PREPARED BY
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EnviroEconomics

FOR
David Suzuki Foundation

# pricing carbon: saving green

## A CARBON PRICE TO LOWER EMISSIONS, TAXES AND BARRIERS TO GREEN TECHNOLOGY

David Suzuki Foundation

SOLUTIONS ARE IN OUR NATURE

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Pricing Carbon: Saving Green
A Carbon Price to Lower Emissions, Taxes and Barriers to Green Technology



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*"The atmosphere can no longer be considered a carbon dump."*

– J. Simpson, M. Jaccard, N. Rivers

*Hot Air: Meeting Canada's Climate Change Challenge*


# Introduction

Human-caused climate change is now a fact[1] and Canadians recognize that addressing global warming will be one of the biggest political and economic challenges for the foreseeable future. Canadians seek leadership on this important issue, particularly from government. At the same time, more and more Canadians realize there is no trade-off between economic prosperity and environmental protection over the long-term. A robust economy depends on protecting the environment, and the climate in particular.

One of the root causes of global warming is that too many goods that take a heavy toll on the climate are produced without any charge for the associated carbon emissions. Ultimately the cost of the emissions is borne, not by the polluter, but by all Canadians in the form of a degraded environment. For instance, while most Canadians have to pay about $90 a tonne to dump waste at their local municipal landfill, anyone can dump thousands of tonnes of carbon into the atmosphere absolutely free of charge.

The bottom line: we must stop using our atmosphere as a free dumping ground.

In today's economy the market, in addition to setting prices, also plays a major role in determining whether activities that contribute to climate change are increasing or declining.

Currently the economy is biased in a way that actually makes the climate-friendly consumer choice much more expensive than the unsustainable choice. That is because the carbon content of most products and services Canadians consume is not reflected in the price they pay. This means that every day many of the purchases and activities of millions of Canadians, while light on the pocketbook, exact a heavy price from the environment.

There is no denying that the market is a powerful force. Several recent studies have shown that the single most effective solution to rising greenhouse gas emissions is using the market to put a price on carbon.[2] Putting a price on carbon, through a carbon tax or a cap and trade system, is a more broadly effective approach than subsidies, voluntary programs and more effective than regulations in most instances.

This report, prepared for the David Suzuki Foundation by M. K. Jaccard and Associates and EnviroEconomics, examines a number of carbon pricing scenarios and establishes some revenue use options for Canada that would lead to a dramatic reduction in greenhouse gas emissions.

## A carbon price to generate investment in energy efficient homes, renewable energy and green technology

Canadians seek leadership on this important issue, particularly from government

Addressing the challenges of climate change will involve shifting to clean, renewable energy such as wind and solar, dramatically improving the energy efficiency of our homes and promoting green technology entrepreneurs and approaches across the country.

Today, anyone who wants to introduce these clean and efficient solutions is at a serious economic disadvantage to the fossil fuel sector, which does not have to cover the cost of its emissions. The playing field is not level for these two approaches to compete fairly with each other.

This report demonstrates that a carbon price can help fix the imbalance between clean energy and carbon intensive fossil fuel in two ways. First, putting a price on carbon will introduce the true cost of carbon emissions into the equation and, second, the substantial revenue generated by a carbon price can be used to help pay for a massive increase in home efficiency retrofits, and the deployment of clean energy technology.

The following table shows the funding that would be available annually to reduce greenhouse gas emissions, if a portion of the revenue generated by a carbon price were invested in renewable energy and in improving the energy efficiency of Canadians' homes. In this example, seven percent of the revenue is invested in renewable energy and 25 per cent is invested in home energy efficiency. The balance of the revenue could be earmarked for other uses described in this report.

**Investment in renewable energy and improved home energy efficiency with the annual revenue from a carbon price in 2020**

| CARBON PRICE (DOLLARS PER TONNE) | 7% INVESTMENT IN RENEWABLE ENERGY, INCLUDING WIND AND SOLAR (FUNDS AVAILABLE BILLIONS $) | 25% INVESTMENT IN HOME ENERGY EFFICIENCY (FUNDS AVAILABLE BILLIONS $) |
|---|---|---|
| $75 | $3.6 | $12.9 |
| $100 | $4.3 | $15.3 |
| $150 | $5.6 | $20.0 |
| $200 | $6.9 | $24.6 |

## A tax on carbon – not on labour, savings or investment

The substantial revenue generated by a carbon price can be used to help pay for a massive increase in home efficiency retrofits, and the deployment of clean energy technology.

One unintended consequence of many types of taxes is that they discourage the very activity that is being taxed. For instance, labour taxes dampen employment levels, income taxes can discourage savings, and capital gains taxes can discourage investment. But it is also well established that if the tax rate is reduced, there will be an accompanying rise in the targeted activity. [3]

Taxes that discourage consumption, particularly undesirable consumption, can be used to replace some of the taxes on activities that society would rather encourage, such as employment or investment. This report shows that putting a price on carbon generates enough revenue to substantially reduce taxes in other areas.

A carbon price, set to bring Canada's greenhouse gas emissions down to a trajectory in line with recommendations made by international climate change scientists, would generate government revenue of at least $50 billion per year by 2020. This revenue could be shifted in order to reduce other taxes, including the level of income tax that Canadians pay. In this manner, instead of paying taxes on wages, savings and investments, Canadians would be paying more of their taxes on the basis of the consumption choices they make.

This analysis shows that if the entire revenue generated by a carbon price were used to offset income taxes, Canadians would experience a 50 per cent average reduction in the income tax they pay. While most of the savings would be offset by an increase in the cost of carbon intensive products, Canadians would be free to tailor their consumption patterns to maximize the income tax savings and to minimize the impact of the carbon price on their wallets.

The same policy could be applied to corporate income taxes, thereby enhancing productivity, investment in Canada, and international competitiveness.

If the entire revenue generated by a carbon price were used to offset income taxes, Canadians would experience a 50 per cent average reduction in the income tax they pay.

## Continued strong economic growth

Recent research into carbon pricing by the National Round Table on the Environment and the Economy (NRTEE)[4] as well as this report shows that with the introduction of a carbon price – even a very steep one – Canada's economy is projected to continue growing rapidly.

According to the research in this study Canada's economy is expected to grow to a GDP of $1.79 trillion per year by 2020. The introduction of a carbon price is projected to slightly reduce the rate of GDP growth by 2020 to $1.76 trillion – a difference of 1.9 per cent.

However, this report shows that if the revenue that government collects from carbon pricing is properly reintroduced into the Canadian economy, the projected decline in the rate of economic growth can be substantially reduced, to 0.9 per cent.

Consequently the economic impact of the introduction of a carbon price can be reduced by half, when accompanied by well-designed revenue use policies such as tax shifting or revenue recycling.

## Protection for low-income Canadians

Low-income Canadians must be protected from the modest economic impact that will inevitably accompany a carbon price policy. While most Canadians could experience an offsetting reduction in income taxes through tax shifting associated with a carbon price, low-income earners often pay little or no income tax and hence would not benefit from a reduction in this tax.

There are several policy options for addressing the economic impact of a carbon price on low-income earners, including tax rebates, credits, and targeted incentives. One of the options that has proven most effective is the refundable tax credit, which has been successfully used with the federal Goods and Services Tax. A refundable tax credit ensures that all Canadians below a certain income threshold receive direct compensation to offset the additional costs associated with a carbon price.

## A revenue neutral carbon price

The analysis establishes that a carbon price can be revenue neutral, meaning that at the end of the day government coffers experience neither an increase nor decline with the introduction of a carbon price.

There is a lingering misconception that a carbon price is nothing more than a *tax grab*.[5] While the receipt of substantial revenue – more than $50 billion per year – accompanies any effective carbon price, the revenue is simply the by-product of putting a price on carbon emissions.

One way to address the substantial inflow of revenue is to reduce another government revenue stream by the same amount that the carbon price increases government revenue. An income tax cut for Canadians for example, can fully offset the additional revenue that the carbon price generates. One further benefit is that Canadians would end up paying taxes on polluting activities, which discourages pollution, instead of paying taxes on desirable activities such as employment.

This report shows that with the introduction of a carbon price – even a very steep one – Canada's economy is projected to continue growing rapidly.

## Conclusion

A carbon price can be revenue neutral, meaning that at the end of the day government coffers experience neither an increase nor decline with the introduction of a carbon price.

There is wide-spread agreement among many quarters of Canadian society that the implementation of a strong and consistent carbon price signal, across the entire economy, is necessary if Canada is to reduce its greenhouse gas emissions.[6] It is also recognized that the quicker the federal government moves on this front, the more likely we will avoid a higher carbon price that accompanies delay and the more we will be able to reduce cumulative emissions released into the atmosphere.

The federal government has the option of introducing a carbon price that either takes the form of an emission tax, a cap and trade system, or a combination of both. The overriding imperative is that government take action.

At the end of the day there is marginal difference between a well-designed carbon trading system or a carbon tax policy. Both can be made to meet very similar ends. A trading system sets an absolute limit on greenhouse gas emissions. Similarly, a carbon tax will also inevitably "cap" emissions, as the price is adjusted until the desired outcome is achieved.

Both policy options involve passing the cost of carbon on down through the supply chain and on to industry and eventually consumers. This is the *raison d'etre* of a carbon price – to let consumers know, through a price signal, that carbon emissions are costing the Earth.

Both policies will generate substantial revenue. It is self-evident that a carbon tax does this. However, a trading system would also generate similar returns if trading permits are auctioned by government and not simply distributed free of charge. Eventually, the revenue generated will be in the tens of billions of dollars and allow Canada the freedom to reduce other taxes such as those on investments, income, and savings, as well as to make substantial investments in green infrastructure and technology.

### Main findings of the Report

- **A phased-in carbon price would eventually generate considerable government revenue. This study shows that setting the price to bring Canada's greenhouse gas emissions down to a trajectory in line with recommendations made by international climate change scientists would generate government revenue of at least $50 billion per year by 2020.**
- **The substantial government revenue generated by a carbon price could allow government to cut personal income tax by 50 per cent for the average Canadian taxpayer.**
- **The implementation of a well-designed revenue use policy, such as tax shifting or revenue recycling, would reduce the economic impact of a carbon price on those sectors and regions of Canada's economy that rely heavily on carbon intensive activities.**
- **With the introduction of a carbon price, even a fairly high one, Canada's economy would continue to grow rapidly.**
- **A well-designed revenue use policy can reduce the economic impact of a carbon price by as much as half, to less than one per cent of lost GDP growth by 2020.**

## Recommendations of the David Suzuki Foundation

Drawing upon the findings and conclusions contained in this report, the David Suzuki Foundation makes the following recommendations to the federal government:

- The results of this research reinforce what several recent studies have shown, that the single most effective solution to rising greenhouse gas emissions is using the market to put a price on carbon. The federal government must act swiftly to introduce an economy-wide carbon price that will lead to deep national greenhouse gas emission reductions by 2020.
- The federal government has the option of introducing a carbon price that either takes the form of an emission tax, a cap and trade system, or a combination of both. The overriding imperative is that government take action.
- A substantial portion of the government revenue from a carbon price should be invested in a large-scale increase in renewable energy, home energy efficiency improvements, and public transportation. This will help further reduce the advantage that the fossil fuel sector, which does not have to fully cover the cost of its carbon emissions, has over clean technologies.
- Any policy should be accompanied by measures to protect low-income Canadians from the economic impact of a carbon price. Measures could include a refundable tax credit similar to that which accompanied the introduction of the Goods and Services Tax.

# Modelling of Carbon Price Revenue Recycling Scenarios

BY

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ENVIROECONOMICS

FOR

DAVID SUZUKI FOUNDATION

## Overview

Policy makers in Canada and other countries are beginning to develop longer-term climate change mitigation strategies, with the aim of achieving substantial emission reductions by 2020 and beyond. However, substantial emission reductions will be accompanied by the potential for economic impacts, and there is a need to understand how to minimize and manage these potential impacts. Specifically, there is a need to understand the likely range of economic impacts associated with different levels of emissions abatement, and to understand how polices might be designed to minimize costs and distributional impacts.

Much of the policy discussion related to deep emission reduction focuses on carbon pricing, whereby government applies a price on greenhouse gas emissions (either directly through a tax or indirectly through an emissions cap and permit trading system). Emission-generating activities would become more expensive in the presence of a carbon price, so firms and individuals would have an incentive to reduce emissions. Economists generally consider emission pricing to be a cost-effective policy for substantial emission reductions.

Several studies conducted in Canada estimate the likely reduction in greenhouse gas emissions corresponding to various levels of emission price. Most of these studies, however, gloss over the issue of what might be done with the substantial revenue that could be raised through carbon pricing.[7] This is an important omission, since other studies have shown that appropriate use of the revenue raised from carbon pricing could help to alleviate and perhaps offset the economic impact of the carbon price.

The objective of this study is to quantitatively estimate the likely economic impact of a carbon price in Canada using a computable general equilibrium model. In addition, the analysis reported here discusses how innovative use of the revenues raised through application of a carbon price could help to manage the impact of carbon pricing in Canada.

This report explores several alternative revenue recycling schemes that could accompany a carbon price, ranging from revenue neutral schemes – where revenue from a carbon price is used to reduce other taxation in the economy – to schemes where some of the revenue is used to provide incentives for environmentally sensitive technologies and behaviours. In some of the scenarios analyzed in this report, the overall burden of taxation in Canada is reduced through the application of a carbon price.

A major focus of the report is to investigate how alternative revenue recycling schemes can reduce the economic impact of carbon pricing through redistribution of revenues or reduction in other taxation. As part of this line of research, we also explore the possibility of a 'double dividend', where the imposition of carbon pricing would produce an environmental dividend (reduced emissions and the associated benefits) and the recycling of revenues might produce an economic dividend (wealthier individuals and increased economic output). Economists have long studied the concept of double dividend, yet despite long-standing conjecture, economic theory remains inconclusive about its likelihood in reality. This is particularly the case in Canada, and therefore the "double dividend hypothesis" remains an open yet important climate policy question.

## Carbon Pricing, Revenue Recycling, and the 'Double Dividend' Hypothesis: a Brief Review of Past Studies

Economy-wide carbon pricing[8] – through implementation of a carbon tax or emission trading system – is widely considered by economists to offer the most cost effective solution for substantially reducing greenhouse gas emissions.[9] By increasing the price of a polluting activity, a carbon price makes that activity more costly and should reduce the level of that activity and the associated emissions. Setting the price at the (marginal) damage from emissions is known as setting a 'Pigouvian' carbon price.[10] Most economic analysis is strongly supportive of Pigouvian pricing to remedy environmental problems like climate change.

There are two key reasons that economists strongly prefer Pigouvian emission pricing for addressing many environmental problems. First, an economy-wide Pigouvian emission price sends the same signal to all emitters, which should result in economically efficient abatement of emissions throughout the economy. Second, imposition of an emission price can raise a substantial amount of revenue for government, which opens up possibilities for productive use of that revenue. For example, government could use that revenue to reduce distributional impacts resulting from the imposition of the carbon price or to reduce the productivity impact of the carbon price.

Despite the widespread support for carbon pricing in the economics literature, most countries have not imposed economy-wide Pigouvian carbon pricing or have only taken limited steps to do so. Progress on carbon pricing has been slowed by concerns over economic and competitiveness impacts, an uneven distribution of costs and benefits (in time and space), and poor scientific understanding of the problem by the public and government decision makers. Partly as a result, economists have focused substantial research attention around the implications of alternative revenue recycling mechanisms that might accompany a carbon price. For example, they have considered the possibility that the substantial potential revenue that could be raised from carbon pricing could be used to reduce the rate of taxation on personal income, on corporate income, on consumption, or on other inputs and outputs in the economy.

An extension of this research has been investigation of the so-called 'double dividend' hypothesis. The double dividend hypothesis suggests that if the imposition of a carbon price can supplant an existing tax that is more harmful to the economy, the result could be an improvement of environmental quality (the first dividend) as well as an improvement of economic output (the second dividend).[11]

Since the idea first originated, the concept of a double dividend further developed into what are referred to as weak and strong *double dividend hypotheses*:[12]

- **Weak double dividend hypothesis**, where there is still a net loss in economic welfare associated with carbon pricing, but the size of this loss is reduced if the revenues are used to decrease productivity inhibiting taxes (as opposed to simply returning the revenues in lump sum payments to consumers and firms); and,
- **Strong double dividend hypothesis**, where the carbon pricing and the recycling and tax shifting result in an overall net gain to the economy.

Economists have used both theoretical and numerical models to investigate the potential of a double dividend, and whether it might be weak or strong.[13] Most theoretical models[14] suggest that a strong double dividend from carbon pricing is unlikely – in other words, the imposition of carbon pricing will cause a net economic loss. However, most also suggest that a weak double dividend is likely, meaning that there are benefits from using the carbon pricing revenues to reduce productivity-inhibiting taxes.[15] Importantly, these conclusions are not absolute, and depend on the assumptions underlying the models – especially those governing the behaviour of individual consumers.[16] Economic theory, therefore, is suggestive but certainly not conclusive on the likely presence of a double dividend for climate policy. That said, an emerging consensus amongst economists based on theoretical modelling suggests that a strong double dividend is unlikely in most circumstances.[17]

Since robust conclusions have not been reached using theoretical approaches, economists have turned to numerical approaches that allow for a more complex formulation of the problem and adaptation to a specific situation (e.g., a specific country and time period). As a result, the conclusions of individual numerical models are potentially more accurate, but also dependent on the specific situation being studied and are therefore not readily transferable. A scan of the results from numerical models indicates that with some of the restrictive assumptions used in theoretical models now dropped, the results are more varied. Several recent studies find that a strong double dividend is possible, while some other suggest that even a weak double dividend is unlikely in certain circumstances.[18] No universal conclusions can therefore be drawn from prior numerical modelling of the double dividend.

One early numerical study of Canadian climate policy focuses heavily on the double dividend hypothesis.[19] Using a computable general equilibrium model, that study reported the presence of a weak double dividend, where accompanying the introduction of a carbon price with reductions in other taxes could alleviate some (but not all) of the negative economic impact of the carbon price. That study found that the best candidate for tax shifting was the payroll tax. A more recent Canadian study peripherally explored the double dividend hypothesis, and found limited support for the notion of a strong double dividend.[20] Other recent work on tax distortions in Canada suggests that taxes on capital are the most distortionary, followed by taxes on labour and then by taxes on consumption. In addition, models that examined the impact of investment incentives found them to be among the most effective measures to reduce distortions.[21]

Although there is a body of evidence to draw from on the impacts of revenue recycling for carbon pricing, past studies in Canada have not reached a consensus on the issue of the double dividend or on optimal revenue recycling schemes. Given the importance of addressing climate change and the growing recognition that carbon pricing will be required and will generate revenue, further study of this question in the Canadian context is of value.

## Modelling Carbon Pricing and the Double Dividend

### THE MODELS

The primary purpose of this report is to numerically investigate the economic implications of carbon pricing in Canada, and to investigate how those outcomes might be impacted by different revenue utilization schemes. Modelling of the effects of carbon pricing and the subsequent implications of revenue recycling and tax shifting requires two key features in a model:

- **Behavioural and technological response to carbon prices.** The key element in modelling the abatement response of the economy to carbon pricing at different levels is a model with realistic behavioural and technology responses. A model that is both technologically detailed and that contains a realistic portrayal of firm and consumer behaviour is best suited for this purpose.
- **Aggregate financial flows in response to emission pries and recycling/tax shifting.** To model the welfare and fiscal impacts of carbon pricing and revenue recycling requires a model that accounts for transactions in all key markets as well as the interactions between those markets. Models that do this are known as a general equilibrium models because they find equilibrium in all markets at once, subject to policies such as carbon pricing.

Unfortunately, these two requirements are somewhat at odds. Most general equilibrium models do not represent alternative technologies in much (if any) detail, and their behavioural responses are based on judgment or a limited number of empirical studies at a very aggregated level from historical periods that may fail to represent the future context with different technology and energy options for firms and households.[22] Most technologically detailed models do not contain a general equilibrium response (they are called partial equilibrium models), and many also make unrealistic assumptions about consumer and firm behaviour.[23]

To bridge this analytical gap between the two types of models, the approach adopted in this report is to link energy and abatement responses from the technologically-detailed and behaviourally-realistic CIMS energy economy model to a broader computable general equilibrium (CGE) model of the Canadian economy more suited to questions of public finance and the economic impacts of tax shifting and revenue recycling:

- **The CIMS model** simulates the technological evolution of fixed capital stocks in Canada (such as buildings, vehicles, and equipment) and the resulting effect on costs, energy use, emissions, and other material flows of various carbon polices such as pricing and standards.[24] With the carbon policy, old stocks are retrofitted to reflect the increased cost of carbon while new and less emission-intensive capital stocks are acquired at retirement and with growth in stock demand (e.g., rising electricity demand). Market shares of technologies competing to meet new stock demands with the carbon policy are determined by standard financial factors as well as behavioural parameters from empirical research on consumer and business technology preferences.
- **The General Equilibrium Emissions Model** (**GEEM**), is a simple general equilibrium model of the Canadian economy. In the model, a representative household supplies labour and capital to industrial sectors. The industrial sectors supply intermediate inputs to one another, and final commodities to the household. Imports and exports to the rest of the world are explicitly modelled. All markets interact through relative producer and consumer prices with policy shocks changing these prices, leading to new equilibriums in the various markets. GEEM is composed of eight industrial sectors, as shown in Table 1.

TABLE 1
**Sectors included in GEEM**

| | |
|---|---|
| **OIL** | Crude oil extraction |
| **ELEC** | Electricity generation |
| **GAS** | Natural gas extraction and transmission |
| **EIM** | Energy intensive manufacturing |
| **COAL** | Coal mining |
| **OMAN** | All other manufacturing |
| **RPP** | Petroleum refining |
| **ROE** | Rest of economy (service sectors) |

To link these two models, we calibrate the emission responses and technology choice in GEEM to mimic CIMS across a wide range of carbon prices. More detail about CIMS and GEEM as well as the emissions and macroeconomic calibration of GEEM is provided in Appendix A.

## THE CARBON PRICE POLICY AND THE EMISSION REDUCTION TARGETS

The core policy modelled in this report is an economy-wide carbon price, implemented either through a carbon tax, a cap and trade system, or a hybrid of the two (i.e., trading for large emitters and a tax for all others). In the case that an emission trading scheme is used, this report only considers the case where all permits are auctioned to emitters. In this case, the models treat an emission trading scheme as identical to a carbon tax.

The magnitude of emission price dictates the level of abatement that will be induced and the subsequent revenue stream. Given the fluidity of climate policy in Canada, this report evaluates carbon prices ranging from \$25 to \$225 per tonne of $CO_2$e in 2020 (all prices are in CDN \$2003). Two emission reduction targets are of note: the Government of Canada's current medium term target of reducing emission to 20% below current levels by 2020 (roughly equivalent to reducing emissions to 1990 levels by 2020), and the environmental non-government organization (ENGO) community's target of reducing emissions to 25% below 1990 levels by 2020.

Given projected growth in emissions in Canada through 2020, both of these targets imply substantial reductions. Several recent reports suggest that greenhouse gas emissions are likely to grow by roughly 15% between 2005 and 2020, from their current level of 747 Mt $CO_2$e to a 2020 level of 850 to 900 Mt $CO_2$e.[25] Recent economic forecasts have revised upwards the growth in economic activity to 2020, with annual growth estimates in the order of 2.5% versus our assumed rate of about 2%. This means that there may be a slight downward bias in our emissions forecast.

In the policies modelled here, the carbon price covers all emissions in Canada. Exports of fossil fuels, which do not produce emissions in Canada (but rather in the country in which they are consumed), are exempt from the carbon price. This exemption refers to direct emissions in a fuel, not to emissions released while producing a given product. For example, in the case of exports of crude oil, the carbon contained in the crude oil would not be subject to the carbon price (since it produces emissions in another country), but any activities that release emissions within Canada would be (for example, the mining or thermal extraction of the crude oil).

In the modelling, we make the assumption that Canada's key trading partners (especially the US) are implementing similar climate policies as Canada. Over the mid- to long-term (the focus of this paper) this is a reasonable assumption, even if policies may differ somewhat in the near term. The parameters in the model governing international trade were adjusted to reflect this assumption.[26]

## CARBON PRICE PATH TO 2020

The results of the modelling are reported for a single year: 2020. But, because of the long lifespan of many of the technologies that produce emissions, an emission price would need to be applied early and increased gradually to deliver significant reductions at a relatively low cost.[27] An optimal emission price path was therefore identified using a reduced form version of the CIMS model to minimize GDP loss for a given target in 2020.[28] The results of this optimization – the carbon price path necessary to achieve the targets – are provided below in Table 2. The second row of the table shows that an emission price that started in 2010 at \$40/t $CO_2$e and increased to \$100/t $CO_2$e by 2020 would roughly return emissions back to 1990 levels – the current Government of Canada target.[29] The final row shows that an emission price that started in 2010 at \$75/t $CO_2$e and increased to \$200/t $CO_2e$ by 2020 would still result in emissions that are slightly higher than target currently promoted by ENGOs.

Throughout the rest of this report, emission prices refer to the values in 2020. The trajectory of prices leading up to 2020 is assumed in the general equilibrium modelling but not referred to directly.

Due to modelling limitations and time constraints, the carbon price path to 2020 outlined in this report does not take into account any complementary measures or the purchase of international carbon credits. This exclusion means that the carbon prices reported here are higher than might be required in practice, if accompanied by other measures.

TABLE 2

**Optimal Price Path to Achieve GHG Targets in 2020 – Path that Minimizes GDP Loss (some industrial fugitive emissions only)**

| CARBON PRICE PATH TO 2020 (2003\$/T $CO_2e$) | | | EMISSION REDUCTION IN 2020 RELATIVE TO: | | |
|---|---|---|---|---|---|
| 2010 | 2015 | 2020 | 1990 | 2006 | 2020 BAU |
| \$25 | \$45 | \$75 | +10% | -12% | -21% |
| \$40 | \$65 | **\$100** | +1% | -19% | **-27%** |
| \$55 | \$90 | **\$150** | -12% | -30% | **-35%** |
| \$75 | \$130 | **\$200** | -19% | -35% | **-40%** |

Source: Reduced form model of CIMS (minimize GDP loss to achieve target reduction)

## ASSESSMENT OF REVENUE USE OPTIONS

This report investigates how alternative mechanisms for carbon price revenue utilization might change the economic impact of carbon pricing. Some of the revenue utilization schemes analyzed here are revenue neutral, while others are not. In this report, we use the term revenue neutrality in reference to revenue from a specific source, rather than overall government revenue. For example, if the revenue raised from carbon pricing were used to lower the personal income tax rate, revenue neutrality (as defined in this report) implies that the revenue from the carbon price would exactly make up for the shortfall in revenue caused by reduction in the income tax rate. Because of other feedbacks in the economy however, government collection of other taxes may change, leaving overall government revenue changed.

Six alternative tax shifting and revenue recycling options are examined:[30]

- **Lump-sum recycling to households** (LUMPSUM). In this scenario, all emission price revenue is collected by government and then totally disbursed as rebates to households. In this scenario, both government revenue and expenditures (transfers) increase relative to business as usual. This scheme therefore, is net revenue neutral, after accounting for government transfers to households. In this report, the LUMPSUM scenario is treated as a comparison benchmark for all other scenarios.
- **Recycling to industrial emitters based on output (production)** (OUTPUT). In this scenario, all emission price revenue is returned to firms proportionately to their economic output.[31] This recycling scheme provides an incentive for firms to increase output if they can do so without substantially increasing emissions. As a result, it should provide a stimulus to economic growth. Like the previous scenario, this one sees both government revenue and expenditures (transfers) increase relative to the business as usual case. Again, we consider the scheme net revenue neutral, since it involves transfers by government to firms but no increase in government expenditures;

- **Income tax on labour shift (LABOUR)**. In this scenario, the rate of tax on labour income is lowered so that the revenue collected from the emission price exactly equals the reduction in revenue cased by reductions in the labour tax rate. The current average income tax on labour is about 22%, which includes both federal and provincial direct income taxes (about 12% of GDP). This scheme is revenue neutral;
- **Payroll tax shift (PAYROLL)**. In this scenario, payroll taxes are lowered so that the revenue collected from the emission price exactly equals the reduction in revenue caused by reductions in the payroll tax rate. Payroll taxes in GEEM include health care premiums, social assistance contributions, and pension contributions. The benchmark payroll taxes are calculated from the SAM with a business as usual value of about 6% of GDP. This scheme is revenue neutral;
- **A hybrid scenario (HYBRID)**. In this scenario, 14% of the revenue raised from carbon pricing is used to subsidize renewable electricity and carbon capture and storage (in both the electricity generation and upstream oil sectors). A further 40% of the total carbon tax revenue is transferred to industry proportionately to output. The remainder is used to reduce the payroll tax rate. Because this scheme involves an increase in government expenditures (subsidies to renewable electricity and carbon capture and storage), it is not considered revenue neutral; and,
- **A second hybrid scenario (HYBRID-RES)**. In this scenario, 7% of the revenue raised from carbon pricing is used to subsidize renewable electricity. Another 25% subsidizes energy efficiency and fuel switching in the residential sector. [32] The remainder of the revenue (68%) was recycled to reduce payroll taxes for households and business. Like the previous scenario, this one is not considered revenue neutral since it involves increases in government expenditures (subsidies).

A scenario in which the revenue from carbon pricing is used to lower corporate income taxes is not conducted due to modelling constraints,[33] but existing literature indicates that the results for the labour tax shift may be similar for key metrics such as welfare and GDP.[34] That said, additional work in this area is needed before one can conclude that the labour and capital tax shifts perform similarly. This is particularly the case since capital taxes have been found to be more distortionary than labour taxes in the Canadian case.[35] The scenarios assessed here are not intended to be representative of all possible revenue recycling possibilities, but instead represent some commonly discussed alternatives.

## Modelling Results

This section first presents the framework used to compare the recycling and tax shifting options and then provides the numerical results and the related analysis.

### A FRAMEWORK FOR COMPARING CARBON PRICE REVENUE RECYCLING PROPOSALS

Most policy assessment frameworks include a common set of policy assessment criteria, including policy effectiveness, environmental efficiency, acceptability, distribution and competitiveness. Annex 4 of the 2005 Federal Budget is one such framework specifically designed to assess environmental tax proposals.[36] Given that it is published by Finance Canada and is consistent with accepted policy assessment frameworks, it is used to assess the policies in this report. We assess four of the five framework elements using quantitative indicators, namely:

- Environmental effectiveness, whether, and to what extent, the proposal will contribute to achieving the environmental goal;
- Economic efficiency, how the proposal will affect the allocation of resources in the economy and Canada's global competitiveness;
- Fiscal impact, how the proposal will affect government expenditures or revenues; and
- Fairness (or distribution), how the impacts of the proposal are distributed across sectors of the economy, regions or groups within the population.

The final element of the Budget Framework, simplicity, is not assessed in this report, since it is not amenable to quantitative evaluation.

### ENVIRONMENTAL EFFECTIVENESS

The Budget Framework states that an environmental tax measure will be effective if it can be targeted effectively and induces a change in producer or consumer actions to achieve the environmental goal. An emissions price is generally considered effective at reducing greenhouse gas (GHG) emissions because it causes firms and individuals to internalize the cost of emitting and directly targets emissions (rather than a related, but not perfectly correlated proxy, like energy consumption).

**TABLE 3**

**LUMPSUM Scenario – Emission Prices and Emission Reductions in 2020. Emission Reductions Below 1990, 2005, and 2020 Baselines (including fugitive emissions)**

| EMISSION PRICE ($2003/T $CO_2$e) | EMISSIONS IN 2020 (MT $CO_2$e) | RELATIVE TO 1990 | RELATIVE TO 2005 | RELATIVE TO BAU IN 2020 |
|---|---|---|---|---|
| | | TONNES IN BASE YEAR | | |
| $0 | 865 | 596 MT | 747 MT | 865 MT |
| $75 | 707 | 19% | -5% | -18% |
| $100 | 625 | 5% | -16% | -28% |
| $150 | 553 | -7% | -26% | -36% |
| $200 | 516 | -13% | -31% | -40% |
| $225 | 501 | -16%* | -33% | -42% |

* including fugitive emissions in GEEM, which explains the difference at $200 between this table and Table 2, where at $200 emissions are reduced -19% relative to 1990. Simply, fugitive emissions are much more expensive to abate and hence the reductions for the same carbon price are less for a base with fugitives (as in this Table (3)).

This effectiveness is evident in Table 3, where the emission reductions at various emission prices for the LUMPSUM scenario are presented (as a reminder, in this scenario carbon price revenue is transferred back to households via the government's consolidated revenue fund). In the table, greenhouse gas emissions in the LUMPSUM scenario are compared to three benchmark years: actual emissions in 1990 and 2005, and forecasted business as usual (BAU) emissions in 2020. An emission price that reaches \$100/t $CO_2e$ by 2020 appears likely to roughly return emissions to 1990 levels by 2020, consistent with announced federal government targets.

Recycling to support building retrofits in the residential sector could increase emission reductions more than the alternative scenarios, with additional reductions typically 3% to 4% greater. For the remaining scenarios, emission reductions are very slightly lower than for the LUMPSUM scenario at the same carbon price, typically because economic activity is also slightly higher in those scenarios.

Table 4 shows that at a \$100/t $CO_2e$ price in 2020, recycling revenue through lump sum rebates to households would generate roughly 1 percent more greenhouse gas reductions than recycling revenues through output subsidies to industry. Other recycling options fall between these two bookends. Overall, the mechanism used to recycle carbon price revenue back to the economy does not significantly affect the environmental performance of the carbon price.

While the analysis described here focuses on the year 2020, it should be noted that greenhouse gas abatement would likely increase over time if carbon prices were maintained. Because of inertia in society's capital stock, only a portion is subject to replacement before 2020. With a longer time horizon, a greater portion of society's capital stock would be replaced under carbon pricing, leading to lower emissions.

**TABLE 4**

**Emission Reductions below the BAU in 2020 by Option**

| RANK | OPTION | CARBON PRICE IN 2020 (\$/t $CO_2e$) \$75 | \$100 | \$150 | \$200 |
|---|---|---|---|---|---|
| Best | HYBRID-RES | -20.36% | -29.31% | -38.22% | -43.09% |
| ↑ | LUMPSUM | -18.30% | -27.73% | -36.02% | -40.35% |
| | HYBRID | -18.85% | -28.55% | -36.62% | -41.18% |
| | LABOUR | -18.54% | -28.02% | -35.91% | -40.19% |
| ↓ | PAYROLL | -18.34% | -27.79% | -35.79% | -40.02% |
| Worst | OUTPUT | -18.12% | -27.56% | -35.42% | -39.64% |

## ECONOMIC EFFICIENCY

The Budget Framework provides three key areas that make up the overall assessment of the economic efficiency of a tax proposal:

- Internal efficiency centres on improving the efficiency of the economy. Here there are two related sub-criteria: (1) how the tax measure affects the allocation of resources in the economy and overall productivity; and (2) whether the proposal can improve the efficiency of the tax system.
- Competitiveness and trade requires an understanding of how a proposal may affect the international competitiveness of an industry. Questions of price changes, balance of payments, and export volumes are central to understanding this impacts.
- Welfare captures the benefit that individuals obtain from leisure activities (time spent not working) as well as consumption. Importantly, the definition of welfare adopted in this

report is narrow, since it does not include the benefit that would be obtained through an improved environment, nor does it factor in how the wealth might be distributed. It is, however, an important metric of the overall desirability of each scenario.

## INTERNAL EFFICIENCY

Introduction of a carbon price would change the allocation of resources relative to business as usual.[37] In the LUMPSUM scenario, where all revenue raised from the carbon price is recycled back as lump sum rebates to households, the emission price is forecast to reduce gross domestic product (GDP) in 2020 by about 1.3% under a \$100/t $CO_2e$ tax and by 2.4% under a \$200/t $CO_2e$ tax relative to the business as usual forecast (see Figure 1). These results are generally consistent with other estimates. [38]

The double dividend question is then whether or not alternative tax shifting mechanisms can improve the overall efficiency of the tax system by totally reversing this loss (a strong dividend) or ameliorating it somewhat (a weak dividend). From a tax policy perspective, if the operational efficiency of the tax system can be improved while raising the same amount of revenue, carbon pricing would be preferred over the alternative taxes regardless of the emission benefits.

The modelling indicates that the revenue recycling schemes investigated here do not improve the overall efficiency of the tax system, but can significantly lessen the impact of carbon pricing relative to lump sum recycling to households. A weak double dividend therefore seems likely; with none of the revenue recycling scenarios we examined totally offsetting the GDP loss across the full range of carbon prices. In other words, if carbon emissions did not present an environmental problem, the current tax system would be preferred over one with a carbon tax. Table 5 presents the results and ranks the options from best (lowest GDP impact for a given carbon price) to worst (highest).

All of the alternative revenue recycling schemes perform significantly better than the LUMPSUM scenario:

- The **OUTPUT** scenario uses carbon price revenue to subsidize economic output, and therefore economic impacts of the policy are smallest. At high carbon prices, the overall GDP impact is about half as large as for the LUMPSUM scenario.
- The **PAYROLL** scenario uses carbon price revenue to reduce payroll tax rates, which reduces labour input costs for industry, stimulating economic output. At high carbon prices, GDP impact is about half as large as for the LUMPSUM scenario.
- The **HYBRID-RES** scenario has similar impacts to the PAYROLL scenario, since the majority of revenue is used to reduce this tax. In addition, it uses carbon price revenue to subsidize renewable energy and residential buildings (like a lump sum transfer with additional reductions), which is somewhat distortionary (reducing aggregate economic output).
- The **HYBRID** scenario has similar impacts to the PAYROLL and OUTPUT scenarios, since it is a combination of these two. In addition, it uses carbon price revenue to subsidize renewable energy and carbon capture and storage, which is somewhat distortionary (reducing aggregate economic output).
- The **LABOUR** scenario uses carbon price revenue to reduce personal income tax rates, which results in a supply of more labour, a modest drop in wage rates, and a lowering of input costs for industry thereby stimulating economic output. At high carbon prices, the GDP impact is just over half that of the LUMPSUM scenario.

**FIGURE 1**
## Ranking of GDP Responses at Various Emission Prices in 2020. Change from BAU GDP of $1,798 Billion in 2020

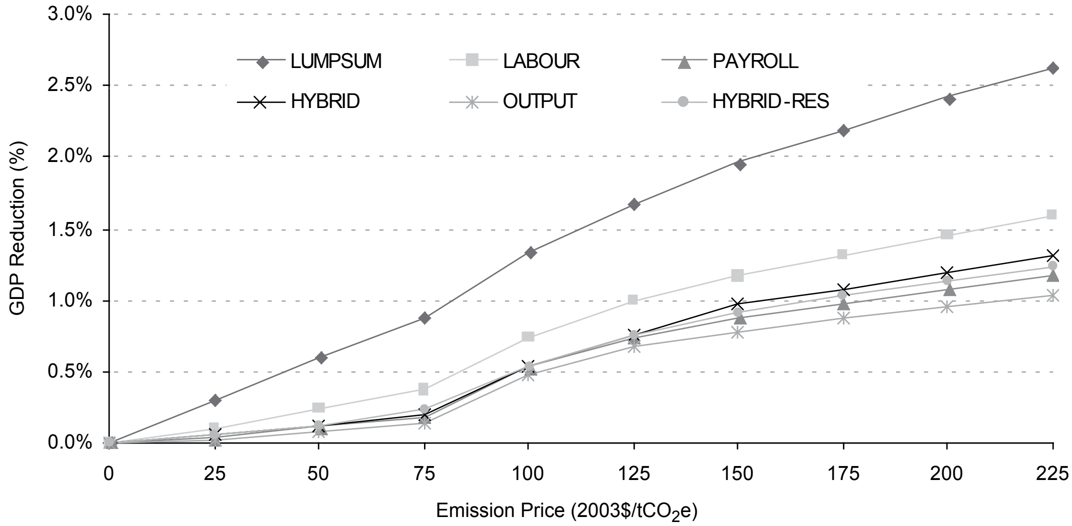
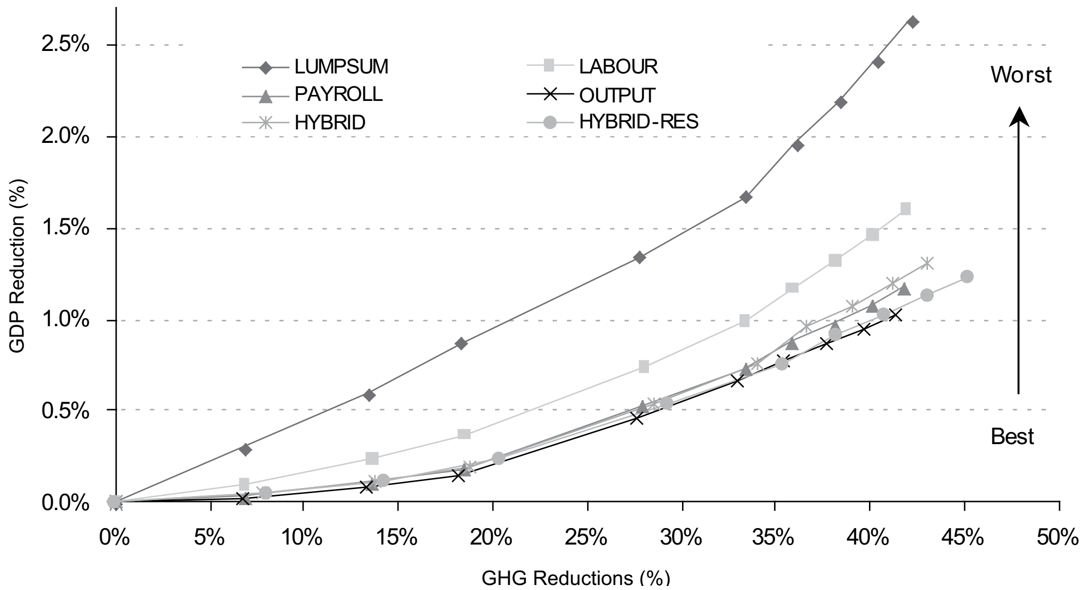



**TABLE 5**
## Ranking of GDP Responses at Various Emission Prices in 2020

| RANK | OPTION | CARBON PRICE IN 2020 (2003$/t $CO_2$e) $75 | $100 | $150 | $200 |
|---|---|---|---|---|---|
| Best ↑ | OUTPUT | -0.14% | -0.47% | -0.78% | -0.95% |
| | PAYROLL | -0.18% | -0.52% | -0.88% | -1.07% |
| | HYBRID-RES | -0.23% | -0.54% | -0.91% | -1.13% |
| | HYBRID | -0.18% | -0.53% | -0.96% | -1.19% |
| | LABOUR | -0.37% | -0.74% | -1.17% | -1.46% |
| Worst ↓ | LUMPSUM | -0.87% | -1.34% | -1.96% | -2.42% |

Figure 2 combines the results on cost and effectiveness discussed above into a measure of cost effectiveness – the reduction in GDP for different levels of emissions reductions. The results are similar to Table 5 – for a given level of abatement, lump sum recycling of the carbon price revenue to households is associated with the largest GDP impact. Alternative revenue recycling mechanisms can significantly reduce the economic impact of applying carbon prices.

**FIGURE 2**
**Cost Effectiveness in 2020**




## COMPETITIVENESS AND TRADE

Competitiveness issues are an important factor in designing climate policy. In 2003, Canada exported roughly $435 billion and imported $395 billion of goods and services, for an overall balance of trade surplus of about $40 billion. As a result, it is one of the most highly traded economies in the world. Canadian exporters have expressed concern about the degree to which climate policy might curtail their exports.

In GEEM, international trade is modelled to track the sensitivity of exports and imports to carbon pricing. As discussed in the Appendix, GEEM treats Canada as a small open economy that cannot influence the world price of commodities.[39] Elasticity values in GEEM determine the response of imports and exports to climate policy. These parameters in GEEM were chosen to reflect the fact that Canada's primary trading partners will be developing climate policies at the same time as Canada. However, to ensure that the results are conservative, we assumed that Canada's policies are somewhat more stringent than those of Canada's trading partners, which means that some competitiveness impacts can be expected.

### Prices

With carbon pricing, producer costs and hence commodity prices rise for carbon intensive products. Carbon pricing also indirectly affects the prices of labour and capital in Canada; depending on the direction of these impacts, the prices for less carbon intensive commodities can increase or decrease. Table 6 shows the forecasted equilibrium price of production in Canada exclusive of emission prices (since exports are not directly subject to domestic emission prices in the model). Prices for carbon intensive products are forecast to increase, while those of non-carbon intensive products remain roughly constant or even decrease slightly. In particular, the price of producing coal, oil, gas, electricity, and refined petroleum products is forecast to increase significantly. The price of producing energy intensive products, like cement, industrial chemicals, and pulp and paper, is also projected to increase somewhat. In contrast, the price of producing non-energy-intensive manufacturing commodities (like vehicles, computers, and pharmaceuticals) is projected to decrease somewhat. The price of services is projected to remain roughly constant or decrease slightly.

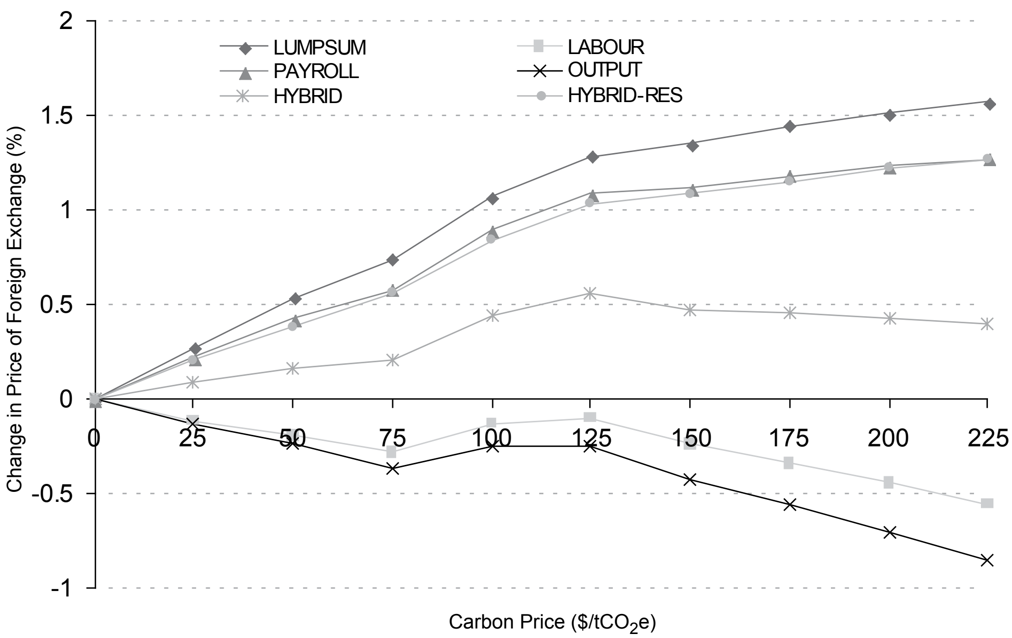
**TABLE 6**
**Equilibrium (real) Price of Domestic Production in 2020 with a $100/t $CO_2e$ Price. Exclusive of carbon price.**

| | OIL | GAS | COAL | RPP | ELEC | EIM | OMAN | ROE |
|---|---|---|---|---|---|---|---|---|
| OUTPUT | 17% | -1% | 27% | 9% | 14% | 6% | -5% | -1% |
| PAYROLL | 16% | -4% | 37% | 14% | 16% | 9% | -3% | -2% |
| HYBRID | 16% | 1% | 41% | 8% | 21% | 11% | -4% | -2% |
| HYBRID-RES | 16% | -3% | 52% | 13% | 23% | 13% | -4% | -3% |
| LABOUR | 16% | 0% | 47% | 13% | 24% | 11% | -6% | -3% |
| LUMPSUM | 17% | 0% | 57% | 15% | 29% | 15% | -4% | -1% |

### Trade Effects

In GEEM, the overall balance of trade is held constant across model runs so that the results are comparable. The Canadian dollar exchange rate is allowed to float relative to other currencies. Figure 3 shows the projected effect of the various policies on the Canadian dollar exchange rate. As shown in the figure, the LUMPSUM scenario causes a 1-2% decline in the value of the Canadian dollar, the PAYROLL scenario causes a slightly smaller impact, and the LABOUR and OUTPUT scenarios both are projected to cause an appreciation in the value of the Canadian dollar. Overall, the impact on the foreign exchange rate appears likely to be modest.

**FIGURE 3**
**Foreign Exchange Rate**




### Exports and Imports

Table 7 shows the predicted change in export volume by commodity for the various revenue recycling schemes, at a $100/t $CO_2e$ emission price. Exports of fossil fuels are expected to be somewhat reduced with carbon pricing. Similarly, exports of energy-intensive manufactured products are expected to be reduced. In contrast, exports of other manufactured products and services are expected to increase. Particular effects relating to the revenue recycling method are given in the table.

**TABLE 7**
**Change in Export Volume by Commodity (in $2003 billions) for a $100/t $CO_2$e Emission Price**

| | OIL | GAS | COAL | RPP | ELEC | EIM | OMAN | ROE | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| **BAU** | **$38.9** | **$44.0** | **$3.2** | **$15.7** | **$3.1** | **$113.0** | **$293.0** | **$147.8** | **$658.6** |
| LUMPSUM | -$10.6 | -$8.3 | -$2.4 | -$4.1 | -$0.2 | -$15.3 | $33.0 | $2.9 | -$5.0 |
| LABOUR | -$13.5 | -$9.2 | -$2.5 | -$4.9 | -$0.4 | -$19.4 | $38.6 | $3.8 | -$7.6 |
| PAYROLL | -$12.5 | -$7.3 | -$2.5 | -$4.7 | -$0.3 | -$19.6 | $32.3 | $6.9 | -$7.7 |
| OUTPUT | -$13.5 | -$10.4 | -$2.5 | -$4.6 | -$0.4 | -$18.0 | $45.9 | $1.7 | -$1.7 |
| HYBRID-RES | -$10.6 | -$8.8 | -$2.6 | -$4.3 | -$0.4 | -$15.7 | $29.0 | $5.3 | -$8.1 |
| HYBRID | -$12.9 | -$8.8 | -$2.5 | -$4.7 | -$0.4 | -$18.9 | $37.9 | $4.8 | -$5.6 |

Table 8 shows the predicted change in import volume by commodity for the various revenue recycling schemes, again at a $100/t $CO_2$e emissions price. Imports of fossil fuel products are expected to be reduced slightly following imposition of an emission price, as a result of lower demand for these products in Canada. In contrast, imports of energy-intensive manufactured products are forecast to increase because of the lower price relative to Canadian primary products. Overall, the change in imports is not large for any of the scenarios investigated.

**TABLE 8**
**Change in Import Volume by Commodity (in $2003 billions) for a $100/t $CO_2$e Emission Price**

| | OIL | GAS | COAL | RPP | ELEC | EIM | OMAN | ROE | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| **BAU** | **$25.7** | **$3.4** | **$5.0** | **$5.3** | **$1.3** | **$105.4** | **$329.7** | **$106.2** | **$581.9** |
| LUMPSUM | -$1.8 | -$0.8 | -$1.9 | -$0.2 | $0.5 | $5.7 | -$3.6 | -$3.6 | -$5.8 |
| LABOUR | -$2.1 | -$0.8 | -$2.0 | -$0.2 | $0.5 | $5.2 | -$3.8 | -$4.2 | -$7.4 |
| PAYROLL | -$2.2 | -$0.8 | -$2.0 | -$0.2 | $0.4 | $5.0 | -$3.0 | -$5.5 | -$8.3 |
| OUTPUT | -$1.6 | -$0.7 | -$1.9 | -$0.3 | $0.5 | $6.5 | -$1.9 | -$2.0 | -$1.4 |
| HYBRID-RES | -$2.4 | -$0.9 | -$2.2 | -$0.3 | $0.3 | $5.4 | -$3.3 | -$5.4 | -$8.7 |
| HYBRID | -$2.0 | -$0.8 | -$2.0 | -$0.3 | $0.5 | $5.6 | -$2.6 | -$4.1 | -$5.8 |

## WELFARE

The measure of welfare includes not only utility gained from consumption of goods and services, but also utility gained from time spent not working (leisure). Importantly, this welfare measure is only partial; it does not capture environmental or health benefits from reduced emissions or distributional effects of policy changes. Nevertheless, it is a useful metric to compare the desirability of the options.

Carbon pricing does not result in a significant change in national welfare. Of the scenarios described here, the LABOUR and the PAYROLL scenarios are the most preferred. This is not surprising since both measures are broad-based tax shifting proposals and provide benefits over the entire economy. This contrasts with the OUTPUT case, which provides a targeted subsidy to industrial firms. The LUMPSUM is the least preferred primarily since it results in lower levels of economic activity and wealth (i.e., it has the lowest labour supply and thus wages to households). Not much better is the HYBRID-RES scenario, where the distortion created by the subsidy in spending patterns for the residential sector results in a slightly better welfare result.

TABLE 9
**Welfare Effects of the Revenue Recycling Scenarios**

| RANK | OPTION | CARBON PRICE IN 2020 (2003$/t $CO_2e$) $75 | $100 | $150 | $200 |
|---|---|---|---|---|---|
| Best ↑ | LABOUR | -0.12% | -0.41% | -0.70% | -0.93% |
| | PAYROLL | -0.14% | -0.43% | -0.72% | -0.95% |
| | HYBRID | -0.16% | -0.45% | -0.75% | -0.99% |
| | HYBRID-RES | -0.18% | -0.45% | -0.76% | -1.02% |
| | OUTPUT | -0.19% | -0.49% | -0.79% | -1.03% |
| Worst ↓ | LUMPSUM | -0.28% | -0.60% | -0.95% | -1.24% |

## FISCAL IMPACT

Environmental tax measures will generally impact tax revenues and a government's overall fiscal position. Even some of the revenue-neutral carbon price measures described in this report are likely to have impacts on both overall government revenue and specific fiscal flows.[40] For this reason, they must be assessed in the broader context of a commitment to balanced budgets, sound fiscal management, and an efficient tax system.

GEEM includes most key taxes used to raise revenue for provincial and federal governments in Canada.[41] In particular, the model includes:

- Personal income taxes collected by both federal and provincial governments are the largest source of government income, representing almost half of total provincial and federal government tax revenue;
- Corporate income taxes collected by both federal and provincial governments represent about 15% of total provincial and federal government tax revenue;
- Payroll taxes include social insurance premiums, contributions to pension plans, and healthcare premiums, and represent about 15% of total provincial and federal government tax revenue.
- Consumption taxes include sales taxes, fuel excise taxes, liquor and alcohol taxes, and represent about 20% of total provincial and federal government tax revenue.
- Import duties are levied by the federal government and represent a small portion (about 1%) of total provincial and federal government tax revenue.

In total, the projected size of federal and provincial governments in GEEM, as measured by collection of these taxes, is expected to be about $475B in 2020 (in 2003 dollars), or roughly 26% of GDP.[42]

Imposition of a substantial carbon price is likely to raise a significant amount of additional revenue for government. As shown in Table 10, a $100/t $CO_2e$ carbon price would raise roughly $60 billion in government revenues, and a $200/t $CO_2e$ carbon price would raise over $100 billion in additional government revenues.

Choosing what to do with that additional revenue could have substantial fiscal implications. The following sections describe the fiscal impacts of the various revenue recycling schemes.

**TABLE 10**
**Projected Revenue in 2020 from imposition of a carbon price in LUMPSUM scenario**

| CARBON PRICE (2003$/T $CO_2$e) | REVENUE (BILLIONS OF $2003) |
|---|---|
| BAU | $0.0 |
| $75 | $53.0 |
| $100 | $62.5 |
| $150 | $83.0 |
| $200 | $103.1 |

**LUMPSUM Scenario.** Revenues collected from the carbon price are transferred back to households in a lump sum. The receipts of government grow substantially in this scenario, as shown in Table 11, from $472 billion to $551 billion for a carbon price of $200. However, after the carbon tax revenue is transferred back to households, the net government revenue falls somewhat in this scenario. This is a result of a slight reduction in economic output, which reduces government receipts of other taxes.

**TABLE 11**
**LUMPSUM Scenario: Total Government Revenue, Billions of $2003 in 2020**

| CARBON PRICE ($/T CO²e) | CARBON REVENUE | GROSS REVENUE | | NET REVENUE | |
|---|---|---|---|---|---|
| | | BILLIONS $ | % CHANGE | BILLIONS $ | % CHANGE |
| BAU | - | $472.2 | - | $472.2 | - |
| $75 | $53.0 | $516.3 | 9.34% | $463.3 | -1.88% |
| $100 | $62.5 | $521.9 | 10.52% | $459.4 | -2.71% |
| $150 | $83.0 | $535.8 | 13.46% | $452.8 | -4.10% |
| $200 | $103.1 | $550.4 | 16.56% | $447.3 | -5.28% |

**OUTPUT Scenario.** Revenues collected from the emission price are transferred by government to industry in proportion to economic output. Again, the revenue of government grows substantially in this scenario – by roughly 20% in the case of a $200/t $CO_2$e emission price. However, after government has returned all additional revenue to industry, net government revenue remains fairly unchanged relative to the business as usual case.

**TABLE 12**
**OUTPUT Scenario: Sources of Government Revenue and Value of Recycling, Billions of $2003 in 2020**

| CARBON PRICE ($/T $CO_2$e) | CARBON REVENUE | GROSS REVENUE | | NET REVENUE | |
|---|---|---|---|---|---|
| | | BILLIONS $ | % CHANGE | BILLIONS $ | % CHANGE |
| BAU | - | $472.2 | - | $472.2 | - |
| $75 | $53.07 | $527.1 | 11.63% | $474.1 | 0.39% |
| $100 | $62.61 | $534.6 | 13.22% | $472.0 | -0.04% |
| $150 | $83.73 | $553.4 | 17.20% | $469.7 | -0.54% |
| $200 | $104.35 | $572.5 | 21.23% | $468.1 | -0.87% |

**HYBRID Scenario.** In this scenario, most revenue is directly recycled to lower payroll taxes, and to provide output subsidies to industry. Payroll taxes are reduced to 66% of their original rate at a \$100/t $CO_2$e price and to 45% of their original rate at a \$200/t $CO_2$e price. After this revenue recycling, net government revenue is relatively unchanged from business as usual. However, a portion of this revenue is earmarked to provide subsidies to renewable electricity generation and carbon capture and storage, meaning that remaining government revenue decreases somewhat in this scenario. This scenario is not considered a revenue neutral scheme for this reason.

TABLE 13

HYBRID Scenario: Sources of Government Revenue, Value of Tax Shifting, Recycling, and Subsidy, Billions of \$2003 in 2020

| CARBON PRICE (\$/T $CO_2$e) | PAYROLL TAX (% OF BAU) | OUTPUT SUBSIDY | NET REVENUE BILLIONS \$ | NET REVENUE % CHANGE | PORTION OF NET REVENUE FOR SUBSIDIES (BILLIONS \$) |
|---|---|---|---|---|---|
| BAU | 100% | \$0.0 | \$472.2 | - | \$0.0 |
| \$75 | 70% | \$21.0 | \$472.6 | - | \$7.4 |
| \$100 | 66% | \$24.7 | \$470.7 | -0.31% | \$8.6 |
| \$150 | 55% | \$32.9 | \$468.3 | -0.83% | \$11.5 |
| \$200 | 45% | \$40.7 | \$466.8 | -1.14% | \$14.2 |

**HYBRID-RES Scenario**. In this scenario, most of the revenue from carbon pricing is used to lower payroll taxes. Payroll taxes are reduced to 44% of their original rate at a \$100/t $CO_2$e price and to 12% of their original rate at a \$200/t $CO_2$e price. After reductions in the payroll tax, net government revenue is roughly the same as in the business as usual scenario. However, a significant portion of this revenue is earmarked for subsidies to residential energy efficiency and renewable electricity, meaning that remaining government revenue (for other programs) falls somewhat in this scenario. As a result, this scenario is not considered revenue neutral.

TABLE 14

HYBRID-RES Scenario: Sources of Government Revenue, Value of Tax Shifting, Recycling, and Subsidy, Billions of \$2003 in 2020

| CARBON PRICE (\$/T $CO_2$e) | PAYROLL TAX (% OF BAU) | NET REVENUE BILLIONS \$ | NET REVENUE % CHANGE | NET REVENUE FOR SUBSIDY TO RENEWABLES (BILLIONS \$) | NET REVENUE FOR SUBSIDY TO RESIDENTIAL EFFICIENCY (BILLIONS \$) |
|---|---|---|---|---|---|
| BAU | 100% | \$472.2 | - | \$0.0 | \$0.0 |
| \$75 | 53% | \$472.3 | - | \$3.6 | \$12.9 |
| \$100 | 44% | \$451.2 | -0.30% | \$4.3 | \$15.3 |
| \$150 | 28% | \$443.0 | -0.76% | \$5.6 | \$20.0 |
| \$200 | 12% | \$435.6 | -1.08% | \$6.9 | \$24.6 |

**LABOUR Scenario.** All revenue from the emission price is used to reduce labour taxes. Starting from an average rate of 22%, labour taxes fall to 13% at a \$100/t $CO_2$e price and to 9% at a \$200/t $CO_2$e price. As a result, the sum of the net revenue from the carbon tax and the personal income tax remains constant. However, reductions in other taxes collected depress overall government revenue somewhat.

TABLE 15
**LABOUR Scenario: Sources of Government Revenue and Tax Shift, Billions of \$2003 in 2020**

| CARBON PRICE ($/T $CO_2$e) | INCOME TAX RATE (AVERAGE) | INCOME TAX | NET REVENUE BILLIONS $ | % CHANGE |
|---|---|---|---|---|
| BAU | 22% | \$185.1 | \$472.2 | - |
| \$75 | 15% | \$128.7 | \$459.8 | -2.62% |
| \$100 | 13% | \$118.2 | \$456.0 | -3.43% |
| \$150 | 11% | \$95.9 | \$450.6 | -4.58% |
| \$200 | 9% | \$75.3 | \$446.6 | -5.43% |

**PAYROLL Scenario.** Payroll taxes throughout the economy are reduced proportionately. Like the previous cases, the revenue neutrality condition implies that the sum of the carbon price revenue and the payroll tax revenue remains constant. While the price ranges in the Table indicate overall tax collection falls slightly, at lower tax rates (\$25-50/t $CO_2$) this scenario slightly increases government revenue.

TABLE 16
**PAYROLL Scenario: Sources of Government Revenue and Tax Shift, Billions of \$2003 in 2020**

| CARBON PRICE ($/T $CO_2$e) | PAYROLL TAX (% OF BAU) | PAYROLL TAX | NET REVENUE BILLIONS $ | % CHANGE |
|---|---|---|---|---|
| \$0 | 100% | \$112.3 | \$472.2 | - |
| \$75 | 52% | \$59.8 | \$472.5 | 0.07% |
| \$100 | 43% | \$50.2 | \$470.8 | -0.30% |
| \$150 | 25% | \$40.5 | \$468.8 | -0.73% |
| \$200 | 7% | \$29.2 | \$467.3 | -1.03% |

Based on the analysis above, the OUTPUT and PAYROLL scenarios generally have the least impact on government revenue. The LABOUR and LUMPSUM scenarios have the largest impact on government revenue: roughly a 3% cut in overall revenues at a \$100/t $CO_2$e emission price. The two HYBRID scenarios leave overall government revenue unchanged, but require that a substantial portion of this revenue be directed towards subsidies to various technologies.

### FAIRNESS (DISTRIBUTION)

The fairness of a proposed tax measure relates to the distribution of the burden of the tax. According to the Budget Framework, it is generally considered fair that polluters pay a tax, and that firms and consumers willing to adopt environmentally friendly behaviour benefit from a tax incentive. However, the application of a substantial carbon price could be perceived to disproportionately impact particular individuals, regions, or sectors of the economy.

The modelling conducted here uses a sectorally disaggregated CGE model calibrated to a technologically detailed abatement model, so it provides a good picture of the cost to different sectors of transitioning towards the polluter pays principle. Because the model assumes perfect competition within each sector, a good indicator of the impact of the carbon price on firms is given by the change in output (revenue) attributable to the policy. Table 17 and Table 18 show the impact on gross output by sector of a \$100/t $CO_2$e and \$200/t $CO_2$e carbon price, respectively.

Impacts vary by sector. On aggregate, the energy extraction and transformation sectors could have output reduced by roughly 10% relative to the 2020 business as usual projection as a result of a substantial carbon price, with particularly dramatic reductions in the coal extraction sector (which is very small to begin with), and significant reductions in the crude oil, gas, and petroleum refining sectors, especially if global action on carbon reductions intensifies. In contrast, the electricity generation sector, which is already relatively clean in Canada (about 75% of Canada's electricity is generated from carbon-free sources of energy[43]) and which appears to have relatively cost-effective abatement opportunities for remaining emissions, is likely to experience substantial growth relative to the business as usual projection resulting from carbon pricing.

The energy intensive manufacturing sector is also likely to see revenues reduced if a carbon price is implemented. The model runs forecast that a substantial carbon price is likely to reduce industrial output by roughly 5-15% relative to the business as usual projection, depending on the level of price and how revenues from the price are used. In contrast, the light manufacturing sector and the rest of economy sector, which together represent almost 85% of Canada's industrial output, are likely to see revenues increase by a small amount as a result of carbon pricing. With output-based recycling, these sectors might see revenues increase by as much as 3.8% relative to the business as usual projection – a substantial increase given the size of these sectors. Of course, we have not modelled detailed sector impacts and these aggregate results could be quite different for a large and important sector like the automotive industry.

The model developed for this project is a nationally aggregated model and is, therefore, not well suited for studying the impacts on specific regions of the economy. However, several recent studies, which use a similar methodology as in this report (but with a provincially disaggregated model) report that the impacts on the economy are likely to be relatively similar in different provinces.[44]

**TABLE 17**

**Impact relative to business as usual projection on industrial output from \$100/t $CO_2$ price in 2020**

| | OIL | GAS | COAL | RPP | ELEC | EIM | OMAN | ROE | GROSS OUTPUT |
|---|---|---|---|---|---|---|---|---|---|
| LUMPSUM | -18.3% | -21.5% | -70.9% | -16.3% | 13.9% | -9.3% | 8.5% | -1.0% | -1.2% |
| LABOUR | -22.6% | -23.0% | -73.0% | -18.0% | 13.2% | -11.2% | 9.5% | -1.3% | -1.7% |
| PAYROLL | -20.8% | -20.0% | -73.2% | -17.4% | 15.2% | -10.7% | 8.5% | 1.5% | 0.2% |
| OUTPUT | -20.7% | -22.9% | -71.1% | -16.0% | 16.1% | -8.3% | 13.4% | 0.9% | 0.8% |
| HYBRID-RES | -18.5% | -22.8% | -75.9% | -17.8% | 8.3% | -9.0% | 8.0% | 1.5% | 0.2% |
| HYBRID | -20.8% | -21.7% | -74.0% | -17.0% | 15.5% | -9.8% | 10.5% | 1.2% | 0.4% |

**TABLE 18**

**Impact relative to business as usual projection on industrial output from \$200/t $CO_2$ price in 2020**

| | OIL | GAS | COAL | RPP | ELEC | EIM | OMAN | ROE | GROSS OUTPUT |
|---|---|---|---|---|---|---|---|---|---|
| LUMPSUM | -9.4% | -35.0% | -86.8% | -22.3% | 28.1% | -16.5% | 12.4% | -2.0% | -2.0% |
| LABOUR | -14.3% | -37.7% | -88.1% | -24.3% | 27.2% | -19.5% | 13.7% | -2.7% | -2.7% |
| PAYROLL | -10.8% | -34.0% | -87.8% | -23.2% | 30.5% | -18.8% | 12.0% | 1.9% | 0.5% |
| OUTPUT | -12.6% | -37.0% | -86.2% | -21.8% | 31.9% | -15.3% | 20.5% | 1.1% | 1.4% |
| HYBRID-RES | -9.8% | -37.3% | -93.9% | -25.0% | 18.2% | -16.2% | 11.6% | 2.0% | 0.4% |
| HYBRID | 4.6% | -35.7% | -90.4% | -21.3% | 30.6% | -18.3% | 13.3% | 1.4% | 0.7% |

Overall then, it appears that there will be some distributional impacts in industry associated with the implementation of a carbon price in Canada. These distributional impacts do not necessarily imply that the policy is unfair (based on the definition adopted in the Budget Framework), but do highlight the challenges in managing the transition towards broad-based carbon pricing in Canada.

The concept of fairness also relates to the impact of the policy on individuals and households. The model shows the impact of the policy on consumer welfare – an aggregate of the welfare gained from consuming goods and leisure.[45] Overall, it appears that the welfare impacts of the policy are likely to be relatively small – on the order of 0.5 to 1.5% reductions in welfare relative to the business as usual projection for all recycling schemes analyzed. From the analysis, it appears that using revenues from the carbon price to reduce labour taxes is likely to cause the least impact on overall consumer welfare, and that the HYBRID scenario is likely to have the largest impact on welfare.

**TABLE 19**
**Impact on Consumer Welfare in 2020 relative to the business as usual projection**

| RANK | SCENARIO | $100/T | $200/T |
|---|---|---|---|
| Best ↑ | LABOUR | -0.41% | -0.93% |
| | PAYROLL | -0.43% | -0.95% |
| | HYBRID | -0.45% | -0.99% |
| | HYBRID-RES | -0.45% | -1.02% |
| | OUTPUT | -0.49% | -1.03% |
| Worst ↓ | LUMPSUM | -0.60% | -1.24% |

The model developed here does not disaggregate households into categories (according to income, rural/urban, or otherwise). As a result, it is not possible to directly estimate the distributional impacts of the policy on households, which would help to reveal if the policy is regressive or progressive. Previous analysis (using a combination of modelling approaches) in Canada suggests that a carbon tax could be modestly regressive.[46] That analysis assumed lump sum transfer of tax revenues to households, and conducted no analysis around alternative recycling methods. It would be possible to design a revenue recycling scheme that would ensure that the overall impact of a carbon price would be progressive, especially given the large financial flows associated with carbon pricing.

## Sensitivity Analysis

Parameters in GEEM that capture the behaviour of firms and individuals are based on results from the CIMS model and on a survey of the literature (for the CGE parameters). Despite the empirical basis of parameter values, however, uncertainty remains about their true value, especially into the future. This section is an exploration of the sensitivity of the key model results reported above to uncertainty in the model parameters.

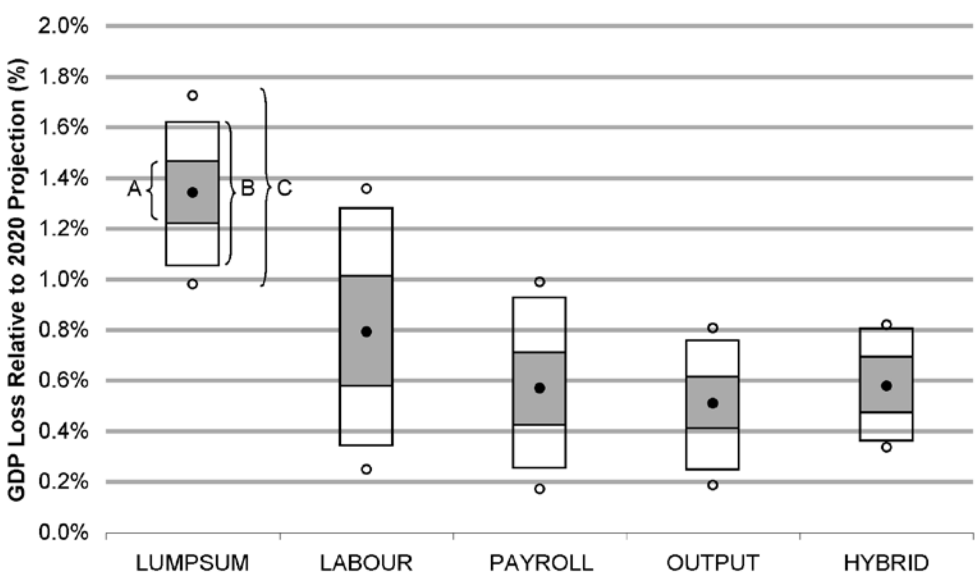
Because there are a significant number of uncertain parameters in GEEM, we use a Monte Carlo approach in conducting the sensitivity analysis. In this type of approach, a range of plausible values is selected for each parameter of interest.[47] Multiple runs of GEEM are then conducted. In each run, a value of each parameter is randomly selected from within the plausible range.[48] By analyzing the output from multiple runs, it is possible to understand the variability in outputs resulting from uncertainty in key parameters. For brevity, we report the uncertainty only in a few of the key output parameters.

### UNCERTAINTY IN GDP LOSS

Table 20 shows the uncertainty in the gross domestic product resulting from uncertainty in GEEM's parameter values. The open circles in the graph represent the full range of all the runs, while the shaded box represents the inter-quartile distribution (the range where 50% of all the runs fall), and the solid circle shows the mean. The open boxes represent the 95% confidence interval. Uncertainty in the distributions for all of the revenue recycling options is of roughly equal magnitude. Based on the Monte Carlo analysis, we can be fairly confident[49] that the GDP loss is within about ± 0.5 percentage points or less (depending on the policy) from the mean.

**TABLE 20**

**Monte Carlo results corresponding to the percentage loss in gross domestic product in 2020 resulting from a \$100/t $CO_2$e carbon tax**



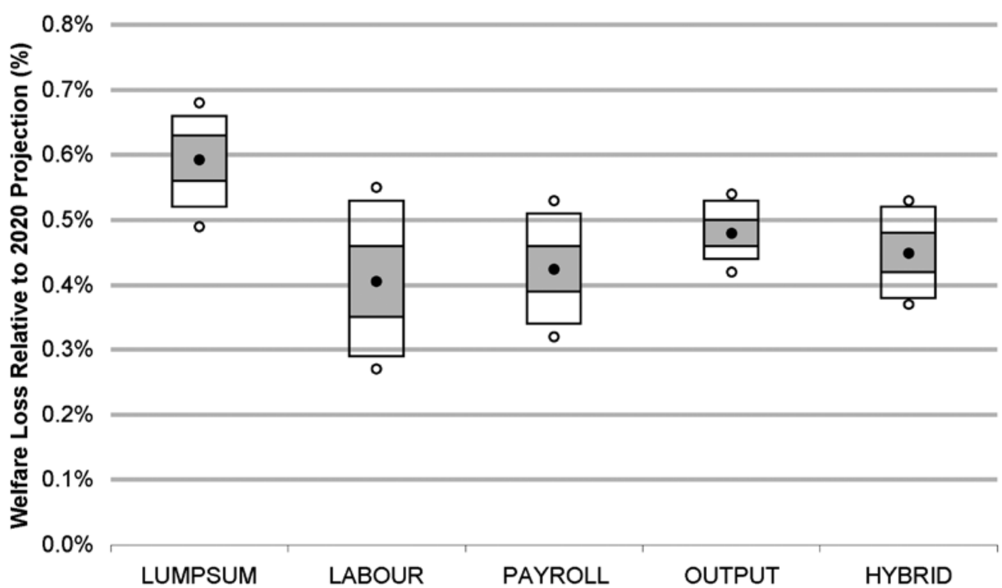

Note: The figure shows the uncertainty in GDP loss for each revenue recycling scheme at a \$100/t CO2e price in 2020. The solid black dot represents the mean estimate from all of the Monte Carlo runs. The shaded grey box, labelled A, represents the interquartile distribution – the zone where the middle 50% of all the runs fell. The outer box, labelled B, represents the 95% confidence interval (i.e, 95% of all the runs fell in this region). The open circles, which bound the region labelled C, represent the minimum and maximum.

Overall, the results of the Monte Carlo analysis reveal a similar message to the deterministic analysis described above. First, the analysis shows that a weak double dividend is likely. That is, recycling revenue raised during implementation of a carbon price by cutting other taxes is likely to cause less economic harm than recycling revenue in lump sum to households. In fact, the model runs show that the impact on GDP can be substantially reduced (by half or more) through appropriate recycling of revenue. Second, the Monte Carlo analysis suggests that a strong double dividend is unlikely. In other words, the application of a \$100/t $CO_2$e price is likely to reduce economic output in Canada. As described in section 2, this conclusion is generally supported by the existing literature on tax recycling.

### UNCERTAINTY IN WELFARE LOSS

Welfare is superior to gross domestic product as a measure of the societal impact of a policy since it includes the value individuals place on leisure as well as being a measure of aggregate economic output (and not just value added). Table 21 shows the same results as described above, but for welfare rather than gross domestic product. In no cases do any of the simulated policies result in welfare gains.[50] In other words, as for GDP, the welfare metric is fairly compelling in suggesting that a strong double dividend due to climate policy is unlikely. Like the results for GDP, the welfare results show that a weak double dividend is likely – the welfare loss when revenues from the carbon price are recycled in lump sum back to households are larger than when the revenues are used to cut other tax rates. In all cases, the welfare loss is relatively small.

**TABLE 21**
**Monte Carlo results corresponding to the percentage loss in welfare in 2020 resulting from a \$100/t $CO_2$e carbon price**




Note: See previous figure for description of how to interpret this boxplot.

A final source of uncertainty is the dynamic effects of year-over-year carbon pricing While we have captured the dynamic emission effects and technology effects through the use of CIMS, adding a dynamic element to the CGE model would allow other aspects of revenue recycling to be more fully investigated. This is an area for further research.

## Conclusion

The objective of this report was to assess the likely economic and environmental impacts of carbon pricing in Canada, and to determine how those impacts might be changed using alternative schemes for recycling the revenue that would be raised from carbon pricing. To that end, analysis was conducted using a technologically detailed and behaviourally realistic model of the Canadian economy coupled with a computable general equilibrium model.

This report explores several revenue recycling options that could be used in combination with an emissions price:

- Recycling to reduce personal income tax
- Recycling to reduce payroll taxes
- Recycling to subsidize economic output
- Recycling using lump sum rebates for households
- Recycling to subsidize low-emission technologies, subsidize economic output, and reduce payroll taxes
- Recycling to subsidize residential energy efficiency and renewable energy, and reduce payroll taxes

Using the two models mentioned above, each of these options was assessed based on how it might affect greenhouse gas emissions, economic growth, welfare, trade, and other key indicators. Table 22 is a summary of the key modelling results.

TABLE 22
**Summary of Key Indicators**

| | $100/T $CO_2$e EMISSION PRICE | | | $200/T $CO_2$e EMISSION PRICE | | |
|---|---|---|---|---|---|---|
| | EMISSIONS | GDP | WELFARE | EMISSIONS | GDP | WELFARE |
| Recycling using lump sum rebates to households | -27.73% | -1.34% | -0.60% | -40.35% | -2.42% | -1.24% |
| Recycling to reduce personal income tax | -28.02% | -0.74% | -0.41% | -40.19% | -1.46% | -0.93% |
| Recycling to reduce payroll taxes | -27.79% | -0.52% | -0.43% | -40.02% | -1.07% | -0.95% |
| Recycling to subsidize economic output | -27.56% | -0.47% | -0.49% | -39.64% | -0.95% | -1.03% |
| Recycling to subsidize low-emission technologies and economic output, and to reduce payroll taxes | -28.55% | -0.53% | -0.45% | -41.18% | -1.19% | -0.99% |
| Recycling to subsidize residential energy efficiency and renewables, and to reduce payroll taxes | -29.31% | -0.54% | -0.45% | -43.09% | -1.13% | -1.02% |

SEVERAL KEY INSIGHTS EMERGE FROM THE ANALYSIS:

- **Emissions can be substantially reduced using emissions prices.** The models used for this analysis suggest that it is possible to reduce emissions by roughly 20 percent below today's level by 2020 (the Government of Canada target) with the application of an emission price that rises to \$100/t $CO_2$e by 2020. Reaching the environmental non-governmental organization target of a 25% reduction below the 1990 level by 2020 would, in the absence of complimentary measures, likely require an emissions price reaching over \$200/t $CO_2$e by 2020. The method used to recycle carbon price revenues back into the economy does not have a significant impact on emissions reductions.

- **Overall economic impact of a high carbon price is likely to be around 1 percent of GDP.** The models show that application of a \$100/t $CO_2e$ emissions price would likely lower gross domestic product by 0.5 to 1.3% in 2020. At historic growth rates, this corresponds to less than one year of delayed economic growth (i.e., the economy would reach a given size in 2021 rather than in 2020). In terms of total GDP, instead of a GDP of \$1,798 billion in 2020 (the reference forecast, in \$2003), with a \$100/t $CO_2e$ emission price, the economy is likely to instead grow to between \$1,775 and \$1,789 billion. The economic cost of a \$200/t $CO_2e$ price is likely to be greater; the model predicts losses of economic output of 1.0 to 2.4% in this case.
- **The sectoral implications are not uniform and could be significant for some.** While the aggregate impacts of emission pricing are not large, sector and perhaps regional impacts would be more acute. Some sectors like electricity could benefit whereas other such as coal would see a large drop in demand, especially at higher emission prices. Revenue recycling schemes could be designed to partially alleviate these sectoral impacts. Output based recycling is one such approach assessed in this report.
- **Recycling and tax shifting can produce a weak double dividend.** The economic impact of carbon pricing with recycling of revenue to cut other taxes or to subsidize output is likely to be less than carbon pricing with lump sum recycling of tax revenues to households. In particular, tax shifting to reduce personal income taxes or payroll taxes can reduce the GDP loss of emission pricing by more than half (compared to lump sum recycling). Similarly, recycling to firms based on their output, while maintaining the integrity of the carbon price, can reduce the GDP cost by more than half.
- **Recycling and tax shifting is unlikely to produce a strong double dividend.** The results of the model show that even with well-designed tax shifting and revenue recycling, a carbon price is likely to dampen economic output somewhat in Canada. None of the scenarios examined here show a strong double dividend, suggesting that the current tax system is more efficient at raising revenue than one including a carbon tax. A carbon price of some level is still likely to improve overall welfare, since it would help to address the environmental externality associated with carbon emissions.
- **A hybrid option can be designed to address multiple policy needs.** While ensuring robust economic growth is an important priority for government, it is by no means the only one; policies are designed to address a range of criteria. The analysis conducted here suggests that some policies with good economic performance may not perform as well on other criteria (e.g., the output-based recycling policy). Using a hybrid option would allow government some leeway in tailoring the effects of the policy to meet multiple criteria. One example examined here was the use of subsidies for energy efficiency and low-carbon energy. Many other examples are possible that could address specific environmental issues, or issues relating to income distribution or regional or sectoral impacts.

Issues surrounding carbon pricing and revenue recycling are significant and complex. This report helps to build on existing literature, but should be recognized as an incremental addition to existing literature, not a definitive conclusion. Much more analysis and research needs to be conducted to understand in detail the likely effects of carbon pricing and revenue recycling in Canada. This report, therefore, is a starting point for opening such a dialogue.

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# APPENDIX A
# Model Descriptions

## CIMS

The CIMS model, developed by the Energy and Materials Research Group at Simon Fraser University and by MK Jaccard and Associates, simulates the technological evolution of fixed capital stocks (such as buildings, vehicles, and equipment) and the resulting effect on costs, energy use, emissions, and other material flows.[51] The stock of capital is tracked in terms of energy service provided ($m^2$ of lighting or space heating) or units of physical product (metric tons of market pulp or steel). New capital stocks are acquired as a result of time-dependent retirement of existing stocks and growth in stock demand (CIMS is characterized as a putty-semi-putty model). Market shares of technologies competing to meet new stock demands are determined by standard financial factors as well as behavioural parameters from empirical research on consumer and business technology preferences.[52] CIMS has three modules – energy supply, energy demand, and macro-economy – which can be simulated as an integrated model or individually. A model simulation comprises the following basic steps:

1. A base-case macroeconomic forecast initiates model runs. The macroeconomic forecast is at a sectoral or sub-sectoral level (for example, it estimates the growth in total passenger travel demand or in airline passenger travel demand). The macroeconomic forecast adopted for this study is described in detail in the following section.
2. In each time period, some portion of existing capital stock is retired according to stock lifespan data. Retirement is time-dependent, but sectoral decline can also trigger retirement of some stocks before the end of their natural life spans. The output of the remaining capital stocks is subtracted from the forecast energy service or product demand to determine the demand for new stocks in each time period.
3. Prospective technologies compete for new capital stock requirements based on financial considerations (capital cost, operating cost), technological considerations (fuel consumption, lifespan), and consumer preferences (perception of risk, status, comfort), as revealed by behavioural-preference research. The model allows both firms and individuals to project future energy and carbon prices with imperfect foresight when choosing between new technologies (somewhere between total myopia and perfect foresight about the future). Market shares are a probabilistic consequence of these various attributes.
4. A competition also occurs to determine whether technologies will be retrofitted or prematurely retired. This is based on the same type of considerations as the competition for new technologies.
5. The model iterates between the macro economy, energy supply and energy demand modules in each time period until equilibrium is attained, meaning that energy prices, energy demand and product demand are no longer adjusting to changes in each other. Once the final stocks are determined, the model sums energy use, changes in costs, emissions, capital stocks and other relevant outputs.

The key market-share competition in CIMS can be modified by various features depending on the evidence about factors that influence technology choices. Technologies can be included or excluded at different time periods. Minimum and maximum market shares can be set. The financial costs of new technologies can decline as a function of market penetration, reflecting economies of learning and economies of scale. Intangible factors in consumer preferences for new technologies can change to reflect growing familiarity and lower risks as a function of market penetration. Output levels of technologies can be linked to reflect complementarities.

Personal mobility provides an example of CIMS' operation. The future demand for personal mobility is forecast for a simulation of, say, 30 years and provided to the energy demand module.

After the first five years, existing stocks of personal vehicles are retired because of age. The difference between forecast demand for personal mobility and the remaining vehicle stocks to provide it determines the need for new stocks. Competition among alternative vehicle types (high and low efficiency gasoline, natural gas, electric, gasoline-electric hybrid, and eventually hydrogen fuel-cell) and even among alternative mobility modes (single occupancy vehicle, high occupancy vehicle, public transit, cycling and walking) determines technology market shares. The results from personal mobility and all other energy services determine the demand for fuels. Simulation of the energy supply module, in a similar manner, determines new energy prices, which are sent back to the energy demand module. The new prices may cause significant changes in the technology competitions. The models iterate until quantity and price changes are minimal, and then pass this information to the macro-economic module. A change from energy supply and demand in the cost of providing personal mobility may change the demand for personal mobility. This information will be passed back to the energy demand module, replacing the initial forecast for personal mobility demand. Only when the model has achieved minimal changes in quantities and prices does it stop iterating, and then move on to the next five-year time period.

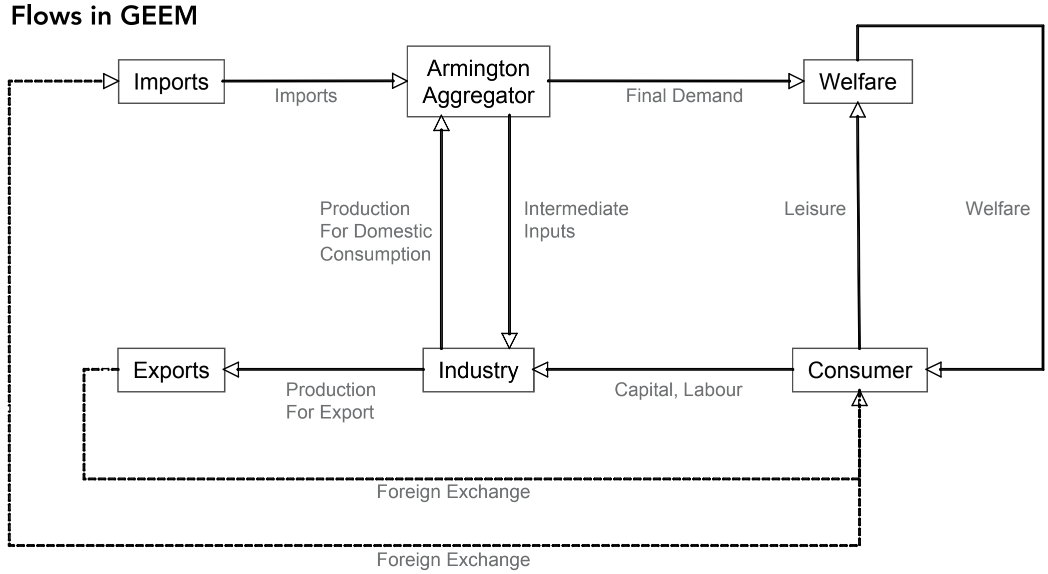
## GEEM

GEEM (Canadian General Equilibrium and Emissions Model) is a simple static computable general equilibrium model of the Canadian economy. It contains a household (representative agent or consumer) sector and eight representative industrial sectors:

- Crude oil extraction [OIL]
- Natural gas extraction and transmission [GAS]
- Coal extraction [COAL]
- Petroleum refining [RPP]
- Electricity generation [ELEC]
- Energy intensive manufacturing [EIM]
- Other manufacturing [OMAN]
- Rest of economy [ROE]

The figure below shows the relationship between the consumer, industry, and the rest of the world as modelled in GEEM.

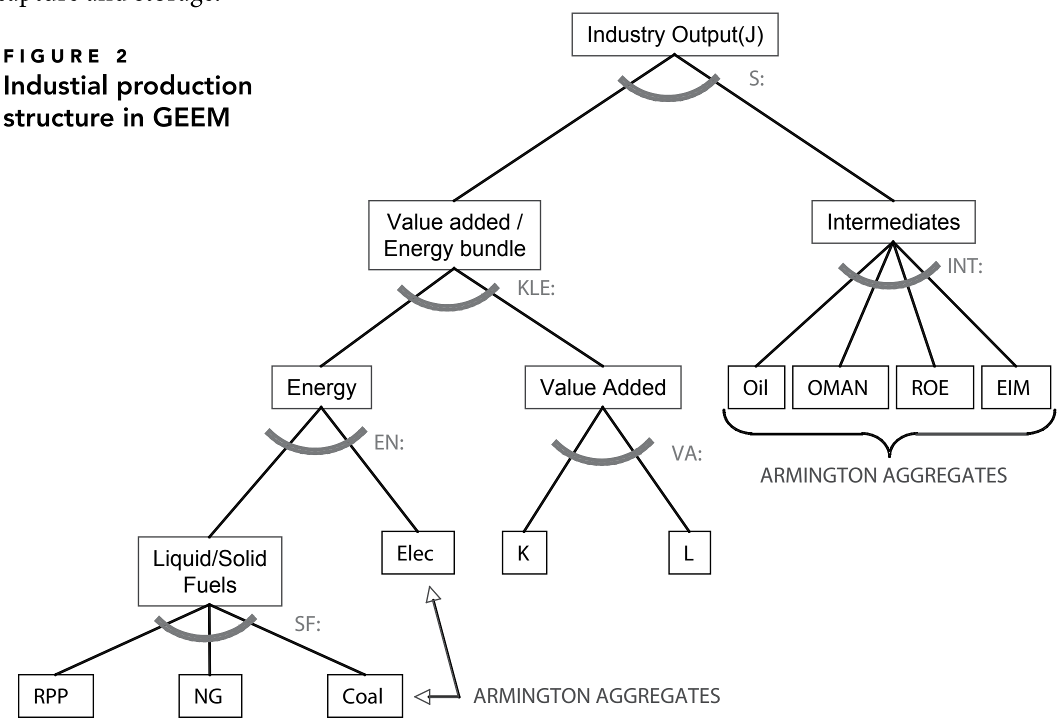
**FIGURE 1**
**Flows in GEEM**



Industrial sectors are assumed to be perfectly competitive (with no excess rents) and produce output from inputs of capital, labour, and intermediate inputs (including energy inputs). As shown the figure, in each industrial sector, natural gas, coal, and petroleum products substitute for one another at a defined rate (depending on their price), while electricity is considered a substitute for the bundle of other energy sources. The capital/labour aggregate is considered a substitute for the energy aggregate and this aggregate is combined with inputs of other goods and services to make total industrial output, which can be either exported or used for domestic consumption. The elasticities of substitution between inputs (the green letters in the figure below) are based on CIMS where possible, and on empirical research otherwise. Elasticities are discussed further later in this section.

Several additional sectors are included to capture alternative technologies that do not exist in the benchmark data set, or which could change dramatically in response to a substantial carbon price. In particular, separate sectors are defined for alternative renewable electricity technologies (not including large hydro, which is included in the base electricity generation sector), for electricity generation with carbon capture and storage, and for crude oil extraction with carbon capture and storage.

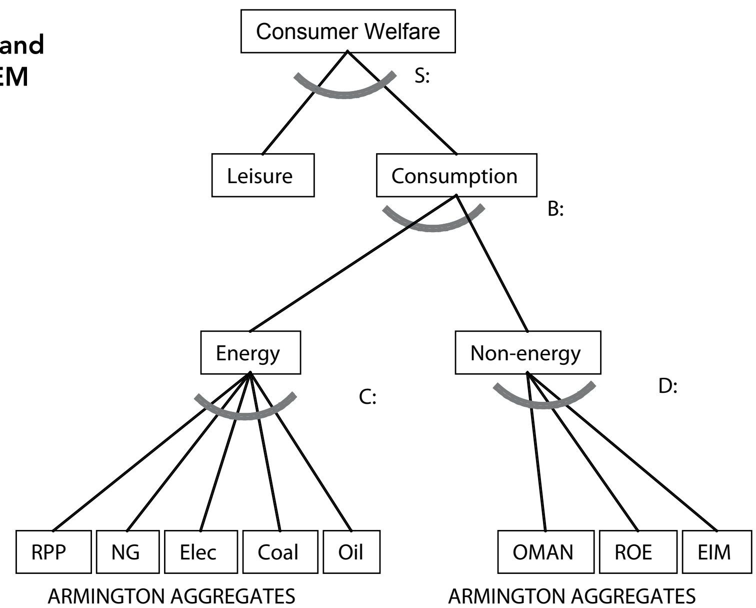
**FIGURE 2**
**Industial production structure in GEEM**




The representative household is assumed to maximize utility subject to a budget constraint by consuming goods from industry as well as leisure. As shown in Figure 3 below, GEEM differentiates between consumption of non-energy goods and energy goods to more accurately capture response to changes in energy prices resulting from carbon policies.

Trade with other countries is modelled using an Armington formulation for demand and a constant elasticity of transformation function for industrial output. GEEM also includes alternative technologies for production of electricity (new renewable electricity generation and electricity generation using fossil fuels with carbon capture and storage) as well as an alternative technology for producing crude oil (crude oil with carbon capture and storage). All production and demand functions in GEEM assume constant elasticity of substitution between alternative inputs according to the nesting structure described here.

**FIGURE 3**
**Household demand structure in GEEM**




## ELASTICITIES OF SUBSTITUTION IN GEEM

The response of GEEM is dependent on the values adopted to characterize consumer and firm response to changing relative prices. Where possible, we based elasticities in GEEM on CIMS.[53] In other cases, elasticities are based on published literature. A summary of the key elasticity values used in GEEM is shown in Table 1 below.

**TABLE 1**
**Elasticities of Substitution**

| ELASTICITY | VALUE | SOURCE |
|---|---|---|
| **Industrial Production** | | |
| Between coal, gas, and petroleum products | 1.15 | CIMS |
| Between fuels and electricity | 0.66 | CIMS |
| Between capital and labour | 0.01-0.06[a] | Calibrated to CIMS |
| Between capital/labour and energy | 0.05-0.4[b] | CIMS |
| Between intermediate inputs | 0.53 | Dissou, 2005; Wigle, 2007; Babiker et. al. 2003 |
| Between capita/labour/energy and intermediates | 0.2 | |
| **Consumer Demand** | | |
| Between energy goods | 0.5 | Dissou, 2005 ; Wigle, 2007; Babiker et. al. 2003 |
| Between other goods | 0.95 | Dissou, 2005 ; Wigle, 2007 ; Babiker et. al. 2003 ; Kallbekken, 2004 |
| Between energy and non-energy goods | 0.3 | CIMS |
| Between consumption and leisure | 0.5 | McKitrick, 1999; Wigle, 2007; Babiker et. al., 2003 |
| **Exports and Imports** | | |
| Between domestic production and exports | 1[c] | Dissou, 2005; Wigle, 2007 |
| Between domestic production and imports | 2.52 | Babiker et. al., 2003; Wigle, 2007; Corrack, 1998; Dissou, 2005; Kallbekken, 2004 |

Note: [a] capital for labour substitutability differs by sector: OIL 0.027, GAS 0.05, COAL 0, RPP .05, ELEC 0.023, EIM .5, OMAN 0.5, ROE 0.5

[b] capital/labour for energy substitutability differs by sector: OIL 0.2, GAS 0, COAL 0, RPP 0, ELEC .2, EIM

[c] the elasticity of substitution between domestic production and exports was chosen to be at the low end of the estimates surveyed, to reflect the fact that trading partners will also be developing climate policies

GEEM is a calibrated model, initially based on the 2003 M-Level input output tables produced by Statistics Canada. A social accounting matrix (SAM) was developed from these tables and aggregated to the level described above. The SAM was updated to 2020 based on sectoral growth rate forecasts developed by Informetrica.

### CALIBRATION WITH MACROECONOMIC FORECASTS

After updating the social accounting matrix to 2020 in terms of both sector and total economy growth in gross output, the model corresponded closely to other forecasts for GDP and gross output in 2020. We conclude that GEEM is calibrated at the national level closely to recent macroeconomic forecasts.[54] Table 2 indicates that GEEM is calibrated for national GDP and gross output to within 5% of other forecasts for 2020.

**TABLE 2**
**Calibration of GEEM to Macroeconomic Forecasts**

| | GDP IN 2020 (BILLION 2003$) | | GROSS OUTPUT IN 2020 (BILLION 2003$) | |
|---|---|---|---|---|
| GEEM | $1,798 | | $3,589 | |
| CEO, 2006 | $1,754 | 2% lower than GEEM | $3,395 | 5% lower than GEEM |
| Informetrica July 04, 2006 | $1,749 | 3% lower than GGEM | 3,446 | 4% lower than GEEM |

Table 3 indicates that GEEM matches reasonably closely to another well-known macroeconomic forecast for 2020 at a sectoral level. Most of the difference in results is due to a slightly different aggregation of sectors in different forecasts.

**TABLE 3**
**Calibration of GEEM to Informetrica, July 2006 Forecast (billion 2003$)**

| | INFORMETRICA | GEEM | CALIBRATION |
|---|---|---|---|
| Oil , Gas and Coal | $161.9 | $159.2 | -2% |
| RPP | $78.3 | $72.7 | -8% |
| ELEC | $52.3 | $51.5 | -2% |
| EIM | $275.2 | $314.6 | +13% |
| OMAN | $532.7 | $585.1 | +9% |
| ROE | $2,345.3 | $2,406.4 | +3% |

### BUSINESS-AS-USUAL EMISSIONS CALIBRATION AND ABATEMENT RESPONSES

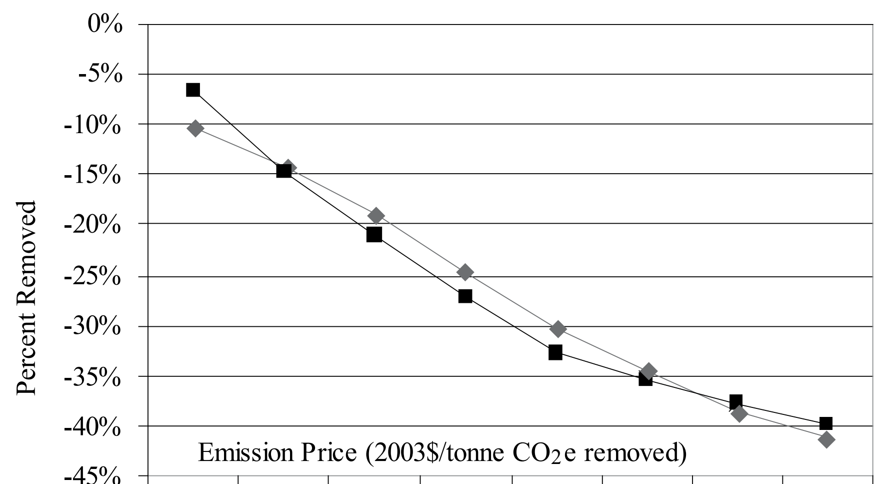
Business-as-usual energy consumption in GEEM is based on NRCAN's 2006 Energy Outlook, which also corresponds closely to business-as-usual energy consumption from a recent analysis using CIMS.[55] Emissions from energy consumption are calculated based on the carbon content of fossil fuels, which are calculated using data from NRCAN.[56] Emissions from non-combustion activities are based on Environment Canada's 2006 Greenhouse Gas Inventory. In total, business-as-usual emissions of greenhouse gases in GEEM in 2020 are 865 Mt $CO_2$e. This total is close to business as usual forecasts from both CIMS and NRCan.

GHG abatement in the model occurs through energy efficiency, fuel switching (including to non-emitting electric power generation), carbon capture and storage, and output reductions. At the national level, abatement response in GEEM is calibrated closely with CIMS across a wide range of emission prices (see Figure 4 below). In addition to the overall emissions calibration, the penetration of renewable electricity and carbon capture and storage in GEEM also matches closely with the forecasts generated in CIMS for a range of emissions prices.

Emission abatement response in GEEM closely replicates CIMS at a sectoral level as well as at an aggregate level. The abatement response of households, the energy intensive industries, electricity generation, and upstream oil and gas extraction match closely to CIMS over a wide range of emissions prices. For the remaining sectors, GEEM differs slightly from CIMS because of non-linearities in CIMS which cannot be perfectly replicated using the constant elasticity of substitution formulation in GEEM. The one exception is petroleum refining, where the emissions abatement profile differs due to the inclusion of significant amount of cogeneration in CIMS that was not included in GEEM. Still, GEEM shows results that are directionally appropriate and consistent with expectations about emission responses in the petroleum refining sector.

**FIGURE 4**

**Calibration of GEEM with CIMS for 2020**




| | $25 | $50 | $75 | $100 | $125 | $150 | $175 | $200 |
|---|---|---|---|---|---|---|---|---|
| CIMS Total Reductions | -10% | -14% | -19% | -25% | -30% | -35% | -38% | -41% |
| C-GEEM Total Reductions | -7% | -15% | -21% | -27% | -33% | -35% | -38% | -40% |

## NOTES

1 The U.N. Intergovernmental Panel on Climate Change has stated that, "[T]he consistency between observed and modelled changes in several studies and the spatial agreement between significant regional warming and consistent impacts at the global scale is sufficient to conclude with high confidence that anthropogenic warming over the last three decades has had a discernible influence on many physical and biological systems." IPCC, 2007: Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, et al., Cambridge University Press, Cambridge, UK, 7-22

2 M. Jaccard, N. Rivers. "Canadian Policies for Deep Greenhouse Gas Reductions", Institute for Research on Public Policy, A Canadian Priorities Agenda (Montreal, 2007); D. Drummond, "Market-Based Solutions to Protect the Environment", TD Bank Financial Group (Toronto, 2007); J. Simpson, M. Jaccard, N. Rivers, Hot Air: Meeting Canada's Climate Change Challenge (Toronto: McClelland & Stewart, 2007)

3 M. Baylor, L. Beausejour, "Taxation and Economic Efficiency: Results from a Canadian CGE Model", Finance Canada Working Paper (Ottawa: Finance Canada, 2004)

4 National Round Table on the Environment and the Economy, Getting to 2050: Canada's Transition to Low Emission Future, (Ottawa: NRTEE, 2008)

5 See for example, T. Corcoran, "Carbon tax looks like roadkill", Financial Post, January 2, 2008

6 Canadian Council of Chief Executives, "CCCE Welcomes National Round Table Report on Reducing Emissions of Greenhouse Gases", January 7, 2008; Canadian Association of Petroleum Producers, "The Canadian Approach to Industry GHG Policy, http://www.capp.ca/raw.asp?x=1&dt=PDF&dn=119902; The Strategic Counsel, "Economy, Leader Positives/negatives, Afghanistan, Carbon Tax", poll released January 14, 2008

7 Other important issues with carbon pricing are not dealt with in this paper. Indeed, we do not address important design elements such as a differentiated incidence of the carbon price (either directly through a differentiated tax or indirectly through allocations) or the flexibility mechanisms allowed, such as price caps for cost containment. Instead, the paper is focused primarily on the implications of revenue recycling and tax shifting.

8 In this report, we use the terms 'carbon pricing' and 'greenhouse gas pricing' interchangeably, even though carbon emissions make up only about 80 percent of Canada's greenhouse gas emissions. Both are assumed to cover all sources of greenhouse gas emissions, including non-carbon emissions.

9 Prominent examples of economists supporting carbon pricing include Greg Mankiw, Harvard professor and former chair of President Bush's Council of Economic Advisors; Paul Volcker, former chairman of the US Federal Reserve; Don Drummond, Chief Economist of TD Bank.

10 Named for economist Arthur Pigou, who introduced the concept in the 1920s.

11 For the double dividend hypothesis to hold, a carbon price would have to supplant a tax that is more distortionary to the economy than the carbon price. Economists measure the level of distortion of different taxes using a measure called the 'marginal excess burden', which shows the cost to the economy of raising a unit of revenue using a given tax. If the marginal excess burden of a carbon price is lower than another tax in the economy, potential for a double dividend exists. See Baylor and Beausejour (2004) for estimates of the marginal excess burden of taxation in the Canadian economy.

12 See Goulder (1995).

13 Almost all models used for analysis of the double dividend hypothesis are general equilibrium models. For examples of theoretical general equilibrium models, see for example Bovenberg and De Mooij (1994). For examples of numerical general equilibrium models, see for example Kuper (1996) and Babiker, Metcalf, and Reilly (2003).

14 Theoretical models are by necessity much-simplified versions of the real world, but their simplicity allows for more rigorous proofs of concepts.

15 See Bovenberg and De Mooij (1994), Goulder (1996), and Chiroleu-Assouline and Fodha (2006).

16 Sanstad and Wolff (2000) focus in particular on the assumed form of the consumer utility function, and describe how alternative utility functions can lead to divergent results on the existence of a strong double dividend.

17 See Goulder (1995) and Bovenberg (1999) for example. An emerging consensus is also forming that under most (but not all) circumstances, a weak double dividend is likely.

18 For numerical models that suggest a strong double dividend, see Edwards and Hutton (2001), Parry and Bento (2000), or Bento and Jacobsen (2007). For examples that suggest a weak double dividend but not a strong double dividend, see Kuper (1996). For examples that suggests the absence of even a weak double dividend in certain circumstances (especially European countries with high rates of pre-existing taxes on energy), see Babiker, Metcalf, and Reilly (2003) or Bovenberg and Goulder (1997).

19 See McKitrick (1999), which is based on a computable general equilibrium model that uses short-run elasticities econometrically estimated from Canadian data.

20 Dissou (2005) reports that a strong double dividend is unlikely using performance-standards for various industrial sectors in Canada.
21 Baylor and Beauséjour (2004).
22 Including a full suite of alternative technologies in all sectors in a CGE model is problematic because of computational limits and difficulties with finding an optimal solution with a large amount of discontinuities.
23 For a full discussion of top-down and bottom-up energy economy models, see Jaccard (2005) or Bohringer (1998).
24 A more complete description of CIMS is available in Bataille et al., (2006) and Rivers and Jaccard (2006).
25 See NRTEE (2007).
26 So that the results were conservative, parameters governing international trade were cut in half from normal estimates, but were not set to zero (which would imply exactly the same policies in other countries).
27 See NRTEE (2007).
28 Although the optimal emission price path was based on GDP calculations from the CIMS model, all other GDP calculations in this report are based on the GEEM model.
29 Unless otherwise specified, all dollar values in this report refer to constant 2003 Canadian dollars.
30 We do not assess a reduction in the consumption tax like the GST or provincial sales taxes, since economic theory is reasonably clear that consumption taxes are relatively efficient (e.g., Baylor and Beausejour, 2004).
31 This type of system is similar to the output-based allocation systems described in Dissou (2005) and Fischer (2001).
32 To model this subsidy, 25% of the carbon revenue is returned lumpsum to households and the emission response of households is changed from the base case to reflect the targeted subsidy. Practically, this meant that in GEEM we changed the household's elasticity of substitution between energy types (ESUB_ENER in Appendix A) and between goods and energy (ESUB_EG). These elasticities we altered so that the emission response in GEEM calibrates to how CIMS responds at various carbon prices with and without the incremental subsidy in the residential sector. Returning the subsidy lumpsum to the household and altering the emission response results in more expenditures on emissions abatement relative to all other goods while triggering emission reductions consistent with CIMS.
33 The distorting effects of investment and capital taxes can only be modelled realistically in an inter-temporal dynamic CGE model, which was beyond the scope of this analysis.
34 See Baylor (2005).
35 See Baylor and Louis Beauséjour (2004).
36 Government of Canada, 2005, Budget 2005 - Budget Plan, Annex 4. A Framework for Evaluation of Environmental Tax Proposals. http://www.fin.gc.ca/budget05/bp/bpa4e.htm
37 Unlike other taxes, which do not address an externality and therefore distort economic activity, an emission price can improve overall welfare even as it reduces economic activity since un-priced externalities represent a market failure.
38 See NRTEE (2007), Table 4, or Stern (2006), p. 242.
39 Like most other models of this type, GEEM holds Canada's overall balance of trade fixed in the analysis, and allows imports and exports of individual commodities to fluctuate subject to this constraint.
40 As described earlier, the concept of narrow fiscal neutrality adopted in this report is specific to a particular tax flow, not to overall government revenue. Thus, if the revenue from a carbon tax is used to lower labour taxes in a revenue-neutral manner, the labour tax is endogenously set at a rate where the sum of the revenue from the endogenous labour tax and the carbon tax equals the labour tax revenue in the benchmark data set. However, because of feedbacks throughout the economy, other tax revenues may change (for example, if consumption decreases, then the consumption tax revenue would decrease).
41 Municipal property taxes are not included in the analysis.
42 The total size of government will be bigger, because it will include municipal and local governments, which are not included in GEEM. Some sources of government revenue, including direct sales of goods and services and certain taxes (notably on investment) are not included in GEEM.
43 Statistics Canada, 2005, Report on Energy Supply-Demand in Canada, 1990-2004, Ottawa, October 2005.
44 Snoddon, T. and R. Wigle (2007a; 2007b) show that although Alberta and Saskatchewan have significantly higher per capita emissions than other provinces, they also have access to low-cost emissions abatement (primarily because of opportunities for emissions reductions in the electricity and oil and gas sectors). AMG (2000) uses several model types to reach a similar conclusion.
45 The welfare gain from improvement in environmental quality is not included here.

46 See Hamilton and Cameron (1994). The simulations show that the absolute reductions in consumable income would be roughly 5 times as large for high-income households compared to low-income households (suggesting that the policy would be progressive), but that relative reductions would be modestly larger in low income families (suggesting that the policy would be modestly regressive).

47 In the analysis conducted here, each elasticity parameter was assigned a range corresponding to upper and lower bounds of estimates in the literature (see Appendix). We assumed a uniform distribution for all parameters.

48 Draws from different parameters are independent of one another, and draws of parameters in one run are independent of draws in another run. In the analysis conducted, a uniform distribution was assumed for each parameter of interest. Morgan and Henrion (1992) describe the method used. It is important to note that we only examine the uncertainty in the model resulting from incorrect parameter specification, not incorrect model structure.

49 In 19 out of 20 model runs (95%), the GDP loss fell within ± 0.5 percentage points or less from the mean. Statisticians normally denote confidence using 95% confidence intervals.

50 Note that welfare in this context does not include the welfare gain from reduced greenhouse gas emissions, nor does it include any other environmental co-benefits (such as improved local air quality) that might occur with a substantial carbon price.

51 A more complete description of CIMS is available in Bataille et al., (2006) and Rivers and Jaccard (2006).

52 Empirical research includes both revealed preferences from historical market behaviour and stated preferences for new technologies under future conditions of carbon-pricing driven fuel price changes.

53 The process used to estimate elasticities of substitution from pseudo-data generated from CIMS is described in Bataille et al. (2006).

54 Natural Resources Canada, 2006, Canada's Energy Outlook 2006; Informetrica, July, 04, 2006.

55 NRTEE, 2007

56 See NRCan (2006).

There is widespread agreement among many quarters of Canadian society that the introduction of a strong and consistent carbon price, across the entire economy, is necessary if Canada is to reduce its greenhouse gas emissions.

*Pricing Carbon: Saving Green – A Carbon Price to Lower Emissions, Taxes and Barriers to Green Technology* offers solutions to government for reducing greenhouse gas emissions while maintaining a robust economy.

This report, prepared for the David Suzuki Foundation by **M. K. Jaccard and Associates** and **EnviroEconomics**, examines a number of carbon pricing scenarios and establishes several revenue use options for Canada that would protect our environment and safeguard Canada's economy.

This report is available online at **www.davidsuzuki.org**.

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