CANADA'S **ECOFISCAL** COMMISSION
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COMPARING STRINGENCY OF CARBON PRICING POLICIES

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EXECUTIVE SUMMARY

Carbon pricing is not automatically effective at reducing greenhouse gas (GHG) emissions. Effectiveness depends on *stringency*, a measure of the policy's ability to drive emissions reductions. More stringent policy creates stronger incentives and leads to deeper emissions reductions over time.

How can we measure the stringency of any given carbon pricing policy, and do so in a consistent manner that allows for comparisons across Canadian provinces? This report seeks to provide governments with a common, consistent framework for comparing provincial carbon pricing policies.

Given the gap between projected GHG emissions under current policies and Canada's existing 2030 target, more stringent policy will clearly be required, across the country. The framework developed here can support federal–provincial efforts to *benchmark* the stringency of existing provincial carbon pricing policies.

This report considers five metrics for stringency, as summarized in the table below. To make these metrics concrete, we estimate them for four different provincial policies—British Columbia's carbon tax, Alberta's carbon levy and (proposed) Carbon Competitiveness Regulation, and the linked cap-and-trade systems in Ontario and Quebec. Each of the metrics shows slightly different aspects of policy stringency. Some are directly observable, while others can only be estimated using economic modelling. Overall, it is useful to consider multiple metrics in benchmarking provincial policies.

As Canadian policy continues to evolve, metrics for comparing stringency can also support efforts to *coordinate* provincial carbon pricing policies. There are different paths to a coordinated pan-Canadian system. The provinces themselves, for example, could choose to align their respective policies. Alternatively, the federal government could define a minimum level of stringency, with provincial policies meeting or exceeding that level being deemed "equivalent." In either case, some metric of stringency is needed to define equivalent policy.

In the context of coordinating provincial carbon pricing policies, equalizing marginal carbon prices can minimize the overall costs of emissions reductions. Yet when provincial policies have different designs—in particular with respect to coverage and international permit trading—price alone may be less useful as a metric for coordination. As a result, the new metrics proposed here that account for these differences in policy design could support efforts to compare and coordinate provincial policies.

No metric of stringency is perfect. Yet even imperfect metrics can be useful and can aid in developing smart climate policy. This report examines differences between provincial policy designs and seeks to find common ground between different perspectives. It recognizes the importance of both quantities of emissions reductions and explicit carbon prices, but explores practical ways to compare them in a common framework.

Summary of Stringency Metrics and Estimates for Canadian Provincial Policies					
Metric	**Significance**	**British Columbia**	**Alberta**	**Ontario**	**Quebec**
Quantity of emissions reduced	**Advantages:** • Measures emissions reduced by policy • Has a direct connection to policy objective (targets) **Disadvantages:** • Emissions data lags by several years • Emissions reductions are not observable • Emissions levels often imply very different emissions reductions • Quantities do not reflect different costs of abatement across provinces	2020: 5-15%	2020: 7%	2020: 11%	2020: 15%
Marginal price of carbon	**Advantages:** • Measures incentive to reduce emissions • Easily observable • Reflects cost-effective distribution of emissions reductions **Disadvantages:** • Does not account for differences in policy coverage • Does not account for international permit trade	2016: $30 2020: $30	2016: $20 2020: $30	2016: n/a 2020: $19	2016: $16 2020: $19
Average carbon cost	**Advantages:** • Measures all policy costs to emitters • Measures incentives regarding building new facilities (and resulting emissions) **Disadvantages:** • Challenging to estimate in practice • Reflects both policy stringency and revenue-recycling choices	2020: $29	2020: $13	2020: $14	2020: $14
Coverage-weighted carbon price	**Advantages:** • Measures incentive to reduce emissions • Accounts for coverage of policy **Disadvantages:** • Shifts provinces away from most cost-effective method of coordination	2016: $21 2020: $21	2016: $10 2020: $23	2016: n/a 2020: $16	2016: $14 2020: $16
Trade-adjusted carbon price	**Advantages:** • Measures incentive to reduce emissions • Accounts for coverage of policy • Accounts for international permit trade **Disadvantages:** • Shifts provinces away from most cost-effective method of coordination	2016: $21 2020: $21	2016: $10 2020: $23	2016: n/a 2020: $18	2016: $14 2020: $18

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1. Introduction

The *stringency* of a carbon pricing policy is its ability to drive reductions in greenhouse gas (GHG) emissions. A carbon pricing policy does not automatically reduce emissions; success depends on the policy's stringency.

More stringent policy is clearly required to achieve Canada's stated emissions-reduction target for 2030—30% below 2005 levels (Environment and Climate Change Canada, 2016). But to what extent will individual provinces contribute toward the overall national effort? This question can only be answered if we are able to compare the stringency of different provincial carbon pricing policies. This report is aimed at developing a consistent framework to be used for such comparisons.

Yet comparing the stringency of different carbon pricing instruments in a consistent manner is not straightforward. The problem is not that some provinces use carbon taxes while others use cap-and-trade systems (and some use hybrids); in broad outline, these policy instruments are actually much more similar than they are different. The challenge lies in the various design details used in any kind of system, and how these details affect the policy's stringency.

This report works through five metrics for comparing the stringency of carbon pricing policies. For each metric, we explain its meaning and consider how it compares across existing (or soon-to-exist) policies in four provinces—British Columbia, Alberta, Ontario, and Quebec.[1] The five metrics are, in turn:

1. Quantity of emissions reduced
2. Marginal price of carbon
3. Average cost of carbon
4. Coverage-weighted carbon price
5. Trade-adjusted carbon price

The fourth measure is an intuitive extension of the marginal price, extended by applying it to the share of the province's total GHG emissions covered by the policy; a policy with wider coverage is seen to have more stringency. The last metric essentially adjusts a policy's coverage by accounting for emissions trading with entities outside the provincial boundaries.

These various metrics have advantages and disadvantages, both in terms of their relevance and the extent to which they can be computed in practice. While some metrics can be directly observed, others can only be estimated using complex economic modelling. Each measure is useful in benchmarking different aspects of carbon pricing policies.

Finally, we consider how various metrics could support the coordination of provincial climate policies, an activity that is currently underway with the provincial and federal governments. Comparing and coordinating the stringency of different provincial policies will naturally be a key part of this exercise. The more these provincial policies are aligned with similar carbon prices, the more cost-effective overall Canadian policy will be. Differences in the design of provincial carbon pricing policies, however, make comparing stringency challenging. In our view, the *trade-adjusted carbon price* is a practical and flexible metric that could assist in the coordination of provincial carbon pricing policies.

1 We have taken the stated federal goal of pan-Canadian carbon pricing at face value, and focus here only on comparing carbon pricing policies. The appendix briefly considers the role of non-pricing policies.

2. The quantity of emissions reduced

The *quantity* of GHG emissions reduced is fundamental to the idea of policy stringency. It determines Canada's contribution to global efforts to prevent excessive climate change. The current policy objective—our national target for 2030—is expressed in terms of emissions reductions. In practice, however, using quantities as a measure of policy stringency can be challenging for several reasons.

First, the estimation and publication of data on the level of actual GHG emissions occurs with considerable time lags. Estimates made by Environment and Climate Change Canada currently involve time lags of up to two years. While this lag is not crucial for the long-run assessment of the success of carbon pricing policies, it does mean that emissions quantities cannot be used as a timely measure to assess and compare the stringency of provincial policies. This is especially important when carbon pricing policies are in their early, expansionary years.

Second, the quantity of emissions reductions is not directly observable (Aldy et al., 2015). The appropriate measure of a policy's effectiveness is the amount that emissions are reduced below the level that would have occurred in the absence of the policy. But it can never be clear what emissions would have been in this counterfactual case (for example, the 2008-09 economic and financial crisis led to reductions in GHG emissions that had nothing to do with climate policy). Emissions reductions *caused by the policy* can be estimated, but only with a complex energy-economy model. As in all economic models, the underlying assumptions are debatable, and thus the estimates themselves can be contentious. Table 1 draws on various modelling exercises that estimate the emissions reductions likely to result from each provincial policy. These estimates rely on different modelling approaches from different sources, so are not perfectly comparable. They do, however, illustrate how the provincial policies vary in terms of expected emissions reductions.

Third, while the level of actual GHG emissions (as opposed to emissions reductions) is easier to measure, it can also be more arbitrary as a measure of stringency. Emissions caps could be defined relative to various historical levels of emissions benchmarks. For example, Canada's national emissions target for 2030 is 30% below 2005 levels; Ontario's 2030 target is 37% below 1990 levels. But provinces have different trends in emissions growth, both historically and projected into the future. If emissions are trending upward in one province and downward in another, a common historical reference point for levels of emissions would imply very different emissions reductions due to policy, and correspondingly different costs.

Fourth, while it may seem natural to compare provincial systems based on the associated reductions in emissions, such a comparison involves an implicit assumption that may be misleading. If we conclude that two provincial carbon pricing systems are equivalent if they both reduced X percent, as might be natural after considering Table 1, we would be ignoring the possibility that achieving those reductions in one province may be more difficult and involve higher costs than in another. And since provinces will have quite different marginal abatement cost curves, such cost differences are to be expected.[2] This issue is of considerable importance when examining how various provincial policies can be coordinated into a cost-effective pan-Canadian system, as we discuss later.

Table 1: Estimated Quantities of Emissions Reduced Under Provincial Carbon Pricing Policies

	British Columbia	Alberta	Ontario	Quebec
Emissions reductions in 2020 (%) relative to no-policy case	5-15%[a]	7%[b]	11%[c]	15%[d]

[a] Estimates based on Murray and Rivers (2015).
[b] Estimates based on Leach et al., (2015) and Government of Canada (2016).
[c] Estimates based on Sawyer et al., (2016).
[d] Estimates based on Ouyed (2015) and Government of Canada (2016).

2 In Alberta, for example, shifting coal-fired electricity generation to gas or renewables can provide relatively low-cost emissions reductions. In Quebec and Manitoba, where electricity is already based on clean hydroelectricity, fewer low-cost opportunities exist for reducing emissions.

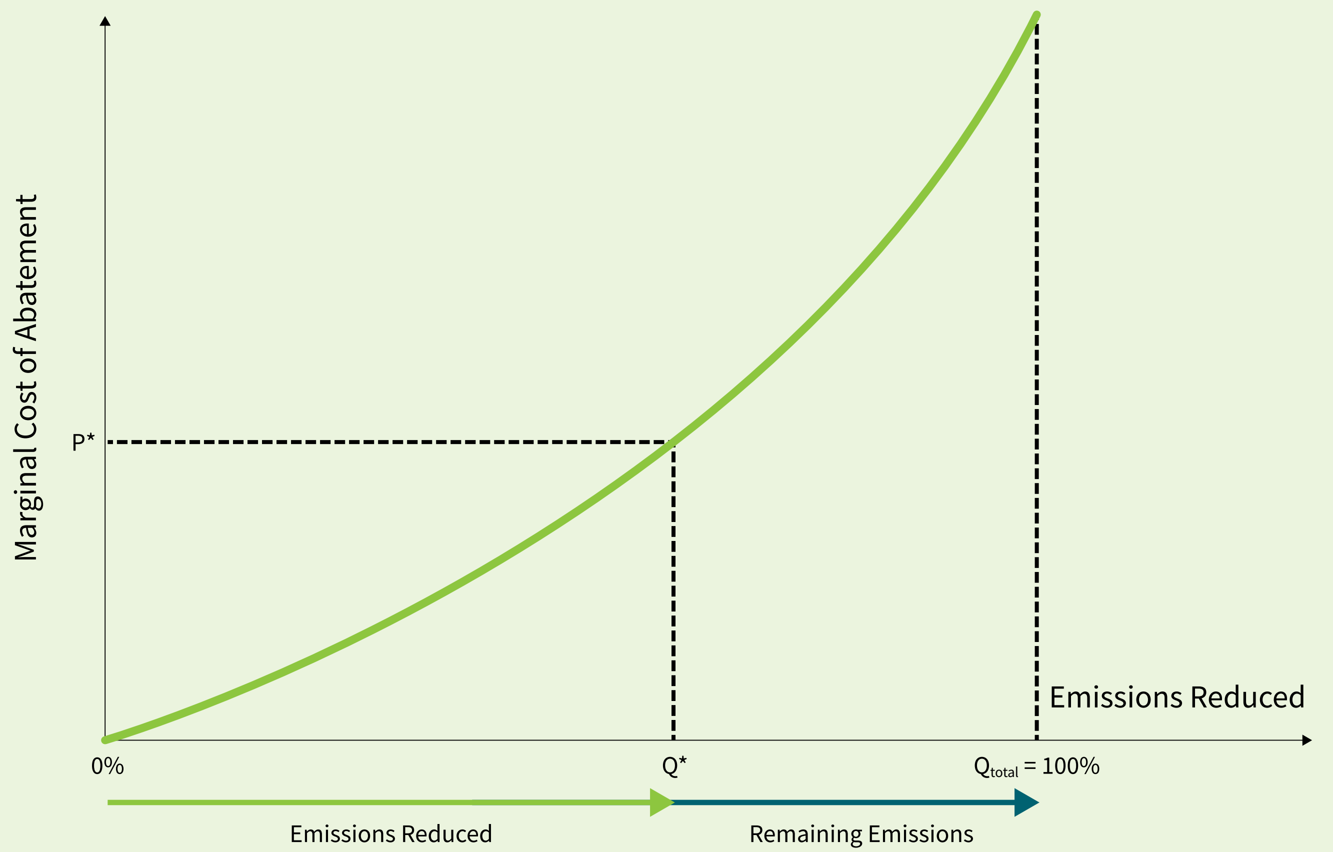
Finally, note that the quantity of emissions reductions can be defined in either *global* or *in-province* terms. British Columbia's carbon tax and Alberta's new pricing policy, for example, rely exclusively on in-province emissions reductions. As a result, for each of the two provinces, the global and in-province reductions generated by their policies are identical. The cap-and-trade systems in Ontario and Quebec, on the other hand, link to California's system through the international trading of permits. This trade allows the two provinces to achieve global emissions reductions that exceed their in-province reductions. The difference between these two concepts has implications for some other metrics, as we will see below.

3. The marginal price of carbon

The simplest way to assess the stringency of carbon pricing policies is with the price of carbon. 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, 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.[3]

Figure 1 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 (see Box 1 for more detail). The *marginal cost* is the cost of reducing one

Figure 1: The Marginal Abatement Cost Curve for a Province



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

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.

Carbon pricing policies create incentives for households and businesses to reduce their emissions. A carbon tax sets the price paid (P*) for producing an incremental tonne of emissions, based on the rate of the carbon tax (such as British Columbia's $30/tonne). A cap-and-trade system, on the other hand, sets the maximum quantity of emissions allowed (such as Quebec's 63.2 Mt cap for 2016), and the carbon price then emerges through auctions and trades in the permit market.[4] As the figure illustrates, a carbon price and the quantity of emissions reductions can be seen as two different sides of the policy coin; a higher price is associated with deeper emissions reductions through the adoption of lower-carbon technologies and practices. Table 2 illustrates the marginal carbon price under current provincial carbon pricing policies. British Columbia's carbon tax and Alberta's carbon levy set the price of carbon directly. Cap-and-trade systems generally set the price indirectly using a quantity cap. Ontario's and Quebec's (linked) cap-and-trade systems, however, are slightly more complicated, because they limit the extent to which the price of carbon can fluctuate in response to changes in market conditions. In particular, a *price floor* sets the minimum auction price in their systems. So far, permits in Quebec have traded at or near the price floor; Ontario's program will launch in 2017 with a similar price floor.[5]

Benchmarking policy stringency based on the marginal carbon price has the considerable advantage of practicality. The price of carbon is easily measurable and transparent, and is explicitly defined in the policies in British Columbia and Alberta. While we have relied on modelling analysis to estimate future carbon prices in Ontario and Quebec, prices in real time will be transparent, based on quarterly permit auctions and even more frequent market trading.

Table 2: Marginal Carbon Prices Under Provincial Carbon Pricing Policies

	British Columbia	Alberta	Ontario	Quebec
Marginal price of carbon	2016: $30 2020: $30	2016: $20 2020: $30	2016: n/a 2020: $19.40[a]	2016: $16.40 2020: $19.40[a]

[a] Projections of Western Climate Initiative (WCI) permit price are drawn from modelling analysis for Ontario (Sawyer et al., 2016).

4 In a cap-and-trade system, permits for emissions are usually auctioned to businesses covered by the policy. If a firm can reduce its emissions for less than the price of a permit, it will do so and sell permits to other firms, thereby increasing its profits. Firms with higher abatement costs can purchase permits at auction or from the low-abatement-cost firms offering theirs for sale. This auctioning and trading results in a market-determined permit price—the carbon price for a cap-and-trade system, shown as P* in Figure 1.

5 All dollar values used in this report are current (nominal) dollars. No correction for expected inflation is made in the forecasted future values.

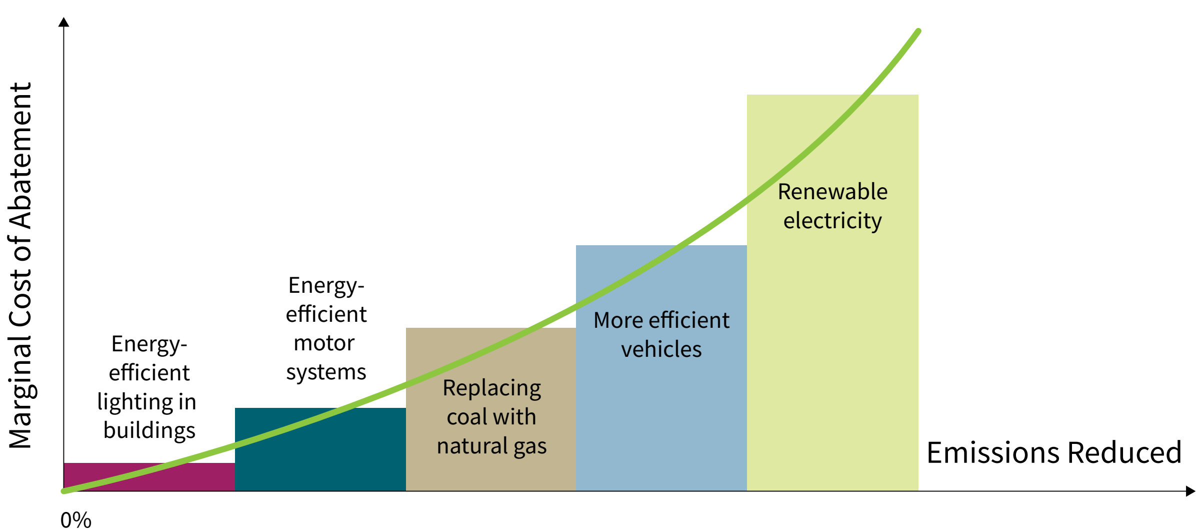
Box 1: Understanding Marginal Abatement Costs

All households and businesses in a given provincial economy have various ways to reduce GHG emissions. They can replace old lighting with more efficient LEDs; shift to less fuel-intensive energy sources; produce electricity using wind, solar, or other renewables; or implement any combination of many other actions to reduce emissions.

Each of the abatement opportunities can be used to reduce GHG emissions at some cost. Using hypothetical options and costs, the figure below orders these options from lowest to highest marginal cost. The vertical axis shows the marginal cost of reducing an additional tonne of emissions, measured in dollars per tonne. The horizontal axis shows the quantity of emissions reductions that could occur with each option.

We can fit a smooth curve to these various abatement options. This curve approximates the marginal abatement costs for various opportunities for emissions reductions within any given province.

Marginal abatement costs for a hypothetical province



As provinces vary by their economic structures and energy mixes, they also have different options for reducing GHG emissions, and with different associated costs. Each province will therefore have a unique marginal abatement cost curve.

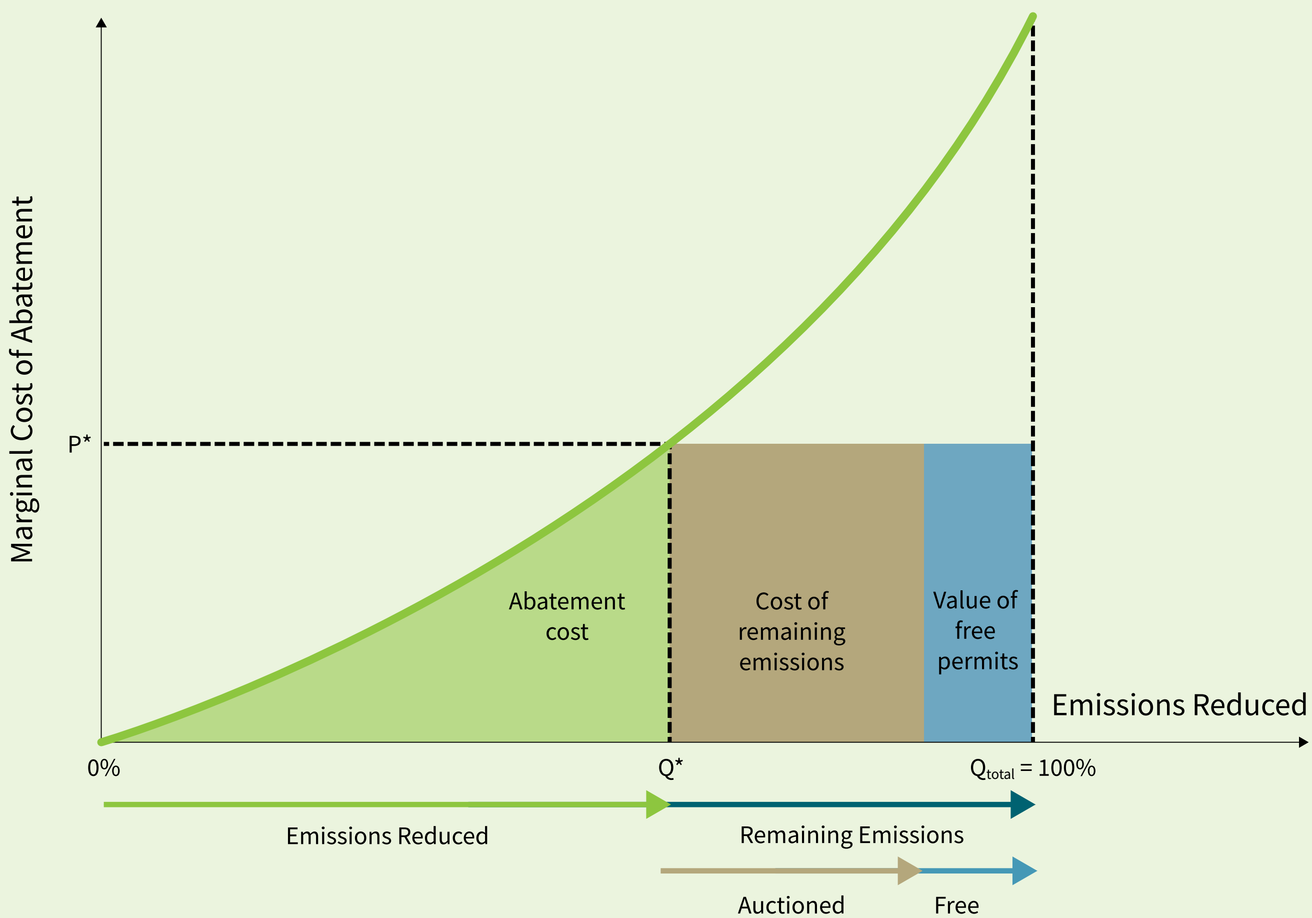
The shape of each province's marginal abatement cost curve is very difficult for policymakers to know with any precision, since it is based on details of abatement technologies across various economic sectors. Indeed, the main attraction of a carbon pricing policy is that it does not require government to have detailed knowledge of the various abatement options, but instead lets emitters respond to the carbon price by choosing approaches that make the most sense for them. We can estimate marginal abatement cost curves with complex economic models, but these estimates depend on many (often contentious) assumptions.

Based on the marginal price alone, the most stringent policy is currently in British Columbia, with Alberta poised to reach that stringency by 2018. Market prices of carbon in Ontario and Quebec are projected to remain lower for the next several years, though they will likely increase over time as the emissions cap gradually declines.

4. Average carbon costs

The average cost of a carbon pricing policy reflects its overall cost to emitters on a per-tonne basis. The *marginal price of carbon* and *average carbon costs* are measured in the same units ($/tonne), but they measure very different things. The marginal carbon price is the emitters' financial incentive to reduce an additional tonne of emissions; the average carbon cost represents all the costs incurred as a result of complying with the policy. Average cost differs from the price of carbon both in terms of how it is estimated for different policies and what it means for stringency, as illustrated in Figure 2.

Figure 2: Marginal Abatement Cost Curve With Total Costs and Some Free Permits



The shaded areas under the curve represent the total costs for emitters. This total comprises two components:

- The green triangle represents emitters' abatement costs. These are the costs of the actions that emitters take to reduce emissions and thus avoid paying the carbon price on those emissions. Collectively, emitters will undertake all actions that cost less on a per-tonne basis than the carbon price, P*, and will reduce emissions by Q*. The exact shape and size of this triangle depends on the shape of a given province's marginal abatement cost curve, as discussed in Box 1.
- The brown rectangle represents the costs of remaining emissions—that is, the amount emitters pay in order to comply with the carbon pricing policy. Under British Columbia's carbon tax, all of these remaining emissions are priced: covered emitters pay the tax on all their emissions. In Ontario's and Quebec's cap-and-trade systems, however, emitters receive some permits for free, thus reducing these costs. Only the permits that are auctioned (brown rectangle) contribute to the costs of these remaining emissions.[6]

Average carbon costs are therefore calculated as the total costs incurred by emitters divided by total covered emissions:

$$\textbf{Average carbon cost to covered emitters} = \frac{\text{abatement cost} + (\text{auctioned permits}) \times (\text{marginal price})}{\text{total emissions covered by the policy}}$$

For two reasons, the average carbon cost is less than the marginal carbon price. First, on a per-tonne basis, the abatement cost is less than the carbon price (P*); indeed, this is exactly why emitters choose to reduce their emissions—because doing so is more profitable than maintaining their emissions and paying the carbon price. Second, if the carbon pricing policy is designed to issue any free permits to emitters (or issue rebates of a carbon tax), the per-tonne cost of remaining emissions will be less than P*.

Average carbon costs are a relevant factor in the overall stringency of a policy, but in a different and subtler way than price. The carbon price gives emitters incentives to find ways to reduce emissions for existing facilities, as well as to design new facilities in less emissions-intensive ways (e.g., to choose more efficient boilers or to use electric rather than diesel motors). Average carbon costs, on the other hand, affect decisions about *whether to close existing facilities* and *whether to build new ones*. When a firm must decide whether or not to build a new production facility, for example, it considers not only the marginal cost of the final tonne of carbon produced, but *all* costs associated with that facility's operations (Leach, 2012).

Estimates of the average carbon cost, however, must overcome one practical difficulty. Since the province's marginal abatement cost curve is generally not known, the abatement cost component is difficult to estimate. Our estimates below assume that the marginal abatement cost curves are linear such that abatement costs in Figure 2 can be represented as a triangle.

6 Alberta's current Specified Gas Emitters Regulation for large emitters also has provisions for (effective) free allocations, as does its planned replacement, the Carbon Competitiveness Regulation (CCR). Under the CCR, large emitters will receive tradable "output-based allocations" based on sector standards for emissions performance (Leach et al., 2015).

Table 3 summarizes our estimates of average carbon costs under each of the four provincial policies. The systems in Alberta, Ontario, and Quebec do not price all remaining emissions (Ontario and Quebec provide some permits for free, while the Alberta Carbon Competitiveness Regulation charges emitters only based on their emissions above an intensity benchmark). As a result, the average carbon costs of these policies are lower than the marginal carbon price. British Columbia's carbon tax provides no rebates, and so is the only one of the four policies with an average carbon cost that approximates the marginal carbon price. Despite the significance of the average carbon cost for firms' investment choices, the metric has some clear limitations as a practical measure of policy stringency.

First, provinces might have good reason to provide some emissions permits for free, thus reducing the average carbon cost. In particular, carbon pricing policies can be designed to address concerns around business competitiveness precisely by providing some free permits to vulnerable sectors on a transitional basis (Canada's Ecofiscal Commission, 2015a). With such a policy approach, emitters have an incentive to reduce their emissions by improving their performance rather than by reducing their output. In other words, the marginal price of carbon is a better indicator of policy effectiveness than is the average carbon cost.

Second, the decision to provide free permits is essentially a revenue-recycling choice (Canada's Ecofiscal Commission, 2016). Providing free permits forgoes collecting revenue, and can thus be seen as a specific method for using the policy's potential revenues. As we have argued elsewhere, provincial autonomy in revenue recycling is a central element of practical carbon pricing policy in Canada (Canada's Ecofiscal Commission, 2015b).

Finally, average carbon costs can be difficult to estimate precisely in practice, for three reasons. First, as we said earlier, estimating the abatement costs requires economic modelling to define the shape of each province's marginal abatement cost curve. Second, it involves estimating the amount of emissions reduced (Q* in Figure 2), and, as we argued previously, this involves modelling what emissions would be in the absence of policy. Third, estimating the average carbon cost requires estimating total GHG emissions (the denominator in the equation above), and this has challenges associated with both timing and estimation.

In summary, neither the average carbon cost nor the quantity of emissions reduced is a practical measure of the stringency of a carbon pricing policy. This leads us to look in more detail at some modified metrics based on the directly observable marginal carbon price.

Table 3: Average Carbon Costs for Provincial Carbon Pricing Policies

	British Columbia	Alberta	Ontario	Quebec
Marginal price of carbon	2016: $30 2020: $30	2016: $20 2020: $30	2016: n/a 2020: $19.40[a]	2016: $16.40 2020: $19.40[a]
Share of covered emissions priced or auctioned	2016: 100% 2020: 100%	2016: 15% 2020: 39%[b]	2016: n/a 2020: 75%[c]	2016: 75% 2020: 75%[c]
Average carbon cost[d]	2020: $29.22	2020: $12.74	2020: $14.25	2020: $14.09

[a] Projections of WCI permit price are drawn from modelling analysis for Ontario (Sawyer et al., 2016).

[b] Share of priced emissions based on estimates of carbon pricing revenue from Alberta's 2016 budget (Government of Alberta, 2016) relative to potential revenue if price is paid on all covered emissions (Environment and Climate Change Canada, 2016; Leach et al., 2015).

[c] Preliminary calculations suggest that free permits amount to at least 25% of covered emissions; these estimates will be the subject of future analyses.

[d] We estimate average costs as the sum of abatement costs (assuming a linear cost curve) and priced remaining emissions, divided by total covered emissions. Estimates are based on projections from Murray and Rivers (2015), Leach et al. (2015), Sawyer et al. (2016), and Ouyed (2015) for B.C., Alberta, Ontario, and Quebec, respectively.

5. Coverage-weighted carbon prices

Using marginal carbon prices to assess the stringency of provincial systems only makes sense if the price incentive applies to an equivalent share of emissions in each province. If a policy applies a high price to only a narrow share of the province's emissions, it will drive relatively few emissions reductions. Put another way, a narrow policy will be less effective at reducing emissions than a broad policy at the same carbon price. The *coverage* of a carbon pricing policy is therefore central when considering stringency.

We define coverage as the share of provincial GHG emissions that face a price incentive for reduction. Existing provincial policies have different levels of coverage. British Columbia's carbon tax is applied to all GHG emissions from the combustion of fossil fuels. Policies in Alberta, Ontario, and Quebec include combustion emissions, but also non-combustion emissions from industrial processes, thereby having slightly broader coverage. Note that a policy's coverage is not affected by whether some permits in a cap-and-trade system are provided for free; such free allocations reduce emitters' average carbon cost, but do not reduce their marginal incentive to reduce emissions.

We define the *coverage-weighted carbon price* as the product of the marginal carbon price and the share of total provincial emissions to which it applies. Both factors—broader coverage and a higher price—contribute to greater stringency.

$$\textbf{coverage-weighted carbon price} = \text{marginal carbon price} \times \left(\frac{\text{covered emissions}}{\text{total GHG emissions}}\right)$$

Like the simpler marginal carbon price, the coverage-weighted carbon price measures the incentives for reducing emissions, and is practical to measure without economic modelling. But by also accounting for policy *coverage*, it offers a more comprehensive measure of policy stringency.

Table 4 calculates the coverage-weighted carbon price for the four provincial policies. Since Ontario and Quebec have the same marginal carbon price, the slightly lower coverage in Ontario explains its slightly lower 2020 coverage-weighted carbon price. British Columbia's current policy has the lowest 2020 coverage of all four policies, but its higher marginal price results in greater stringency than in Ontario or Quebec.

By this metric, Alberta's policy by 2020 will be the most stringent in Canada. Its marginal price will match that of British Columbia's carbon tax, but the coverage of the policy will be broader, given that it will include non-combustion process emissions for large emitters (whereas B.C.'s carbon tax covers only combustion emissions). Despite relatively broad policy coverage in Ontario and Quebec, the lower marginal price in those linked cap-and-trade systems leads to notably lower stringency.

Table 4: Coverage-Weighted Carbon Prices of Provincial Carbon Pricing Policies

	British Columbia	Alberta	Ontario	Quebec
Marginal price of carbon	2016: \$30 2020: \$30	2016: \$20 2020: \$30	2016: n/a 2020: \$19.40[a]	2016: \$16.40 2020: \$19.40[a]
Coverage	2016: 70% 2020: 70%	2016: 50% 2020: 78%	2016: n/a 2020: 82%	2016: 85% 2020: 85%
Coverage-weighted carbon price	2016: \$21 2020: \$21	2016: \$10 2020: \$23.40	2016: n/a 2020: \$15.91	2016: \$13.94 2020: \$16.49

[a] Projections of WCI permit price are drawn from modelling analysis for Ontario (Sawyer et al., 2016).

6. Trade-adjusted carbon prices

One critical piece of the stringency puzzle remains to be examined: international trade in emissions permits. If emissions permits from other jurisdictions can be purchased to comply with a provincial carbon pricing policy, additional low-cost emissions reductions are made available to emitters. In this setting, the carbon price on its own is no longer tightly connected with the quantity of emissions reduced (as in Figure 1).

Linking systems through the trading of permits leads to changes in the carbon price. If a province were a net *importer* of permits, the price of carbon would be lower than would be the case if no permit trading were allowed; put differently, purchasing permits from an outside jurisdiction helps to keep the carbon price low. Alternatively, if a province were a net *exporter* of permits, the carbon price would be higher than would be true in the absence of permit trading; the sale of permits has the effect of elevating the carbon price. This tendency is precisely the point of allowing trade in permits; it results in low-cost emissions reductions being realized independent of jurisdictional boundaries. It also, however, weakens the extent to which the carbon price within a single jurisdiction measures the stringency of policy.

One way to adjust for international permit trade is to extend the coverage-weighted price discussed above. Mechanisms that allow for the purchase of international permits essentially broaden coverage by extending the reach of the policy beyond provincial borders—emissions reductions from outside the province can "count" toward compliance within the province. Just as extending the coverage of a policy within a province can increase emissions reductions and thus the stringency of the policy, so too can extending coverage beyond its borders.

To account for this effect, we define one final metric, the trade-adjusted carbon price. This metric expands the coverage-weighted carbon price to consider the emissions reductions associated with international permit trade:

$$\textbf{trade-adjusted carbon price} = \text{marginal carbon price} \times \left(\frac{\text{covered emissions} + \text{net imported permits}}{\text{total GHG emissions}} \right)$$

In a linked cap-and-trade system, trade in the permit market will result in price equalization for all permits, no matter their origin; there is a single marginal carbon price. The trade-adjusted carbon price adjusts the ratio of covered emissions to include cross-border permit trading. In extreme cases, the number of imported permits could be large enough that the coverage ratio exceeds one, thus increasing the estimated stringency above the marginal price of carbon.[7]

Table 5 estimates the trade-adjusted carbon price for the four provincial carbon pricing policies. For British Columbia and Alberta, the trade-adjusted carbon price is identical to the coverage-weighted carbon price, because there are no provisions for international permits under their policies.[8] We estimate Ontario's and Quebec's projected permit trade based on publicly available analysis (Sawyer et al., 2016). The imported permits expected by 2020 increase the stringency of the two provinces' policies when compared to their coverage-weighted carbon prices.

7 As an aside, this metric could also account for domestic offsets used for compliance. The quantity of offsets would be added to the numerator of the expression, as they come from sectors not covered by the pricing policy. Like international permit trading, offsets essentially broaden the coverage of a carbon pricing policy.

8 This is not the result of inherent differences between cap-and-trade systems and carbon taxes. Tax-based approaches (as in Alberta and British Columbia) could be designed to allow the purchase of international permits or offsets.

Table 5: Trade-Adjusted Carbon Prices of Provincial Carbon Pricing Policies

	British Columbia	Alberta	Ontario	Quebec
Marginal price of carbon	2016: $30 2020: $30	2016: $20 2020: $30	2016: n/a 2020: $19.40[a]	2016: $16.40 2020: $19.40[a]
Coverage	2016: 70% 2020: 70%	2016: 50% 2020: 78%	2016: n/a 2020: 82%	2016: 85% 2020: 85%
Imported emissions permits	n/a	n/a	2016: n/a 2020: 15 Mt[b]	2016: ? 2020: 7 Mt[b]
Trade-adjusted carbon price	2016: $21 2020: $21	2016: $7.50 2020: $23.40	2016: n/a 2020: $17.83	2016: ? 2020: $18.08

[a] Projections of WCI permit price are drawn from modelling analysis for Ontario (Sawyer et al., 2016).
[b] Total import estimates are drawn from Sawyer et al. (2016), and split between Ontario and Quebec based on the relative size of their emissions inventories.

Using a trade-adjusted carbon price allows for a more accurate comparison of the stringency of carbon pricing policies. The provincial governments in Ontario and Quebec have rightly argued that price alone does not accurately reflect the stringency of their cap-and-trade systems, given their access to emissions permits from California. International permits represent real emissions reductions—globally—and ignoring them in stringency benchmarking would result in misleading comparisons.[9]

On a practical basis, measuring trade-adjusted carbon prices is relatively straightforward. As discussed above, marginal carbon prices can be directly observed in real time. In addition, a policy's coverage can be accurately estimated, and imports of international permits are similarly straightforward to observe (once compliance data are reported at the end of the year). The result is that provinces' trade-adjusted carbon prices can be estimated relatively easily, and without relying on complex and often contentious economic modelling.

7. Applying the metrics: Coordinating provincial policies

The focus of this report has been on comparing the stringency of carbon pricing policies in Canada within a consistent framework. Though challenging in the presence of important provincial differences, benchmarking the contributions of provincial policies is essential as Canada charts a course for achieving its national 2030 emissions target. We find that our five metrics are useful in different ways, and all can make a meaningful contribution to the benchmarking exercise.

Comparing policy stringency also serves a second important policy objective—for *coordinating* policies in an effort to construct a coherent pan-Canadian system. While we have argued that policy stringency is fundamentally about effectiveness in reducing GHG emissions, another important policy objective is to achieve those reductions in the most cost-effective manner possible. Coordinating provincial carbon pricing policies can help ensure that low-cost emissions reductions across the country are realized, while high-cost abatement is avoided. The stringency metrics developed here can support efforts to coordinate provincial policies. The trade-adjusted carbon price could be especially useful in this context.

Different paths can be taken to achieve a coordinated pan-Canadian policy. The provinces themselves, for example, could choose to align their respective policies. Alternatively, the federal

9 As long as the cap-and-trade system in California is credible and verifiable, these permits do represent additional emissions reductions: every Californian permit purchased by an Ontario emitter must be accompanied by one fewer tonne of emissions in California.

government could define a minimum level of stringency, with provincial policies that meet or exceed that level being exempt from the federal policy. There are likely other options, but in any case, some metric of stringency is required to define equivalent policy. How could our stringency metrics apply in this context?

Coordinating provincial policies by aligning the marginal carbon prices can minimize the overall costs of emissions reductions. When carbon prices are equalized across all provinces, the result is that low-cost emissions reductions (i.e., those that cost less than the carbon price) are realized across the country. In contrast, differential carbon prices result in higher-cost reductions being implemented in those jurisdictions with higher carbon prices, leading to higher abatement costs overall.[10]

There is no single "right" way to coordinate provincial policies based on quantities of emissions reductions. As Böhringer et al. (2015) note, there are multiple ways to divide up the required emissions reductions among provinces. Different approaches might be more or less equitable, though defining a "fair" distribution of effort can be subjective and highly contentious. In addition, dividing up a fixed total quantity of emissions reductions is a "zero-sum game," thus increasing the potential for provincial disharmony.

Allocating required emissions reductions to each province could also make it harder for the pan-Canadian system to be cost-effective.[11] As we argued earlier, provinces have different economic structures, energy systems, and emissions profiles, and these differences result in quite different marginal abatement cost curves (see Box 1). As a result, a common level of emissions reductions (such as equal percentage reductions) would, in principle, result in higher total abatement costs than would be achievable if policies were aligned with a common marginal carbon price. While Boothe and Boudreault (2016) accept this principle, they suggest in practice, that allocating future provincial emissions based on historical levels would be close to the cost-effective allocation.

Coordinating provincial policies by aligning average carbon costs is not required for cost-effective emissions reductions across Canada, and is also challenging in practical terms. The policy choice to provide permits for free (thus reducing average carbon costs) is essentially a revenue-recycling choice (Canada's Ecofiscal Commission, 2016). We have argued that allowing provinces to make their own revenue-recycling choices according to their own context is an essential element of practical carbon pricing policy in Canada (Canada's Ecofiscal Commission, 2015b). As a result, it is likely impractical to consider an approach to coordinating provincial policies that hinders this flexibility.

The coverage-weighted carbon price identified in this report could support efforts to coordinate provincial carbon pricing policies. Broader coverage and a higher carbon price each lead to more emissions reductions. The metric accounts for both aspects by weighting the price of carbon based on the share of emissions to which this incentive applies. Aligning provincial policies around the coverage-weighted carbon price would also allow provinces some flexibility in choosing the precise combination of price and coverage for their own policies.

The final metric proposed in this report, the trade-adjusted carbon price, could be an even more useful tool when coordinating carbon pricing policies. Building on the coverage-weighted price, this metric is easily computed and is closely linked to the marginal price of carbon. As a result, it can serve as a valuable point of reference. And because it accounts for differences in both coverage and international permit trading, it can apply to a range of carbon pricing policies.

Consider this example. In consultation with the provinces, the federal government could define a minimum threshold of stringency based on the trade-adjusted carbon price. This minimum standard could be scheduled to rise over time and be sufficiently stringent for Canada to achieve its 2030 emissions target. Provincial policies with equal or greater stringency would be deemed equivalent to this minimum standard. In practice, "equivalency" would likely require some minimum level of coverage. Such a minimum would help to avoid particularly high-cost policies, such as a province choosing a very high carbon price applied to only a small share of emissions.

Depending on how such a minimum standard was enforced, provinces would likely align the stringency of their policies to this benchmark—although the nature of the metric would provide each province with considerable flexibility regarding the carbon price, policy coverage, and reliance on international permits, as illustrated in Box 2. Further, using the trade-adjusted carbon price as a benchmark would create incentives for each province to broaden the coverage of its carbon pricing policy, thereby enhancing overall cost-effectiveness.

10 With unequal marginal carbon prices across provinces, marginal abatement costs will also be unequal. In this situation, a given amount of national emissions reductions could be redistributed across provinces in a way that reduces total abatement costs. Such opportunities for redistribution are exhausted only when the marginal abatement costs are equalized (as would be the result with interprovincial permit trading); at this point, minimal total abatement costs will be achieved.

11 An important exception would be if all provinces used carbon pricing systems to achieve their allocated reductions and also linked their systems via permit trading. In this case, linking would lead to a common marginal carbon price and cost-effective emissions reductions. It appears, however, that some provinces prefer to not allow out-of-province trading at this time.

Box 2: Policy Flexibility With an "Equivalent" Trade-Adjusted Carbon Price

Different carbon pricing policies could each achieve equivalent stringency as measured by the trade-adjusted carbon price. The key design parameters are 1) the marginal price of carbon, either set directly or emergent from a market for tradable permits; 2) the coverage of the policy; and 3) the net flow of emissions permits to or from other jurisdictions.

The following three examples illustrate the flexibility of policy, and all assume a common (and hypothetical) marginal abatement cost curve. The three policies differ in carbon price, level of coverage, and amount of international trade in permits. Yet each has a trade-adjusted carbon price of $45 per tonne.

	Policy 1	Policy 2	Policy 3
Marginal price of carbon	$50 per tonne	$60 per tonne	$35 per tonne
Coverage	90%	75%	90%
Total annual GHG emissions	100 Mt	100 Mt	100 Mt
Annual net permit imports	0 Mt	0 Mt	39 Mt
Trade-adjusted carbon price	**$45 per tonne**	**$45 per tonne**	**$45 per tonne**

This shows the flexibility provinces would have in demonstrating equivalent policy. Various designs could achieve this benchmark. However, whether the federal government were to set a minimum level of stringency or the provinces themselves were to align their policies to a common level of stringency, it would likely make sense to place some limit on the variation in coverage and the use of international permits. Equivalent policy might, for example, require a minimum level of coverage or a maximum number of permit imports. These limits would ensure that marginal carbon prices are not too different across provinces, thus improving the overall cost-effectiveness of the system of policies.

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9. Appendix: The role of non-pricing policies

This report has focused exclusively on the stringency of carbon pricing policies. We have taken the stated federal goal of pan-Canadian carbon pricing at face value, and examined how various provincial policies can be compared, and how this comparison might be used to assist the coordination of these policies.

Policy approaches that do not rely on carbon pricing—such as regulations and subsidies—could also play a useful role in reducing GHG emissions. In some cases, such policies might be complementary to carbon pricing. For various reasons, some provinces might prefer to rely on non-pricing policies, even if they result in higher total abatement costs.

Defining and comparing the stringency of environmental policies more generally is challenging (Brunel & Levinson, 2013; Sauter, 2014). In principle, however, the stringency of non-pricing policies could be included within our conceptual framework. All policies that drive emissions reductions, even if they apply to only a narrow share of total emissions, have an “implicit carbon price” that can be estimated (OECD, 2013). These policies could be included when computing the trade-adjusted carbon price; they would likely have a relatively high (implicit) marginal carbon price but narrow coverage.

The trade-adjusted carbon price could therefore be used to assess the stringency of an *entire package* of policies, not just a single carbon pricing policy. With various non-pricing policies, however, there would be several different (implicit or explicit) carbon prices within the economy, each applying to a different segment of emissions. In general, such a policy approach would raise the overall costs of emissions abatement even as it increased the total amount of emissions reduced.

In practice, however, such an extension is problematic for two key reasons. First, estimating implicit carbon prices is analytically very challenging. It involves a range of assumptions and economic modelling. A large number of policies might contribute to an overall emissions strategy, and quantifying the full set of climate policies, and their implicit carbon prices, would be very difficult, with a great deal of uncertainty associated with the estimates. This challenge is compounded by the overlap and complex interactions between the various policies.

Second, non-pricing policies tend to be less cost-effective than carbon pricing policies. Policies that are inflexible and do not generate revenue to be recycled back to the economy generally have a greater economic cost than pricing policies. In other words, while it may be useful to consider *benchmarking* non-pricing policies, the discussion of *coordinating* provincial policies is best applied to carbon pricing alone.

This is not to say that only carbon pricing policies can be used to generate deep emissions reductions. But the objective of cost-effectiveness suggests that only a subset of non-pricing policies will be valuable complements to a carbon pricing policy. Future work from the Ecofiscal Commission will consider in more detail the implications of non-pricing policies and the extent to which they might—or might not—complement carbon pricing policy in a cost-effective manner.

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