Technical Backgrounder:

Modelling Conducted for Made-in-Manitoba Climate and Green Plan

Extensive modelling was conducted to provide estimates of greenhouse gas (GHG) emissions reductions emanating from a wide series of scenarios. This was done to consider the impacts – GHG, economic, and financial – from the application of various carbon prices across various categories of emissions. Its purpose was to inform government's policy choices and compare impacts across different scenarios.

The goal of the government's analysis was to choose the most effective policy mix to achieve **the most emission reductions at the least economic cost**.

What is Carbon Pricing?

Carbon pricing is the application of a price to a specific amount of carbon pollution – typically one tonne of carbon dioxide (CO_2) emitted. The application of a price to emitted carbon gives it value. It causes emitters to adjust behaviour and to maximize the value to them by reducing their carbon costs.

The World Bank defines it this way:

> *"Carbon pricing is an instrument that captures the external costs of greenhouse gas (GHG) emissions—the costs of emissions that the public pays for, such as damage to crops, health care costs from heat waves and droughts, and loss of property from flooding and sea level rise—and ties them to their sources through a price, usually in the form of a price on the carbon dioxide (CO_2) emitted.*

A federal/provincial/territorial working group report on carbon pricing prepared for First Ministers stated it this way:

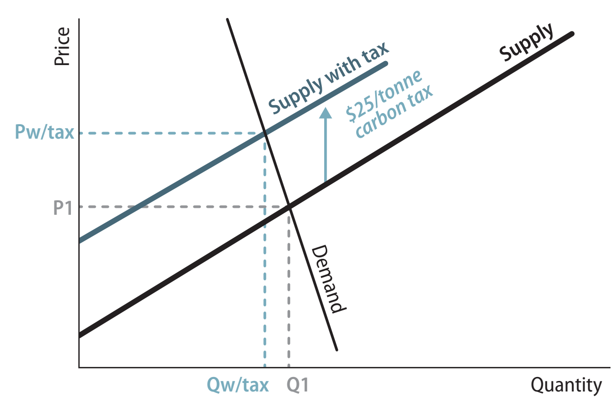
> *The main goal of carbon pricing is to reduce emissions by sending a price signal to the economy as a whole and to various economic actors, in particular, to reduce emissions. By internalizing a carbon price in their daily decision-making, this kind of signal incentivizes companies, investors and consumers to change their behaviour. Carbon pricing thus creates economic incentives for economic agents to make more environmentally sustainable strategic choices, to redirect their investments, and to reduce their emissions as well as their carbon footprint, notably by substituting carbon-intensive goods (such as fossil fuels), for goods that have a lower or no carbon content.*

How Does Carbon Pricing Work?

Carbon pricing works by assigning an economic value to fossil fuels. Fossil fuels are a commodity, and like most commodities, raising the price of fossil fuels encourages households and businesses to consume less of them, as long as viable alternatives are available that can be accessed in a cost-effective way. It is a market-based instrument that can reduce carbon emissions.

The figure below provides an illustrative example of the changes in the demand and supply of fossil fuels after a carbon tax is introduced. As fossil fuel prices increase from P1 to Pw/tax, the quantity of fossil fuels demanded and supplied drops from Q1 to Qt. The end result is less carbon emissions in the atmosphere.

FIGURE 1: Fossil Fuel Energy Supply and Demand with a Carbon Tax



Canada's EcoFiscal Commission explains and illustrates how a carbon price signal works in a provincial economy this way:

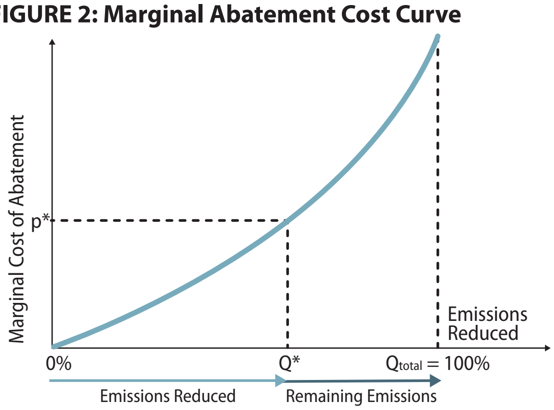
> *"A higher carbon price creates a greater incentive to reduce GHG emissions. If households or businesses can avoid paying the price on emissions—for example,*

Manitoba

by purchasing more energy-efficient equipment, or switching from coal to natural gas or from natural gas to electricity—they will tend to do so, as long as the cost of these actions is less than the amount they would pay for the emissions that would otherwise occur."

Figure 2 (below) shows a marginal abatement cost curve, a smooth line that approximates the increasing costs of potential abatement opportunities across various sectors of the provincial economy. The marginal cost is the cost of reducing one more tonne of emissions, often called incremental cost. Marginal cost increases with deeper reductions: early reductions tend to be relatively easy and therefore inexpensive, but additional, deeper reductions require increasingly expensive investments.

FIGURE 2: Marginal Abatement Cost Curve



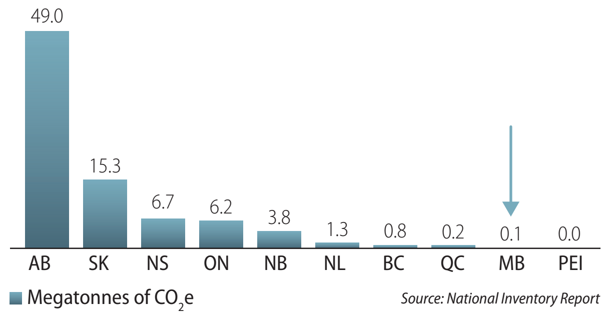
It is not just the current carbon price that matters. Emitter's expectations regarding the future price drive innovation and the developement of new technologies and processes that reduce emissions.

The Manitoba Context

The application of carbon pricing within Manitoba needs to be considered within the province's unique energy and emissions profile, along with the composition of its economy. Manitoba has two unique features that will affect the effectiveness of high or more stringent carbon prices compared to other jurisdictions.

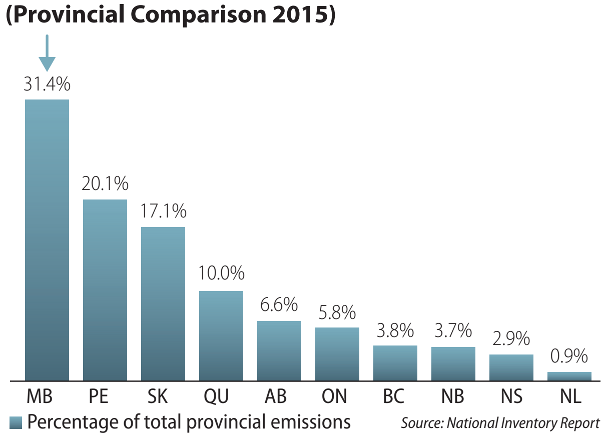
First, Manitoba's electricity grid is already clean as the figure below shows. Few emissions reductions can come from this sector, unlike most other provinces. That means it will require higher marginal carbon pricing rates to achieve emissions reductions elsewhere, as noted by EcoFiscal Canada above.

FIGURE 3: GHG Emissions from Electricity Generation (Provincial Comparison 2015)



Second, Manitoba has the highest proportion of agricultural emissions in Canada as the figure below shows. With marked fuels and non-combustion emissions from agricultural activities being exempt from direct carbon pricing (as in every other jurisdiction), that means emissions reductions must come from other sectors of the economy to be meaningful. That, too, would require higher marginal carbon pricing rates to achieve those emissions reductions.

FIGURE 4: GHG Emissions from Agriculture (Provincial Comparison 2015)



These realities provided the context in which carbon price modelling should be conducted for Manitoba.

Carbon Price Modelling

Modelling the effects of carbon pricing is a well-established, proven tool used by governments, industries, and companies around the world to estimate emissions reductions. It has grown in sophistication and utility in the decades it has been in use, now also providing insight on economy-wide impacts. Modelling is used for these main reasons:

- analysis of various policy pathways to reduce emissions
- consideration of economic impacts of different price signals and scenarios
- comparison of price stringency and trade-offs with non-price policy actions

The modelling of carbon pricing impacts begins with a projection of Manitoba's economy and GHG emissions in the absence of new climate policies. This scenario serves as a point of reference to which all subsequent scenarios are compared to determine the incremental change attributable to the new policy. For example, the effect of a Made-in-Manitoba plan is determined by the extent to which the growth of economic activity and GHG emissions differs from the "reference case" or business-as-usual scenario.

Typically, modeling and analysis of carbon policy alters the relative costs of low and high emitting technology so that behaviour changes in response to the price. With the cost of high-emitting technology rising with carbon policy, households and businesses will make choices that minimize cost to them. If the gap between the high and low-emitting technology price is large, and the policy is insufficient to close that gap, the models will predict that there will be very little low-emitting technology deployment.

In the case of Manitoba, analysis and modelling suggests that Manitoba has a large stock of inexpensive emission reductions available given the historical absence of a comprehensive climate policy in the province. However, this stock is available up to approximately $30 per tonne; but after that price, costs rise fast and incremental emission reductions fall off. When this is the case, households and businesses will just pay the carbon price without necessarily changing their behaviour, as it is cheaper to do so. Therefore, there is a balancing of cost and emission reductions that good economic and emission modelling and analysis will highlight for decision makers. This was a key finding that informed the government's decision to choose a flat $25 per tonne carbon price rather than a higher, rising one.

Manitoba Modelling Scenarios

To ensure Manitoba received the most extensive and consistent data and analysis on a range of carbon pricing scenarios, the government undertook two distinct modelling streams.

1. Conducted modelling through Environment and Climate Change Canada (ECCC) and its proprietary energy-economy model called EC –PRO.
2. Conducted modelling and analysis through EnviroEconomics[1], an independent environmental economics expert consulting service. The scenario analysis for Manitoba is based on the R-GEEM model (see below). Versions of the model have been used to inform climate policy development in British Columbia, Alberta, Saskatchewan, Ontario and Nova Scotia.[2] Modelling and analysis using R-GEEM also featured prominently in the Government of Canada's Mid-Century Long-Term Low-GHG Development Strategy. The model was also used to develop the Canadian report for the United Nations Sustainable Development Solutions Network Deep Decarbonization Pathways Project.

The results of both sets of modelling were analyzed and compared for additional rigour in Manitoba's analysis. As both models have coexisted in the Canadian climate policy space for some time, it is recognized that they both provide a complementary and comparable view of impacts and impact drivers.

Environment and Climate Change Canada's EC-PRO Model

The EC-PRO model is a small open-economy, recursive-dynamic, computable general equilibrium (CGE) model of the Canadian economy. It captures characteristics of provincial production and consumption patterns through a detailed input-output table and links provinces via bilateral trade. Each province and territory is explicitly represented as a region. The representation of the rest of the world is reduced to import and export flows to Canadian provinces, which are assumed to be price takers in international markets. To accommodate analysis of energy and climate policies, the model incorporates information on energy use and GHG emissions related to the combustion of fossil fuels. It also tracks non-energy related GHG emissions. The EC-PRO model, being a CGE model, is an appropriate tool for modelling carbon pricing scenarios, since it allows the entire economy to respond as relative prices change throughout the economy *(source: cited from pg. 20, Working Group on Carbon Pricing Mechanisms, Final Report)*.

Four scenarios were modelled with ECCC as follows:

Scenario 1: Introduction of a $10 per tonne direct carbon price in 2018 and rising to a capped amount of $50 per tonne in 2022.
Scenario 2: Introduction of a $10 per tonne direct carbon price in 2018 and rising to $150 per tonne in 2032.
Scenario 3: Introduction of a hybrid carbon pricing system with a direct carbon price of $10 per tonne in 2018 and rising to a capped amount of $50 per tonne in 2022.
Scenario 4: Introduction of a hybrid carbon pricing system with a direct carbon price of $10 per tonne in 2018 and rising to $150 per tonne in 2032.

R-GEEM Model

The analysis for Manitoba relies on the GEEM regional macroeconomic model to generate an economic forecast for Manitoba's economy. Both Navius Research and Dr. Chris Bataille run versions of the GEEM model. GEEM is a computable general equilibrium (CGE)

1 In partnership with Dr. Chris Bataille.
2 Navius Research uses a version of the R-GEEM to support policy development in many Canadian jurisdictions..

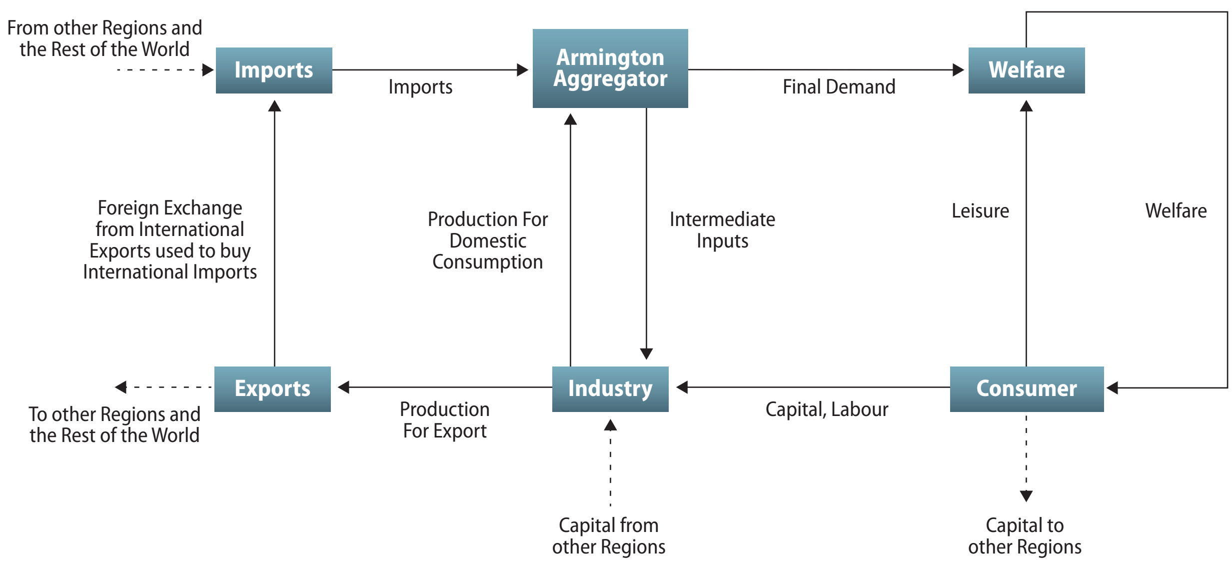
model of the Canadian provincial economies and the United States, simulating how economies evolve under different economic conditions. In the GEEM model, households and sectors that produce goods and services (e.g., electricity generation, lime production, fertilizer production) are explicitly represented. Each sector is characterized by what it produces (e.g., electricity) and the inputs required in production (e.g., capital, labour, energy and materials). Commodities that are produced can then be sold to other producers (as intermediate inputs), to households (the final consumers of goods produced in the economy), or to other regions and the rest of the world as exports. Commodities can also be imported from other regions or the rest of the world.

As the model steps through time, it ensures that markets clear for all commodities and factors by adjusting prices. For example, growth in pulp and paper production may increase demand for electricity in a single region, which must be generated provincially or imported. The price for electricity increases or decreases until supply matches demand.

Due to their framework, CGE models show how policies or different economic conditions alter the structure and growth of the economy. A policy leading to the contraction of one sector has a ripple effect throughout the economy as all sectors of the economy return to equilibrium. For example, a carbon price causing an increase in the cost of producing lime or refined petroleum products (assuming the prices for these goods remain constant) can lead to a loss of competitiveness and lower production levels. In turn, lower production would reduce the output from sectors that supply these sectors with goods and services, and capital and labour would be reallocated throughout the economy to those sectors and facilities with a lower carbon exposure. CGE model address this important dynamic, capturing the direct compliance response to the carbon price but also the indirect ripples throughout the economy.

The key economic flows in the GEEM model are shown below in Figure 5.

FIGURE 5: Overall structure of the GEEM model



The GEEM model is recursive and can solve in selected increments from 2002 to 2050. One of the benefits of using a recursive model is it can simulate policies that change over time. For example, GEEM can simulate carbon taxes that rise over time, or regulatory policies (e.g., vehicle efficiency standards) implemented in a certain year. Furthermore, the model simulates capital stock turnover over time. The data underlying the model is derived primarily from the Statistics Canada System of National Accounts.

The following sections describe the model's representation of industry and consumers.

Industry

Sectors can be disaggregated into various industries across North America (see examples in Table 1. All industrial sectors in the GEEM model are represented by constant elasticity of substitution (CES) functions, which represent the technologies that industry can use to produce goods and services. Central to this function are the elasticity of substitution parameters, which represent how easily a sector can substitute between different inputs while maintaining a given level of production. For example, the model simulates a trade-off between energy consumption and value added (e.g., capital and labour) in each industry through an elasticity of substitution parameter. A low value for this parameter indicates that capital and labour are not very substitutable for energy, and as a result, the energy intensity of the sector is largely unaffected by new economic conditions or policies. A high value for this parameter indicates greater substitution possibilities, and economic conditions or policies that raise the price for energy relative to the price of capital and labour will induce improvements in energy efficiency.

Figure 6 through Figure 8 show the structure for each industry. The model uses a generic structure to represent every industry, while elasticities of substitution and the inputs are specific to each industry. In other words, the model captures different industrial structures for energy consumption, the consumption of other goods and/or services and abilities to substitute between inputs.

Figure 6 shows the key end-uses captured in GEEM. These are comprised of six complementary (e.g., substitution is not possible) end-uses: 1) electric only end-uses (e.g., lighting or electric motors), 2) transportation, 3) process heat, 4) demand for non-energy intermediate goods (e.g., cement or services), 5) value-added unrelated to energy consumption, and 6) non-combustion GHG emissions (e.g., GHG emissions unrelated to energy consumption, such as venting/flaring in natural gas extraction or process emissions resulting from industrial activities such as aluminum smelting or fertilizer production).

The energy end-uses are discussed in more detail below.

FIGURE 6: End-uses in GEEM

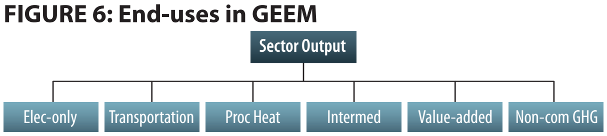
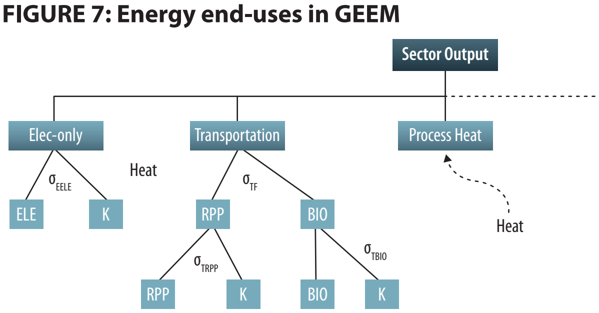


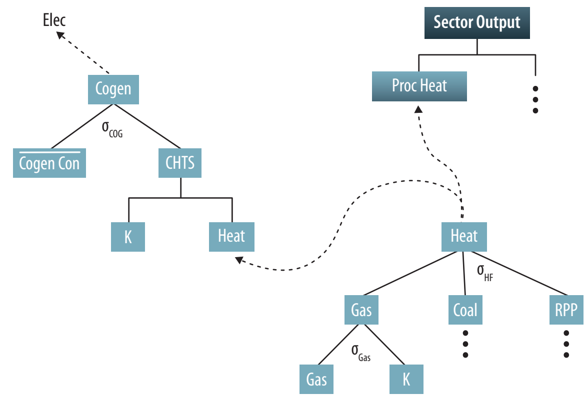
Figure 7 shows the energy end-uses in GEEM. Electric-only end-uses captures the ability of industry to improve efficiency. The transportation end-use captures the ability to improve the efficiency of vehicles (e.g., freight trucks), but it further captures the ability of the sector to substitute between refined petroleum products and biofuels. The structure of process heat is described in more detail below.

FIGURE 7: Energy end-uses in GEEM



The structure of process heat is shown in Figure 8. The model captures that ability to substitute between different fuels (e.g., natural gas, coal and refined petroleum products); as well as potential improvements to the efficiency of heating services. In addition to using process heat for direct industrial processes (e.g., space heating in commercial buildings or to meet the heating requirements for a refinery), heat can be used to generate electricity.

FIGURE 8: Process Heat in GEEM



The elasticities of substitution in GEEM implicitly represent the ability of different sectors to improve energy efficiency as well as substitute between fuels. To link the CIMS and GEEM models, the values for the most elasticities of substitution have been statistically estimated from CIMS. In other words, GEEM provides a reasonable approximation of the technological responses observed in CIMS.

Although energy efficiency and fuel switching capture a large portion of the abatement opportunities in the economy, some sectors have opportunities to directly control their GHG emissions. Examples of these opportunities include carbon capture and storage, capture of landfill gas, and efforts by the aluminum industry to reduce the emission of perfluorocarbons. These actions are captured in GEEM by using discrete technologies. For example, the "heat" services produced by natural gas are available in two options: with and without carbon capture and storage. Likewise, a sector may have multiple representations for non-combustion emissions with greater or fewer GHG emissions.

In the GEEM model, all industries maximize profits (e.g., revenue minus costs of production) subject to technology constraints through Lagrangian optimization.

TABLE 1: Example of sector coverage in GEEM

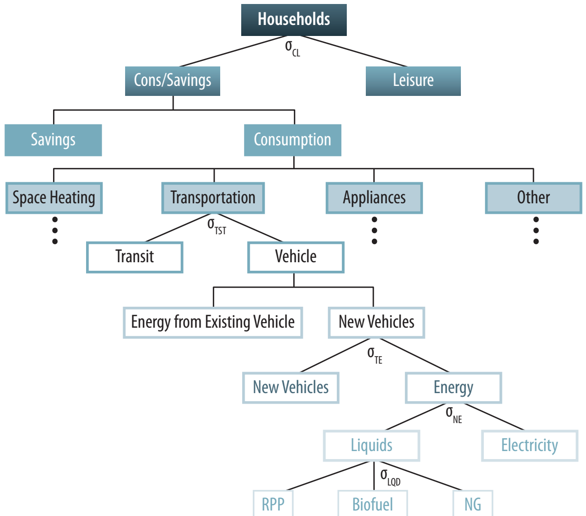
GEEM Code	Description
PEXT	Crop and animal production
	Forestry and logging
	Fishing, hunting and trapping
	Support activities for agriculture and forestry
OCHY	Heavy crude oil extraction
OCLM	Light and medium crude oil extraction
OSMIN	Mined bitumen extraction
OSIS	In-situ bitumen extraction
BITUP	Bitumen upgrading
CNGAS	Conventional natural gas extraction
TNGAS	Tight natural gas extraction
SNGAS	Shale natural gas extraction
EOROIL	Enhanced oil recovery
COALMIN	Coal mining
MINING	Mineral mining
OGSER	Support activities for mining and oil and gas extraction
CELEC	Conventional electric power generation
RELEC	Renewable electric power generation
ELDIS	Electric power distribution
NGDIS	Natural gas distribution
PAPER	Paper manufacturing
WOODPM	Wood product manufacturing
REFLOL	Petroleum products manufacturing from light crude
REFHOL	Petroleum products manufacturing from heavy crude
PETCHEM	Petrochemical manufacturing
OBCHEM	Other basic chemical manufacturing
FERT	Fertilizer manufacturing
BIOFUEL	Biofuels manufacturing
CEMMAN	Cement manufacturing
LIMMAN	Lime manufacturing
IRONST	Primary iron and steel manufacturing
ALMAN	Primary aluminum manufacturing
OPMMAN	Other primary metal manufacturing
OMAN	Other chemical manufacturing
	Other non-metallic mineral product manufacturing
	Miscellaneous manufacturing
LQDNG	Liquefied natural gas production
WRTD	Wholesale trade
	Retail trade
TRANSIT	Transit and ground passenger transportation
TRANS	Truck transportation
	Pipeline transportation
	Rail transportation
	Water transportation
	Other transportation
SERV	Warehousing and storage
	Water and other utilities
	Construction
	Information and cultural industries
	Finance, insurance, real estate and rental and leasing
	Professional, scientific and technical services
	Administrative and support services
	Educational services
	Health care and social assistance
	Arts, entertainment and recreation
	Accommodation and food services
	Other services (except public administration)
	Operating, office, cafeteria, and laboratory supplies
	Travel and entertainment, advertising and promotion
	Non-profit institutions serving households
WASTE	Waste management and remediation services
TRMARGIN	Transportation margins
GOVT	Government sector

Consumers

GEEM uses a representative agent framework, where all households are represented by a single representative agent. In this framework, the representative agent maximizes his/her welfare, where welfare is a function of consumption of various commodities, savings (e/g/., future consumption) and leisure. The structure of the household welfare model is shown in Figure 9 (note that the methodologies for space heating, appliances and other goods are similar to the transportation methodology, and so are not shown in detail). Most of the elasticity values (shown as σ in Figure 9) have been econometrically estimated from Navius Research's CIMS energy-economy model, while the values representing the substitutability between an end-use and other goods (σTST) are from Paltsev (2005)[3]. The representative agent in GEEM maximizes his/her welfare subject to available income through Lagrangian optimization.

3 Paltsev et al, (2005). The MIT Emissions Prediction and Policy Analysis (EPPA) Model: Version 4. Available from: http://globalchange.mit.edu/igsm/eppa.html.

FIGURE 9: Structure of household welfare



Reference Case

The analysis begins by providing a projection of Manitoba's economy and GHG emissions in the absence of new climate policies. This scenario serves as a point of reference to which all subsequent scenarios are compared to determine the incremental change from the reference case. The effect of a Made-in Manitoba plan is determined by the extent to which the growth of economic activity and GHG emissions differ from the reference case scenario. This means GHG emissions are reduced from waht they would have been without carbon pricing. The carbon pricing impact is therefore isolated and measured for effectiveness.

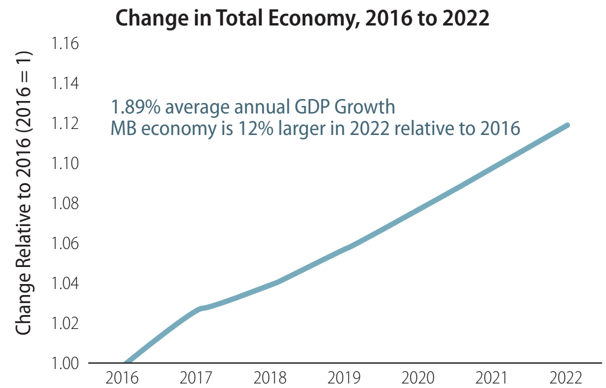
The reference case developed for the analysis reflects the current low oil and natural gas price environments[4] as well as the current GHG measures already in place such as federal vehicle efficiency standards. Importantly, we include other provincial polices to ensure we capture the relative price dynamics between Manitoba industry and its competitors in home and away markets. For example, Ontario's cap and trade program is included in the baseline.

Economic Activity

In the absence of new policy, Manitoba's provincial GDP in the reference case grows at an average annual rate of 1.89 per cent as shown in Figure 10. Economic growth is driven by an expansion of the service sector, which is strongly linked to population. The manufacturing sector and resource sectors also grow, but they contribute relatively less to the provincial economy. The implication of these results is that Manitoba's economy is likely to become less carbon intensive per unit of GDP in the reference case.

The projection of economic growth serves as a benchmark against which to compare the impact of differing scenarios, including the proposed Climate and Green Plan. In other words, the impact of a policy is measured by the extent to which it leads to a different projection of economic growth from the reference case. Figure 10 provides a graphical representation of GDP forecast to 2022.

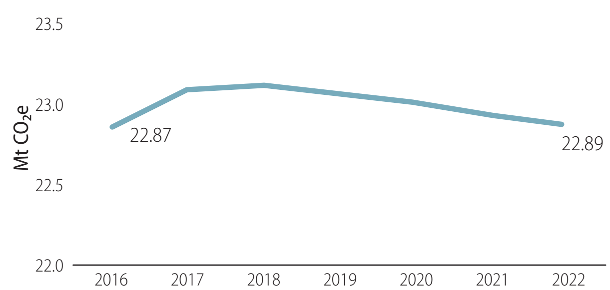
FIGURE 10: Reference Case Provincial GDP Forecast



Emissions

Employing the key economic assumptions highlighted in the previous section, we developed an integrated Reference Case forecast for economic activity, energy consumption and GHG emissions through 2022. Figure 11 provides a graphical representation of Manitoba GHG forecast to 2022.

FIGURE 11: Reference Case Provincial GHG Forecast (Mt CO_2e)



Based on Manitoba's 2014 GHG emissions profile and sources of GHG emissions subject to the federal carbon price:

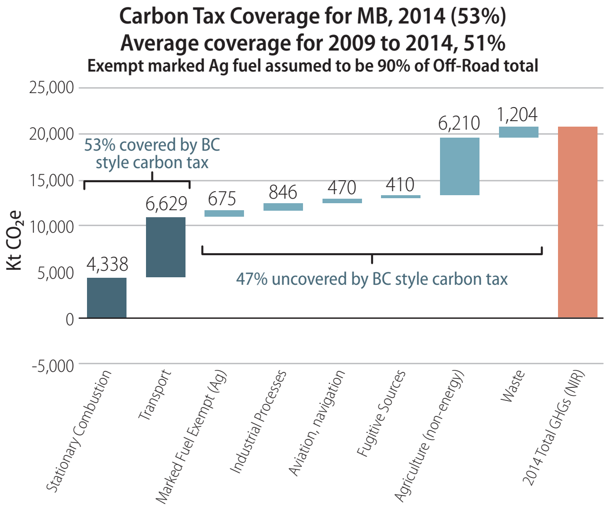
- Approximately 53 per cent of Manitoba's GHGs could be covered by a British Columbia (BC) style carbon tax.
- Marked fuels used primarily by agriculture are exempt from carbon price.

The figure below provides a detailed breakdown of the emissions coverage under a BC style carbon tax (adding

4 http://www.eia.gov/forecasts/steo/

unique treatment for the emission intensive and large trade exposed industries under an output based pricing system).

FIGURE 12: Carbon Tax Coverage



GHG Policies in the Reference Case

A critical assumption to ensure that we estimate a realistic set of emission reductions is to account for policies that are already deploying low carbon technology. Accounting for existing policies also ensures that we account for differences in relative prices for traded commodities that flow between Manitoba and its trading partners. The list below includes the assumptions employed in the model to capture current policy with Manitoba's trading partners:

- For **British Columbia (BC)**, we model the economy-wide carbon tax at a flat rate of $30 per tonne to 2030 in today's dollars, which effectively means it is falling in real terms. We apply this rate to new liquefied natural gas (LNG) facilities that come online starting in 2019 (consistent with the NEB, 2016) but recognize an intensity standard similar to Alberta's Specified Gas Emitter Regulation would apply under the Greenhouse Gas Industrial Reporting and Control Act (GGIRCA). We therefore may underestimate the GHG reductions from the new 0.5 megatonne (Mt) of LNG GHGs in our reference case (specific to the facilities, not upstream emissions).[5] Municipal solid waste reductions are also included. Significant upstream process formation gas (CO_2) and methane emissions are associated with LNG production, but these are not covered under existing policy. Further, we update the BC Low Carbon Fuel Standard (under Climate Leadership Plan), resulting in a 50 per cent increase over current or ~1.2 Mt. Land use changes are not assessed.
- For **Alberta (AB)**, we model the June 2015 update to *the Specified Gas Emitter Regulations (SGER)*, with a tightening of the intensity limit and rise in price in 2018 to $30 per tonne of CO_2e. Municipal solid waste regulations are also modeled.

  Further, we model the announced Climate Leadership Plan, including: an output-based intensity standard moving forward for large point source emissions; an aligned carbon tax on liquid fuels and natural gas, starting at $30 per tonne in 2018, not indexed to inflation; an orderly coal power phase-out by 2030 and a renewable power requirement 5,000 megawatts (MW) via competitive process, by 2030; and a methane regulation to achieve a 45 per cent reduction from a fixed target in 2005 in upstream oil and gas by 2025 (we assign a starting target of 25 per cent in 2020 rising to 45 per cent in 2025 below 2005). The impact of this policy is to reduce GHGs in 2025 more than 45 per cent below the forecast given the reductions are fixed to 2005, and emissions growth is occurring. This fixed historical target effectively acts like a hard cap on emissions growth from methane. The 100 Mt emissions limit on oil sands does not bind in our analysis because we have included advanced oil sands technologies that reduce emissions intensity in the order of 2 per cent per year, including solvent extraction and direct contact steam generation (e.g. . oxy-combustion of pet coke slurry to extract bitumen, where most of the CO_2 binds to the underground bitumen source matrix). Municipal solid waste regulations are also modeled.
- For **Saskatchewan (Sask)** we include the Boundary Dam GHG CCS (carbon capture and storage) project and a 50 per cent renewable capacity standard in electricity by 2030. Municipal solid waste reductions are also included.
- For **Manitoba (MB)**, we have no policies in the current scenario, with the coal heating ban likely having a negligible impact on GHGs. Municipal solid waste reductions are included.
- For **Ontario (ON)**, we include the Cap and Trade Regulation, with about 82 per cent coverage and the same carbon price trajectory as indicated below for Quebec. A true-up to the provincial target with Western Climate Initiative (WCI) imports is enabled to the extent there is a gap between domestic abatement with the WCI carbon price and the 2020 and 2030 targets (-15 per cent and -37 per cent below 1990 levels).[6] We also include the coal phase-out in the baseline projection. Ontario's municipal solid waste regulations are also included.
- For **Quebec (QC)**, we model the WCI program, assuming coverage of about 85 per cent of total GHGs and a carbon price rising from a real $21 per tonne CO_2e Canadian in 2020 to $45 per tonne in 2030 (real $2016). This WCI price reflects public forecasts of the WCI carbon price made by CaliforniaCarbon, using an historical average Canada-US exchange rate of 1.17.

5 Based on an earlier NEB forecast, the model predicts roughly 2 BCF/day of BC LNG starting in 2019. The current NEB 2016 forecast is 2.3 BCF/day, starting a more slowly and rising to 0.3 higher than our current forecast.

6 This assumption is likely valid in the short-term where Ontario in its proposed cap and trade regulation has aligned its cap decline factor to its 2020 target. The same applies to Quebec. This assumption is less certain however to 2030.

We true-up to the provincial targets with WCI imports or domestic offsets when domestic reductions from regulated entities are insufficient to meet Quebec's 2020 or 2030 targets (-20 per cent and -37.5 per cent below 1990). Municipal solid waste reductions are also included.

- For the **Atlantic region**, we model Nova Scotia's cap on electricity to 2030 under its Greenhouse Gas Emissions Regulations, with no other policies for the other provinces as they do not yet exist. Municipal solid waste reductions are included. Nova Scotia's proposed cap and trade system is modelled under the Pan-Canadian Framework on Clean Growth and Climate Change (PCF) scenario with the federal carbon price floor.
- **Federal policies** include the light and heavy duty vehicle regulations which we simulate to decline to 2025, as per the regulations, and then flat line to 2030. We also simulate the federal coal -fired generation regulations which, by requiring the emissions intensity of a typical natural gas generation facility, effectively bans new coal plants and requires shutting down aging plants after 50 years of useful life (unless equipped with CCS, which is more expensive than natural gas generation).

We have included all residential, commercial and institutional building codes and appliance efficiency policies.

Heavy Duty Vehicle Regulations. By 2027, a ~16 per cent improvement in fuel efficiency over 2021 or 2.5 per cent per year, then flat to 2030.

We also add in **national oil and gas methane regulations** similar to those contemplated by the United States, but extend its coverage to all fugitives, most importantly natural gas (NG) formation gas.[7] Using Alberta's regulation as a template, we assume a 25 per cent reduction in oil and gas methane and other fugitives by 2020 from a fixed target of 2012, culminating in reductions greater than 45 per cent by 2025 from the baseline forecast given growth in emissions. This policy is particularly important in British Columbia, where fugitive CO_2 formation gas from shale production for LNG is not covered under the current carbon tax or provincial intensity regulation.

Federal Price Backstop. In provinces with a carbon price now, the federal backstop only binds when it exceeds the current carbon price.

- AB and BC, 2021; SK, MB and Atlantic see price increases in 2018.
- QC and ON exempt given caps aligned to 2030 federal Nationally Determined Contribution (NDC).

Policy Options Modeled

Four main scenarios were modelled:

1. **Federal Backstop (Hybrid of Levy/OBP $10/tonne to $50/tonne).** BC style levy on combustion fuel, Alberta style output based pricing on large emitters. Price schedule is federal floor to 2022, as announced: $10/tonne in 2018 rising to $50/tonne by 2022.
2. **BC Levy Flat @$25/tonne.** BC style levy on combustion fuel, including full pricing on all large final emitter (LFE) combustion emissions.
3. **Manitoba Hybrid Levy/OBA Flat @$25/tonne.** Same as federal benchmark hybrid, but price schedule is flat at $25/tonne.
4. **BC Levy Flat @$20/tonne.** BC style levy on combustion fuel, including full pricing on all large final emitter combustion emissions.

Below, are the estimated GHG and GDP impacts of the four options. Figure 13 provides the GHG results for the four scenarios. Two columns are provided. One is the total GHGs reduced while the second is the total cumulative GHGs emitted. The GHGs reduced are compared against the reference case baseline discussed in the previous section. While the BC style levy reduces more emissions, the GDP implications are more negative given the Made-in-Manitoba plan focus on alleviating competitiveness concerns for emission intensive and trade exposed sectors.

FIGURE 13: GHG Impacts of Scenarios for Period 2018 to 2022

	GHGs Reduced (Mt)	Cumulative GHGs Emitted (Mt)
Federal Backstop Hybrid (Levy/ OBA $10/tonne > $50/tonne)	0.99	114.03
BC Levy Flat @$25/tonne	1.34	113.68
Manitoba Hybrid Levy/OBA Flat @$25/tonne	1.07	113.95
BC Levy Flat @$20/tonne	0.85	114.17

Figure 14 provides an overview of the GDP impacts of the policy scenarios, expressed as a change in the annual growth rate relative to the Reference Case. All scenarios show a minimal impact on GDP. However, the federal price climbing above $25/tonne later in the simulation has a larger impact on GDP, even with output based pricing for the large final emitters:

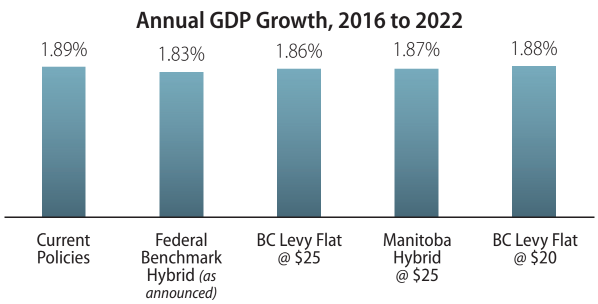
- **Federal Backstop hybrid.** Gains in partial GHG pricing with output based pricing for LFE is offset by higher price on the rest of the economy.

7 Tri-lateral methane announcement. "Prime Minister of Canada (PMC). June 29 2016. Leaders' Statement on a North American Climate, Clean Energy, and Environment Partnership."

- **BC Levy Flat @$25 /tonne.** Price on all combustion emissions has minimal impact on GDP, but LFEs down more relative to the rest of the economy.
- **Manitoba Hybrid Levy/OBA Flat @$25/tonne.** Partial pricing with LFE hybrid maintains GDP the most of the three scenarios. The lower price plus LFE relief helps.
- **BC Levy Flat @$20/tonne.** Maintains GDP the most (but emission reduced are lowest as indicated above).

It is important to remember that all scenarios here were modelled equally to ensure an accurate comparison of one to the other.

FIGURE 14: GDP Impacts of Scenarios for Period 2018 to 2022



Considerations for a Made-in-Manitoba Carbon Price

The federal/provincial/territorial working group report sets out considerations for choosing a carbon pricing mechanism. These are quoted in full below:

- the desired level of certainty around reduction in GHG emissions in a given time frame
- the desired clarity and strength of the carbon price signal over time, both for covered sectors and companies and for the economy as a whole
- the desire to provide GHG reduction opportunities at the lowest cost in order to limit the impact on covered sectors and low-income households, while achieving GHG reduction objectives
- the desired level of compliance flexibility for covered sectors and companies
- the interaction with other climate change policies and regulations
- the risks to competitiveness of trade-exposed sectors and desired mitigation approaches

For each of these reasons, Manitoba selected a flat $25 per tonne carbon levy as the best tool to achieve its goal of *maximizing emissions reductions at the least economic cost*.

Here's why:

- It gives Manitobans certainty about the carbon price and emissions reductions for the next five years.
- It creates a clear and strong starting price signal compared to any other jurisdiction to achieve emissions reductions.
- It produces the lowest cost emissions reductions compared to the federal backstop price schedule at a cheaper price and less cost to the economy as the modeling showed much higher prices are required to achieve more expensive reductions.
- It provides compliance flexibility for large industrial emitters through the output-based carbon pricing system.
- It allows for interaction with other regulatory measures set out on page 55 of the Made-in-Manitoba Climate and Green Plan.
- It reduces competitiveness risks to the province's energy-intensive and trade-exposed sectors such as fertilizer, cement, steel, mining, and oil and gas through a lower levy than the federal carbon tax plus the Manitoba output-based pricing system.

Summary

Carbon pricing offers a least-cost economic alternative to reducing GHG emissions compared to other policy instruments. Carbon pricing modeling illuminates the extent of emissions reductions that can be estimated to occur under different prices. It also illuminates the limits of carbon pricing by itself reducing emissions at different costs to the economy. Modeling is an established and recognized tool used by governments across Canada to inform policy choices by providing estimates of emissions reductions and economic impacts of different price scenarios. Manitoba used top-line modeling techniques and expertise as part of developing the Made-in-Manitoba Climate and Green Plan. Scenarios were all modelled equally to ensure fair and accurate comparisons could be made between them.