarily by the industrial sector, in addition to its use for electricity generation. Studies show that the price elasticity of demand for this fuel are quite low in the short-run, but increase substantially in the long-run. IEA [2003] estimated short-run elasticities of -0.25 for the U.S., while Liu [2004] derived short-elasticities of -0.17 and long-run elasticities of -0.52 for OECD countries.

Selected Elasticities. Since the carbon tax is being evaluated as a permanent tax and since its environmental effects will work their through the economic system over time, it is more meaningful to use long-run elasticities. The values of these elasticities used in this study are based on the results of various studies shown above and are presented in Table 14.

Table 14. Long-run Own Price Elasticities Used in this Study.

	Residential	Commercial/Institutional	Industrial
Electricity	-0.50	-0.50	-0.50
Natural Gas, Furnace Fuel, Propane Kerosene	-0.30	-0.30	-0.30
Heavy Fuel Oil	-0.30	0.30	-0.50
Gasoline	-0.45	-0.45	n/a
Diesel	-0.45	-0.35	-0.35
Aviation Fuel	n/a	-0.45	-0.45

VII. ENVIRONMENTAL EFFECTS OF A CARBON TAX

The combination of the effective relative prices and price elasticities presented above, when applied to the pattern of energy consumption, allows the calculation of the effect of the proposed carbon tax and carbon dioxide emissions. In this section, the detailed results are presented for the case where the increased costs of electricity generation are entirely passed on through higher power rates. The case where only half of these costs are shifted forward to electricity users is discussed briefly later.

A. Direct Effects

Full Forward Shifting of Electricity Costs. The estimated changes in energy consumption due to the proposed carbon tax are shown in Table 15.

I estimated that the proposed carbon tax would reduce electricity demand in New Brunswick by 1,040 GGWH in 2006. 6.4 percent of in province use. I assumed that this reduction would take place entirely in the generation of thermal-steam generation. This source of electricity generation would fall by 12.5 percent. Given the existing generating capacity, this reduction would be equivalent to the elimination of 169 MW of thermal-steam generating capacity. I also assumed an equal reduction between coal generation and heavy fuel oil generation. The result would be a decline of 138 thousand tones of coal and 113 million litres of heavy fuel oil.

The consumption of refined petroleum products (excluding toe used in electricity generation) would fall by 108 million litres or 4.3 percent, and the use of natural gas (excluding electricity generation) would decline by about 10 percent.

Table 15. Estimated Changes in Energy Consumption Due to the Carbon Tax in 2006.

Energy Type	Units	Change in Consumption
A. Electricity	GWH	-1.049
B. Refined Petroleum Products		
Gasoline	Millions of Litres	-37.6
Diesel	Millions of Litres	-18.7
Aviation Fuel	Millions of Litres	-2.4
Light Fuel Oil and Kerosene	Millions of Litres	-6.1
Propane	Millions of Litres	-1.8
Heavy Fuel Oil	Millions of Litres	-41.6
Sub-Total	Millions of Litres	-108.2
C. Natural Gas	Terajoules	-849.6

The associated reduction in carbon dioxide emissions is shown in Table 16. This table shows that the proposed carbon tax would cut CO2 emissions by 7.3 percent or 978 kilotonnes in 2006. Emissions would continue to grow over time in response to economic growth and population increase, but it would follow a path that would be 7 percent lower than the path in the absence of the carbon tax. Because the carbon tax generates a level effect on carbon emissions, shifting downward its future trend but not reducing the slope of that trend, economic growth would quickly offset this reduction and in a few years the C)2 emissions would exceed the before-tax level in 2006.

The most striking feature of Table 16 is that two-thirds of the estimated reduction in CO2 emissions is due to the decline in electricity consumption leading to a lower thermal-steam generation. The reduction in CO2 emissions from the consumption of refined petroleum products (other than those used in electricity generation) would account for only 30 percent of the total decline in emissions. There are three main reasons for the large role of electricity in the estimated CO2 reductions. First, under full forward shifting of electricity costs, the increase in the relative price of electricity is higher than the average increase for refined petroleum products. Second, I used a higher price elasticity of demand for electricity than for refined petroleum products. Third, the energy sources involved in the reduction in electricity generation (coal and heavy fuel oil) have above average emission factors.

The information contained in Table 16 has important implications for environmental policy. The carbon tax is a demand-side market instrument of environmental policy. Yet, in New Brunswick it would operate as a market instrument only for a small portion of its potential effect, even when we exclude energy consumption by the public administration sector. Since the electric utility (NB Power) is a Crown corporation, it does not need

market signals to change the mix of its generating capacity. It needs the appropriate political signals. Instead of concealing a tax increase through higher electricity rates for the purpose of providing an incentive to NB Power to change its revenue mix and reduce electricity consumption, the government can achieve the same goal directly by providing support for the expansion of generating capacity from renewable energy sources. Should this expansion require higher power rates, consumers would pay to acquire clean electricity instead of filling the government coffers.

Table 16. Reduction in Carbon Dioxide Emissions Resulting from the Carbon Tax: 2006.

Energy Type	Kilotonnes of CO2	Percentage of Total Reduction
A. Electricity		
Coal	294	30.06
Heavy Fuel Oil	349	35.68
Subtotal	643	65.74
B. Refined Petroleum Products		
Gasoline	89	9.10
Diesel	51	5.21
Aviation Fuel	6	0.61
Light Fuel Oil and Kerosene	17	1.74
Propane	1	0.10
Heavy Fuel Oil	129	13.20
	293	29.96
Natural Gas	42	4.30
Total	**978**	**100.00**
Percent of Total Emissions	7.3	

Fifty-Percent Forward Shifting of Electricity Costs. The environmental effects of a carbon tax where the government allows NB Power to pass on only half of the increased costs depend on a variety of factors. Therefore, instead of presenting a set of alternative estimates, I will simply discuss the potential influence of such factors.

Such a constraint would impose on NB Power a financial burden of $91 million. This additional cost may be offset by reducing costs (for example, reducing the growth of salaries and bonuses), and importing tax-free electricity from other jurisdictions to offset part of the taxed generation. How much of these imports would be used to reduce costs depends on the cost of the imported electricity and whether its price is fixed or increases with the amount imported.

With respect to the environmental effects, there are two opposing forces at work. Passing on only half of the carbon tax costs to costumers will lower the reduction in electricity prices in half and the associated reduction in CO2 emissions. Replacing domestic thermal-steam generations with imports will raise the reduction in emissions, but the

magnitude of this effect depends on two major factors. First, if the purchased electricity is generated by renewable energy, there is a maximum environmental effect. If it is replaced by some form of thermal-steam generation in another jurisdiction, emissions in New Brunswick will fall by the full amount of the imports, but overall emissions will decline only to the extent that the imported electricity is generated by using fuels with lower emissions factors than coal and heavy fuel oil.

B. Indirect Effects. When taxes on carbon-based fuels are sufficiently high, they may stimulate a process that leads to environmental effects in excess of the demand effects discussed above. These include the development of new technology for improving the efficiency of energy use in general, energy-saving changes in production processes, and the development of more cost-effective alternative sources of energy.

While acknowledging that these effects may be significant in the long-run, we must also recognize that the magnitude of these effects depends crucially on the size of the market affected by the carbon tax. The development of this new technology is an expensive endeavour and can be justified only if it will generate profitable economic activities. A New Brunswick carbon tax would affect only a miniscule market and could not be expected to generate the research and development activity that would be needed to produce these indirect effects. It is likely, therefore, that the environmental effects of a carbon tax in New Brunswick would be largely confined to the direct effects discussed above.

VIII. CONCLUSIONS

This paper evaluated the environmental effects of the proposed carbon tax in New Brunswick and is a complement to the paper by Ruggeri and Bourgeois [2009] that analyzed the incidence of this tax among families with different income levels.

The results of this paper indicate that two-thirds of the estimated reductions in CO2 emissions would come from lower thermal-steam generation in response to a decline in the domestic demand for electricity. Since the electric utility is a Crown corporation that does not operate as a "market" entity, there is no need to introduce a market instrument of environmental policy to achieve the desired environmental goal.

In the New Brunswick context, a carbon tax would operate as a market instrument for environmental policy only for one third of the potential reductions in emissions. The use of such a blunt instrument can hardy be justified by the small reduction in emissions that would be generated in this "market" sector. The potential reduction in emissions in this sector are only half of those that would be generated in the electricity generation sector and would be equivalent to a reduction of 88 MW of thermal-steam generating capacity.

The case against a carbon tax in New Brunswick becomes more compelling when we look at its effects on different families. Because it has limited potential to reduce emissions in the "market" sector, and because its revenue would be used mostly to offset

reduction in personal and corporate income taxes, the carbon tax effectively becomes a tool of tax policy. Moreover, because it would shift the tax burden from high to lower income families, it would make the tax system more regressive.

The overall effect of the carbon tax would be to lighten the tax burden on high income families, increase the tax burden on lower income families, and do little to reduce greenhouse gas emissions in the "market" sector.

REFERENCES

Al-Sahlawi, M. [1989], "The Demand for Natural Gas: A Survey of Price and Income Elasticities," *The Energy Journal,* Vol. 10, pp. 77-91.

Angevine, G. and D. Hrystak-Lieffels [2007], "Ontario Industrial Electricity Demand Responsiveness to Price," *Teachnical Paper No. 1,* The Fraser Institute.

Asche, F., O. Nielsen and R. Taveras [2008], "Natural Gas Demand in the European Household," *The Energy Journal.*

Bataille, C. [2008], "Calculating the GHG and Energy Price Elasticities Using a Hybrid Top-Down and Bottom-Up Model," Paper Presented at the 2008 IAEE International Conference, Instanbul.

Bernard, J-T [2006], "Energy Demand Elasticities: Empirical Results in the Quebec Context," *Department of Economics, University of Laval,* mimeo.

Brons, M, P. Nijkamp, E. Pels and P. Rietveld [2006], "A Meta-Analysis of the Price Elasticity of Gasoline Demand: A System of Equations Approach," *Research Paper,* Tinbergen Institute, Amsterdam.

COMETR [2007], "Competitiveness Effects of Environmental Tax Reforms," *Final Report to the European Commission.*

Department of Finance [2008], *Discussion Paper on New Brunswick's Tax System.* Government of New Brunswick, Fredericton.

Energy Information Administration [EIA 2003], "Annual Energy Outlook 2003 (AEO2003), Washington, D.C.

Espey, M. [1998], "Gasoline Demand Elasticities: An International Meta Analysis f Elasticities," *Energy Economics,* Vol. 20, pp. 273-95.

Filippini, M. [1995], "Swiss Residential Demand for Electricity by Time Use," *Resources and Energy Economics,* Vol. 17, pp. 281-90.

Goodwin, P., J. Dargay and M. Hanly [2008], "Elasticities of Road Traffic and Fuel Consumption with Respect to Price and Income: A Survey," *Transport Reviews,* Vol. 24, pp.275-92.

Hunt.,L. and E. Lynk [1992], "Industrial Energy Demand in the U.K.: A Cointegration Approach," in D. Hawdon (ed.), *Energy Demand, Evidence and Expectations,* Surrey University Press.

Jaccard, M. and C. Bataille [2000], "Estimating Future Elasticities of Substitution for the Rebound Debate," *Energy Policy,* Vol. 28, pp. 451-55.

Joutz, F., T. Trost, D. Shin and B. McDowell [2008], Estimating Regional Short-run and Long-run Price Eladticities of Residential Natural Gas Demand in the U.S.," Paper Presented at the 28th USAEE/IAEE Annual North-American Conference, New Orleans.

Liu, G. [2004], "Estimating Energy Demand for OECD Countries," *Discussion Paper 373,* Research Department, Statistics Norway.

Ma, H., J. Gibson, L. Oxley, and B. Kim [2008], "Inter-factor and Inter-fuel Demand Elasticities in China," *University of Canterbury,* mimeo.

Ministry of Small Business and Revenue [2008], *Carbon Tax Rates by Fuel Type,* Government of British Columbia, Victoria.

NEM [2007], The Own-price Elasticity of Demand for Electricity in NEM Regions, *Report Prepared for the National Institute of Economic and Industry Research,* Victoria, Australia.

Nicol, C. [2003], "Elasticities of Demand for Gasoline in Canada and the United States," *Energy Economics,* Vol. 25, pp. 201-214.

OECD [2006], *The Political Economy of Environmentally Related Taxes,* Paris.

Ruggeri, J. and Bourgeois J-P. [2009], *The Distributional Effects of a Carbon Tax in New Brunswick,* Department of Economics, University of New Brunswick, mimeo.

Ruggeri, J. [2009], *The Environmental Effects of a Carbon Tax in New Brunswick,* Department of Economics, University of New Brunswick, mimeo.

Statistics Canada, *Electric Power Generation, Transmission and Distribution,* Catalogue Number 57-202-X.

----- *Report on Energy Supply and Demand,* Catalogue Number 57-003-X

----- *The Social Policy Simulation Database/Model (SPSD/M).*
Stevens, T. and G. Adams [1986], "Testing for Changes in the Price Elasticity of Residential Electricity Demand," *Northeastern Journal of Agriculture and Resources,* Vol. 15, pp. 123-129.